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Quasi-experiments in Competition and Public Policy: Evidence from Chilean Economic History

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Quasi-experiments in Competition and Public Policy: Evidence from Chilean Economic History

A dissertation submitted in partial satisfaction

of the requirements for the degree Doctor

of Philosophy in Economics

by

Felipe B. Carrera Galleguillos

2020

ABSTRACT OF THE DISSERTATION

Quasi-experiments in Competition and Public Policy: Evidence from Chilean Economic History

by

Felipe B. Carrera Galleguillos

Doctor of Philosophy in Economics

University of California, Los Angeles, 2020

Professor Simon Adrian Board, Chair

Compared to other disciplines, one of the distinctive features of Economics is the impossibility of doing experiments to study empirically relevant questions. In this dissertation, I use two episodes from the past where the unique features of the institutional environment created quasi-experiments that help us understand relevant issues relate to cartels and neighborhood effects. In the fist two chapters, I use the Chilean nitrate industry between the War of the Pacific and the start of the First World War (1880-1914) to shed light on the effects of entry for cartels and the importance of learning for effective cartel organization. The Chilean nitrate industry was very important at the time: Chilean nitrate was the main commercial fertilizer used in the world. Also, it was the main industry of Chile, the only country where it is found, where it represented 70% of exports and 45% of government revenues. Importantly, there was no antitrust legislation and no domestic consumer surplus to protect in Chile. Thus, cartels could be freely formed by nitrate producers. Moreover, these cartels were completely public: Their decisions were publicly discussed by the press and the public and they would be formed by the signature of a public contract. I collected from handwritten archival records an original data set of monthly output and inputs that covers 35 years

of this industry, period over which 5 cartels were organized. In the third chapter, I introduce a novel new dataset to study neighborhood effects that uses a massive program of forced-displacement of population within the city of Santiago in the context of the Chilean dictatorship in the early 1980s.

Chapter 1 studies the effect of cartels on entry, and the long-term effect of cartel-induced entry for the evolution of industry productivity. Intuitively, as cartels artificially increase prices entry becomes more attractive and less productive firms may decide to enter. Because of data limitations, previous researchers have not quantified the extensive margin mechanism. My analysis has 3 steps. First, I evaluate if nitrate cartels caused more entry of new firms. I find that cartels generated an additional entry of 4 plants per year or about 5% of the initial number of plants in my main period of interest. Second, I estimate the productivity of all the plants in the industry to analyze if firms that entered during cartel periods where less productive. I find that there is a sizable gap in average productivity between entrants during competition and cartel periods: If the median-sized plant in the industry had received this productivity gap its revenue would have increases by one-third. Third, I conduct two counterfactual simulations. The first, studies the effect of entry on cartel profits by estimating incumbent cartel members counterfactual profits if they had been able to prevent any additional entry. I find their counterfactual profits would have been 40% larger had there been no entry. The second counterfactual studies the effect of having a cartel on entry. Specifically, what would the number of new firms and their productivity have been, if during the Fourth and Fifth Cartels there had been competition? I find that 18% of the plants that entered in the data would have not entered. This translates into an increase on mean plant productivity of 3%.

Chapter 2 studies the degree to which experience helps firms to organize successful cartels. Unlike in most of the previous literature on cartels, in the nitrate cartels issues related to monitoring and enforcement were of secondary importance with respect to the challenge of allocating the collusive surplus among the colluding firms. I document that cartel contracts gradually became more complete, generated a smoother transition from competition to collusion, and that producers eventually discarded inefficient methods of market share allocation, associated to larger production costs, in favor of better alternatives. In particular, I am able to estimate that the time method used during the Second Cartel directly caused higher production costs of about 10%, while the trial method implemented during the Third Cartel caused higher costs of approximately 20%.

Finally, Chapter 3 describes a novel large dataset that combines archival records and administrative data to study a natural experiment that occurred during the Chilean dictatorship between 1979 and 1985, when the government mandated the relocation of a large number of slums in the city of Santiago, Chile. Some features of the program's implementation make it of unique interest to study the broad effects of neighborhoods on social mobility and inequality: the unit of treatment was the slum, participation was mandatory and compliance was very high, since the policy was implemented during a highly repressive dictatorial government. In addition, and only some of the slums were removed from their original location creating two groups of families: movers and non-movers, which allows me to identify a causal displacement effect. The dataset comprises data for more than 26,000 households that were part of this program (out of a total of 40,000 households) and more than 58,000 of their children, providing the potential for causal estimation of the long-term and inter-generational effects of moving to a high-poverty neighborhood on education, mortality, income, and crime.

The dissertation of Felipe B. Carrera Galleguillos is approved.

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Learning-by-colluding: Experience and Effectiveness of Cartels in the Chilean Nitrate Industry.
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Chapter 1

Cartels, Entry, and Productivity: Evidence from the Chilean Nitrate Cartels

This paper studies the effect of cartels on the quantity and quality of new firms in an industry with low barriers to entry. Intuitively, since cartels generate artificially high profits, low-productivity firms may enter and erode the industry's productivity, raise dispersion, and reduce total surplus. To quantify these effects, we analyze Chile's nitrate cartel in the early 20$^{\text{th}}$ Century, an industry that dominated Chile's economy at the time. We show that during cartel periods, entry was higher (by 4 plants per year) and that these entrants had substantially lower productivity (by roughly one-third of the mean TFP). We show that low barriers to entry reduced the profits of incumbent cartel members by 40%. Moreover, we simulate each firm's entry decision and show that, had prices been determined competitively, 25% of the new plants would have postponed or canceled their entry to the industry.

1.1 Introduction

Cartels are a common feature in most economies. For instance, in the period 2015-19, the European Commission imposed fines in excess of €8.3 billion in 27 cartel cases.[1] Moreover, it is likely they are present in even greater numbers in nations with weaker antitrust systems than those of the EU or the United States.

As is well understood, cartels impose costs to society by increasing prices, and thereby reducing consumer surplus (e.g., Harberger (1954)). In addition, recent papers have shown that cartels reduce productive efficiency by misallocating output to less efficient cartel members (e.g., Asker, Collard-Wexler, and De Loecker (2019)). This paper considers a new channel through which cartels lead to productive inefficiency: By artificially making entry more attractive, they induce less productive inefficient firms to enter the industry.

We quantify the effect of cartels on entry by studying the Chilean nitrate cartel in the early 20th Century. This industry is attractive because the cartel was legally enforceable, entry barriers were low, and, over 35 years, the industry switched between cartel and perfect competition multiple times. Using a newly collected dataset, we show that during cartel periods, average entry increased from 5 to 9 plants per year. Moreover, entrants during cartel periods were less productive by one-third of the mean TFP. We conduct two counterfactuals. First, using detailed accounts from historical records about these cartels' inner workings, together with our structural estimates, we show that low barriers to entry lowered incumbent profits by 40%. Second, we estimate a model of firm dynamics and show that had the cartel not existed, 25% of plants would have postponed or cancel their entry.

These findings are important from a historical and present day perspective. At the time, Chile's nitrate industry dominated Chile's economy, accounting for 65% of exports and 45% of government revenues. The excess entry lowered the mean productivity of the industry by 3% and had a measurable effect on tax revenue and GDP. This poses important lessons for other developing countries that are dominated by extractive industries. Moreover, the paper speaks to the literature on productivity dispersion (e.g., Syverson (2004)) by showing that market power caused by coordinated action by otherwise independent firms can generate inefficient entry.

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[1] European Commision, Directorate-General for Competition (2019).

Our analysis proceeds in four steps. First, we obtain reduced-form evidence about the effect of cartels on entry. Second, we estimate the productivity of the nitrate-producing plants. Third, combining the distribution of productivity in the industry with additional cost data, we compute plant-level continuation values. Fourth, we perform counterfactual estimations.

The Chilean nitrate industry between 1880 and 1914 is well suited to answer our research question. The industry had low concentration, a large number of firms and potential entrants, and low barriers to entry. In this period, nitrate producers periodically formed quantity-setting cartels with the goal of raising prices. These cartels were completely public, and produced abrupt shifts between perfect competition and cartel settings. Moreover, these shifts were exogenous from the point of view of potential entrants. We focus our analysis on two incarnations of the nitrate cartel, which are regarded as the most efficiently organized according to historical records and for which we have extensive data.[2] Finally, all producers used the same technology of production, which remained unchanged throughout this period.

We collect new plant-level and industry-level data from several archival sources in Chile: plant-level inputs and outputs; plant characteristics; industry-level output, exports, and consumption; market prices; and contracts used to implement each cartel. These rich data allow us to estimate the production function for each plant in the industry, and to study their entry problem.

We first explore the relationship between a competitive regime and the amount of entry and exit. The cartel generated an increase in prices by reducing aggregate output. We show that cartels, even controlling for contemporaneous price, generated a significant additional entry of new plants of more than 2 plants per year (4 plants per year for the cartels that are our main focus of analysis). Moreover, a competitive regime was not significantly related to plant exit.

In order to compare the productivity of firms that entered in periods of cartel and competition, we estimate the productivity of the plants in the industry. We implement a control function method based on Olly and Pakes (1996) to generate consistent productivity estimates. We find the productivity distribution of entrants to be significantly different depending on the competitive regime at the moment of entry. The average productivity of plants that entered during cartel periods was smaller than that of plants that entered during competition by about one-third of the mean TFP. This difference in productivity is economically significant: A median-sized plant would

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[2]The organization of nitrate cartels is explained in detail in a complementary paper, Carrera and Titov (2020).

increase revenue by one-third, or $400k in current dollars, if it increased its productivity by the average productivity difference between entrants in competition and cartel periods.

We then compute continuation values for the plants in the industry in order to perform counterfactual simulations. To do this, we use our productivity estimates to develop a simple model that combines empirically expected levels of output with a Markov model that regulates the transition across prices and competition regimes and a plant-specific cost function. Median plant value at moment of entry is estimated at approximately $25m (in current dollars), although there is significant dispersion. Once entry costs are incorporated, estimates are consistent with observed entry behavior.

We use two counterfactuals to further explore the relationship between cartels, productivity, and entry. First, we evaluate the effect of low barriers to entry on cartel profits by computing counterfactual profits for incumbent cartel members, assuming they are able to prevent entry. We estimate that aggregate profits for those firms would have been 39% larger than observed, demonstrating that low barriers to entry are quite costly for cartels.

In the second counterfactual, we estimate how industry composition would have changed if two cartel episodes, between 1901 and 1909, had not occurred. We find that 18% of observed new plants would have not entered, and an additional 6% would have postponed their entry in the absence of the cartel. Plants that would not have entered in the counterfactual case had lower productivity, which translates into a 3% decrease, over 8 years, in mean industry productivity.

Our main results indicate that cartels have a substantial positive effect on the number of entrants to an industry and a negative effect on their productivity—eroding industry's productivity and reducing total surplus in the long run. Low barriers to entry are also shown to be costly to incumbent cartel members, as entry induced by cartel profits will significantly reduce their initial market shares.

Our paper is organized as follows. Section 3 presents the industry, emphasizing relevant features for identification and modeling decisions presented later in the paper. Section 4 introduces our datasets and summary statistics for the plants in the industry. In Section 5, we perform a reduced-form analysis of the effect of cartels on entry. In Section 6, we estimate plant-level productivity and compute the effect of cartels on mean productivity of entrants. In Section 7, we introduce a simple model of plant entry decision and we estimate plant-level continuation values. Finally, in

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Section 8 we describe our counterfactual simulations. The appendix presents additional industry background, tables, and figures that complement the main text.

1.2 Related Literature

Our paper studies the welfare consequences of cartels through their effect on productivity—unlike most of the literature, which has focused on surplus losses due to output restrictions and higher prices. Our work is closely related to a broader literature on the welfare costs of monopolies that dates to Harberger (1954), who understood the potential distorting effect of market power on resource allocation. Modern examples include applications on settings with cartels (e.g., Bridgman, Qi, and Schmitz Jr (2015)) and trade liberalization (e.g., Schmitz Jr (2005), Pavcnik (2002) and Dunne, Klimek, and Schmitz (2010)).[3]

Our paper is most closely related to Asker, Collard-Wexler, and De Loecker (2019), who study the misallocation of output in the global oil industry due to OPEC's market power. The focus of each paper is different, since our paper deals with extensive margin productive inefficiency while theirs studies the inefficiency caused by the suboptimal timing of oil field exploitation. Moreover, there are two significant differences in the setting of each paper. First, productivity dispersion in the nitrate industry is more representative of a typical industry, with a TFP ratio between a firm in the 90th decile of the productivity distribution and a firm in the 10th decile (90-10 TFP ratio) of 2.67. This value is on the same order of magnitude of the average 90-10 TFP ratio in the U.S. manufacturing sector of 1.92 (Syverson, 2004).[4] In contrast, the oil industry presents a much larger 90-10 TFP ratio of 9 (Asker, Collard-Wexler, and De Loecker, 2019). Second, the OPEC is an international permanent cartel formed by national governments and dominated by members with a permanent and large cost advantage. These characteristics distinguish OPEC from a standard intranational cartel.

So far, works dealing with the relationship between cartels and productivity have used settings with important barriers to entry. Bridgman, Qi, and Schmitz Jr (2015) and Rucker, Thurman, and Sumner (1995) analyze deadweight losses in industries in which incumbent producers cannot trans-

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[3]See Holmes and Schmitz Jr (2010) for a short survey.

[4]In developing countries, productivity dispersion seems to be larger. For instance, Hsieh and Klenow (2009) find an average 90-10 TFP ratios of about 5 for China and India.

fer their production quotas outside a limited geographic area. Monke, Pearson, and Silva-Carvalho (1987) analyze the outcomes of a flour-milling cartel in Portugal, and find large productivity losses from both misallocation of production and capacity restrictions imposed by the cartel together with the government. Similarly, in the case of the Norwegian cement industry analyzed by Röller and Steen (2006), industry productivity suffered as incumbent firms raced to expand capacity, given the quota allocation rules of the cartel, before merging to form a monopoly.

Some studies take a cross-industry or aggregate approach. Cole and Ohanian (2004) study the economy-wide effect of New Deal cartels, and show that they negatively affected economic activity. Symeonidis (2008) does a reduced-form analysis of the effects of competition on productivity and wages in a large sample of manufacturing sectors in the United Kingdom during the 1960s, taking advantage of passage of the Restrictive Practices Act in 1956 as a natural experiment. In contrast, we choose to study a single industry to understand fundamentals behind productivity and costs, which allow us to conduct counterfactual simulations.

Finally, our work contributes to the literature that studies cartel organization (an extensive survey is provided by Levenstein and Suslow (2006)) by being the first to quantify the effect of cartels on the amount of entry in a low-barriers-to-entry industry. This literature has identified four key challenges cartels must address in order to succeed (McAfee and McMillan, 1992): bargaining, monitoring, entry, and resistance from authorities. However, because of the demanding data requirements to study entry, this aspect of cartel organization has thus far been largely overlooked.

1.3 Industry Background

This section describes some important institutional details of the nitrate of soda industry, with a focus on the Chilean Nitrate Age (1884-1914). In particular, it presents industry characteristics important for identification and for understanding the modeling decisions implemented later. For additional details on the Chilean nitrate industry, please go to Section 1.A of the Appendix.

1.3.1 Historical development and expansion

The period between the War of the Pacific (1879-84) and the outbreak of the First World War is often referred to as the Chilean Nitrate Age. During this period, nitrate of soda was the main

Table 1.1: Evolution of the Nitrate Industry

Year	Plants (number)	Output (thous. of tons)	Workers (thous.)
1882	43	492	7.1
1887	57	713	7.2
1892	NA	804	13.5
1897	42	1,187	16.7
1901	66	1,329	20.3
1906	96	1,822	NA
1910	102	2,465	43,5
1914	137	2,463	44,0

Sources: Cariola, Sunkel, and Sagredo (1991), Semper et al. (1908), and Godoy Orellana (2016).

commercial fertilizer used in the world. For instance, by 1900, nitrate of soda represented two-thirds of the world's total supply of commercial fertilizers (Wisniak and Garces, 2001). At the same time, the entirety of the industry was, for the first time, located in a single nation.

Nitrate of soda is a natural fertilizer used to transfer nitrogen to the soil. The only commercially viable deposits are found in two provinces of the Chilean Atacama Desert (Vicuña, 1931).[5] It is an homogeneous product, since it was only sold in two versions[6] without any differentiation across producers. The closest available substitute during this period was sulphate of ammonia. Besides its use as a fertilizer, which accounted for roughly three-quarters of consumption, it had some alternative uses, the most important of which was as an input in the manufacture of explosives.

Nitrate was produced by private firms in purpose-built plants located on the desert. Figure 2.2.1 shows La Patria nitrate plant as a representative example. The basic configuration of a nitrate plant consisted of a central refining facility in the midst of the nitrate-bearing grounds that would feed it.[7] Packaged nitrate would then be dried and stored near the refining facility before being transported by railroad to the nearest port. In a standard transaction, producers would sell ready-for-export nitrate at the port. Traders would then transport it by boat to the consuming markets of Western Europe and the United States.

The nitrate industry featured a large number of firms and experienced constant expansion

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[5]The two provinces were Tarapaca (previously owned by Peru) and Antofagasta (shared by Bolivia and Chile before the war).

[6]The two versions were ordinary (95% purity) and refined (98% purity), with ordinary constituting almost all of output.

[7]The only exception to this configuration was the Antofagasta Company before 1907, which instead used a central refining facility in the port of the same name.

Figure 1.1: Nitrate Plant Example: La Patria Plant
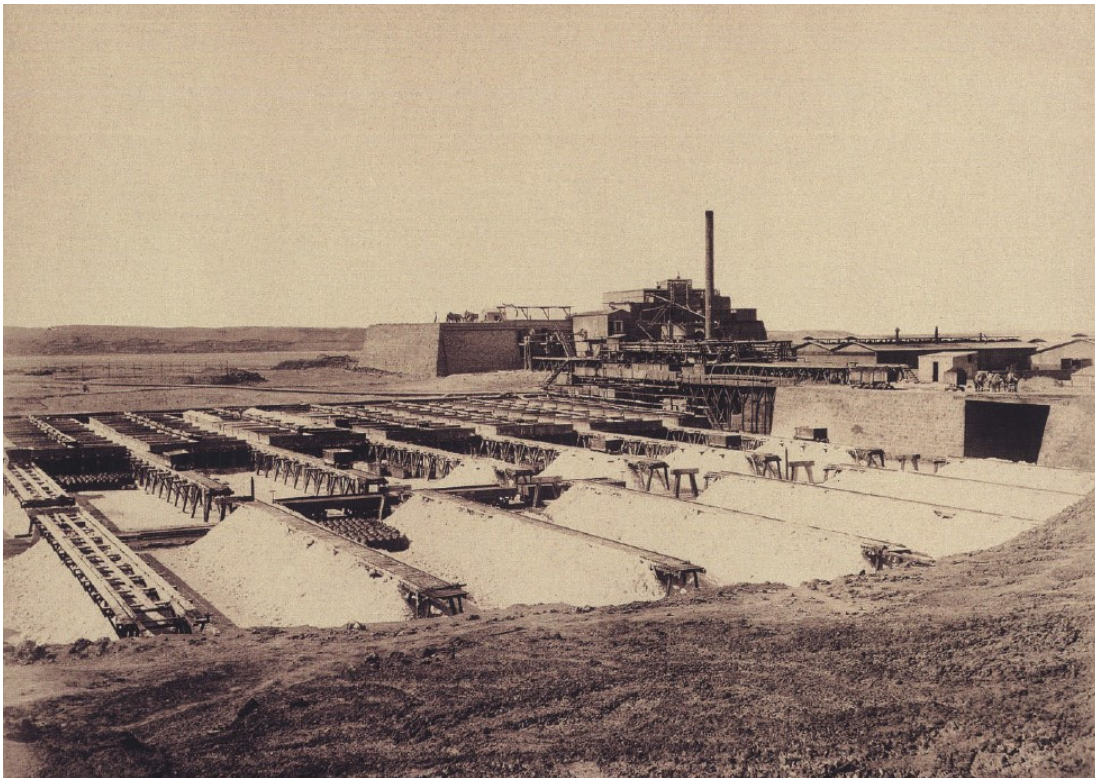
Sources: Boudat (1889).

during the Nitrate Age. Table 2.2.1 presents basic statistics regarding the industry's evolution during our period of interest. As a consequence of the large number of firms,[8] the industry had persistently low levels of concentration. For instance, in 1901 the largest firm had a market share of 6.4%, while in 1907 the largest market share was 7.6%. Firms were owned mostly by British, German, and Chilean entrepreneurs.

A distinct industry characteristic is that demand and prices were very volatile. This came as a result of three market characteristics (Bertrand, 1910). First, most nitrate was used during the European harvest season, between March and June of each year, which corresponded to about 90% of the agricultural consumption of nitrate. Second, the European demand had high variance, depending on the current year's weather shocks. Third, the large distance between Europe and Chile meant that nitrate producers were not able to react to same-year demand shocks,[9] since nitrate production, due to economies of scale, was bound to be year-round. These patterns are summarized in Figure 2.2.2. This situation was reinforced by the fact that nitrate intermediaries provided only minimal storage, because of the financial risks associated with its wide fluctuations in price.

The Chilean government implemented a nitrate policy based on two pillars: private ownership of the industry with low regulation, inspired by *laissez faire* principles, and heavy taxation using a per-unit export tax of approximately 2.54 pounds sterling per ton exported (this corresponds to about $400 per ton in current dollars) (Brown, 1963).[10] Nitrate of soda rapidly became the most important export of Chile, accounting for approximately 65% of exports.[11] At the same time, the nitrate export tax became the most important source of government revenues and explained, on average, 45% of total tax revenues between 1885 and 1914 (Chilean Ministry of Finance, 1925).

The First World War fundamentally changed the market for nitrate of soda,[12] as Chile lost its monopoly on nitrate of soda due to the invention of the Haber-Bosch method for production of

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[8]Some firms owned more than one plant. Most of the firms that entered during our main period of interest were single-firm plants.

[9]Semper et al. (1908) estimate average times of travel of 90 to 100 days for sailboats and 45 to 65 days for steamboats.

[10]Figures regarding the nitrate export tax also include the export tax collected on iodine exports. Iodine is a by-product of the elaboration of nitrate of soda.

[11]Computed from Cariola, Sunkel, and Sagredo (1991, p. 139), as the average of nitrate participation on exports in years ending in 0 or 5 during the Nitrate Age.

[12]The outbreak of the war also greatly disrupted the industry, as the blockade of the Central Powers closed some of the most important export markets overnight at the same time as the industry experienced a positive demand shock, driven by sales to the Allied powers.

Figure 1.2: Industry Output and Consumption
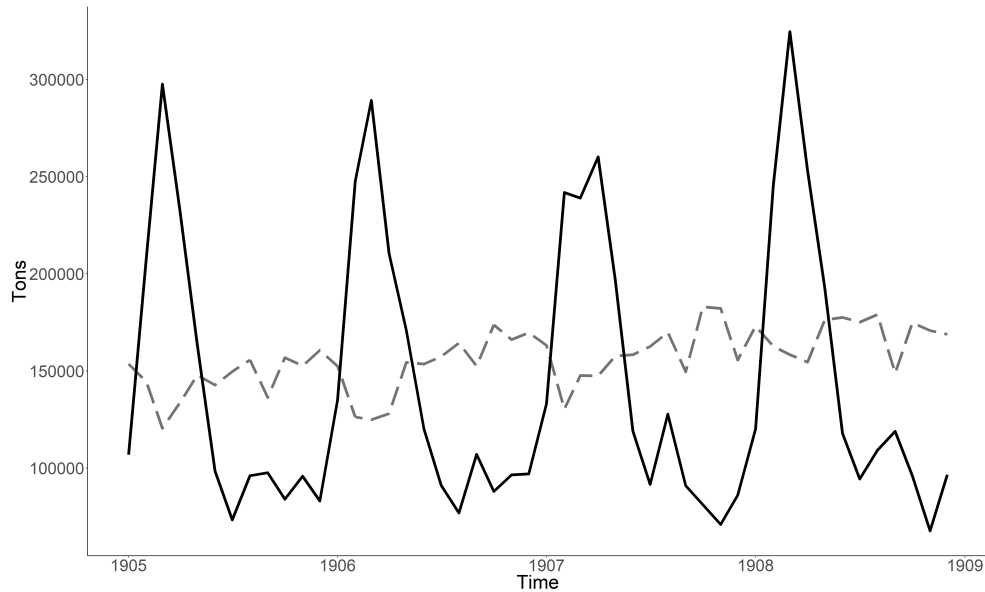
Notes: Monthly industry-level output (dashed line) and consumption (solid line) between the years 1905 and 1908.

synthetic nitrate. The effects of this event for the Chilean nitrate industry were devastating; it never recovered its previous levels of profitability.

1.3.2 Public cartels in the Chilean nitrate industry

Nitrate of soda producers formed cartels on five separate occasions (see Table 2.3.1). These cartels lasted from a minimum of 17 months to a maximum of 5 years, and had almost unanimous participation by nitrate firms.[13]

Historical records show that producers formed cartels to take advantage of their joint market power in the global fertilizer market. For instance, during a competitive period, a nitrate producers' publication states:[14]

> Currently, it can be said the industry is producing as much as it is allowed by the potency
> of the elements at its disposal ... On the other hand, it is the conviction of every and
> each producer that today they deliver their valuable product ... depressed by at least a
> shilling in the price consumers can still pay at great advantage for their economy ... The

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[13]Collusive agreements generally required the participation of at least 95% of industry output for the cartel to become operative.

[14]NPA Quarterly Circular, Number 18, May 25, 1899, p. 6.

Table 1.2: List of Nitrate Cartels

Cartel	Start Date	End Date	Early termination
First	1884-August	1886-December	No
Second	1891-March	1894-March	No
Third	1896-April	1897-October	Yes
Fourth	1901-April	1906-March	No
Fifth	1906-April	1909-March	No

Notes: Early termination indicates whether the End Date corresponds to the original termination date agreed on in the collusive contract or if an early termination clause of the collusive contract was invoked. *Source:* Brown (1963).

result, therefore, of sound advice and mere commercial foresight would be to agree on a formula under which all [producers] consulted their interests and marched together in pursuit of own and general welfare.

Before the start of each cartel, a collusive contract would be signed by all participating producers. Among the aspects regulated by these contracts were cartel duration, allocation of collusive quotas, dispute resolution mechanisms, rules regarding a potential early dissolution of the cartel, and norms for inclusion of new producers. Day-to-day operations of the cartel were managed by an elected board of producers, who were supported by the permanent staff of the trade association of nitrate producers (called the "Nitrate Propaganda Association," or NPA henceforth) after its creation in 1894.

A distinctive feature of these cartels is that they were completely public, including their collusive contracts. This was the result of the absence of any antitrust legislation in Chile at the time.

Cartel duration was explicitly agreed upon in the collusive contracts.[15] In the case of the first two cartels, duration was initially set for a short period of time (1 or 2 years), under the understanding that the cartel would, at the expiration date, be renewed under the same basic collusive contract. After the Third Cartel, duration of the contract became longer (3 or 5 years), and to extend collusion after that date, a whole new contract would have to be agreed upon by producers, allowing for a more complete renegotiation of the terms.

Regarding the effects of nitrate cartels, as an illustration, Figure 2.3.1 shows the industry yearly

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[15]After the Second Cartel, a specific procedure to trigger an early dissolution of the cartel was also included in the contracts. This procedure required the agreement of a super-majority of producers as a fraction of industry output. Only in the case of the Third Cartel was an early dissolution discussed and approved.

Figure 1.3: Industry yearly output (tons)
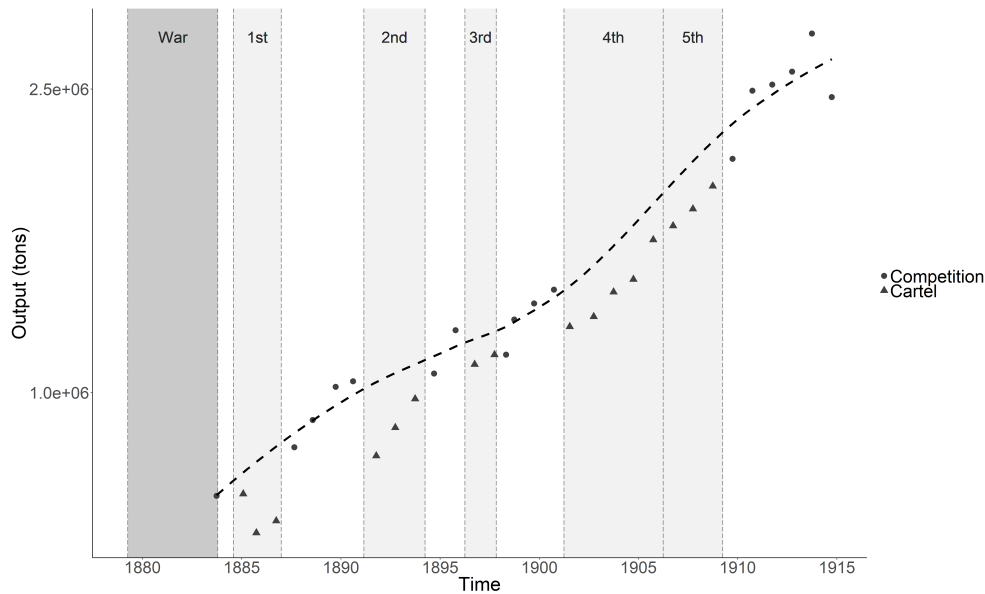
Notes: Yearly industry output shown as circles (triangles) for competition (cartel) years. The dashed line presents a nonparametric trend, computed only using industry output observed during years in competition. Cartel and War of Pacific periods are shaded. Each cartel's number by chronological order is written on its respective period.

output, together with a trend that considers only years with free competition, showing that output during cartel years was always below what could be expected given the previous trend of output during competition.

Table 2.3.2 summarizes the effect of cartels on industry output. In this table, the dependent variable is monthly industry-level output, while the main independent variables of interest are individual cartel dummies. The regression also includes dummies related to high-and-low-demand seasons and a time trend. The main result of Table 2.3.2 is that going from competition to cartel was correlated with an industry output reduction of around 18%. Cartels had heterogeneous results, which is consistent with contemporaneous descriptions.[16]

1.4   Data and Summary Statistics

Unlike most industries in the developing world at the time, producers and government agencies that were related to the nitrate industry placed great importance on the collection of detailed statistics.

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[16]Sources emphasize how the use of different contractual rules led to disparate degrees of success. In particular, Cartels Fourth and Fifth had a significant effect on aggregate output. Cartel rules are explained in detail in a complementary paper, Carrera and Titov (2020).

Table 1.3: Cartel Effects Regressions

	Dependent variable:	
	log(Nitrate Output)	
	(1)	(2)
Cartel	−0.187***	
	(0.031)	
Cartel 1		−0.549***
		(0.084)
Cartel 2		−0.045
		(0.053)
Cartel 3		−0.019
		(0.095)
Cartel 4		−0.137***
		(0.022)
Cartel 5		−0.167***
		(0.029)
Time	0.0002***	0.0002***
	(0.00001)	(0.00001)
Constant	16.426***	16.184***
	(0.132)	(0.145)
Observations	404	404
Controls	Yes	Yes
R^2	0.818	0.841
Adjusted R^2	0.817	0.838

Notes: Robust standard errors in parentheses. Observations correspond to months at the industry level. *Cartel* takes the value 1 if any cartel was active and 0 otherwise. *Cartel 1* takes the value 1 if First Cartel was active and 0 otherwise. Additional indicator variables for individual cartels follow the same logic. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Meticulous record-keeping was also helped by the isolated nature of the industry's environment, where it was the solely economic activity of importance.

The main dataset is a panel describing plant-level output and input decisions with a monthly frequency. This dataset, put together for the first time, was compiled from two main contemporaneous sources. The first corresponds to monthly plant-level industry reports compiled in the form of handwritten spreadsheets by the Nitrate Agency, which cover the period 1883 to 1909.[17] The second source is plant-level output and export monthly reports produced by the NPA, which mostly cover the period 1900-1914.

For the complete sample of months and plants, the data contained in the Nitrate Agency spreadsheets include nitrate output, exports, and stocks; iodine output, exports, and stocks; number and nationality of workers; and number and type of animals. There was also a partial collection of statistics on days worked and energy inputs. In total, we were able to collect spreadsheets for 228 months over this period, with $15,804$ observations at the plant-month level The dataset generated using Nitrate Agency data was complemented by monthly plant-level output data from the NPA monthly output reports (our second source). In this case, records are available for 21 months before 1900 and for every month after that year, for a total of $23,518$ observations. The merged dataset, once redundant observations were removed, contains a total of $32,623$ plant-month observations.[18]

Constructing the main dataset proved challenging at times. Both of our main sources come from physical archives and had never before been assembled into a single dataset. Spreadsheets produced by the Nitrate Agency were scattered in several archives located in Santiago and the Nitrate Region.[19] Moreover, these spreadsheets are original internal reports, produced to be sent from the agency's local office in the Nitrate Region to the Ministry of Finance in Santiago, which means that they are handwritten. Additional archival work took place in order to gather complementary data: Supplementary spreadsheets were gathered from reprints of the *Official Journal of the Republic of Chile* and local newspapers from the Nitrate Region, and NPA monthly output and exports reports were available in physical format at the Chilean National Library. Furthermore, data processing imposed additional challenges. For instance, several plants shared the same name (e.g., there were

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[17]For an example of a typical spreadsheets, see Figure 1.B.5 in Appendix 1.B.

[18]A summary of the coverage of both primary sources can be seen in Figure 1.B.1 in Appendix 1.B.

[19]Specifically, from the Ministry of Finance Section of both the National Historical Archives and the National Archives of the Administration in Santiago, Chile; and the Tarapaca Regional Archives in Iquique, Chile.

Table 1.4: Summary of Data Sources

Data	Sources
Prices UK	*The Economist, Chemical Trade Journal*
Prices Chile	Nitrate Agency, NPA
Cost parameters	Semper et al. (1908)
Plant characteristics	Narro (several issues), Boudat (1889)
1st Cartel contract	Comité Salitrero (1884)
2nd Cartel contract	National Notarial Archive. Iquique Notaries. Volume 132.
3rd Cartel contract	National Notarial Archive. Iquique Notaries. Volume 141.
4th Cartel contract	NPA (1900)
5th Cartel contract	Semper et al. (1908, p. 321)

five plants named "Sacramento" and seven named "Rosario"). To distinguish between them, the Nitrate Agency and the NPA used naming conventions, such as adding a geographical or ownership reference to the name, which were not always consistent. Finally, industry sources did not use a standard set of units to produce their reports. Hence, each reporting agency would use a different units convention.

The main dataset was complemented by data from several other sources, which are summarized on Table 2.4.1.[20] From sources in the National Notarial Archive and the National Library, we collected the five collusive agreements signed by the nitrate producers between 1884 and 1909. UK price data, for nitrate of soda and related products, was obtained from *The Economist* and *The Chemical Trade Journal.* Chilean prices were gathered from the Annual Report of the Nitrate Agency and the "*Estadística Comparada de Años Salitreros,*" which is a compendium of aggregate statistics published by the NPA. Extensive historical evidence from nitrate producers' internal discussions was obtained from the Quarterly Circulars published by the NPA and the nitrate producers' meeting minutes (NPA, 1909). Additional qualitative evidence comes from the internal correspondence of one of the main nitrate firms, the Antofagasta Company.

Some limitations remain regarding our data. First, before 1890, Nitrate Agency spreadsheets included only the Tarapaca Province (which, at that time, corresponded to around 90% of industry output). Second, there are 22 months between March 1883 and February 1897 for which we do not possess output plant-level data. Third, our inputs data ends in 1909 which means that we can't estimate productivity for plants that entered after that year. Finally, one company (the

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[20]Additional details are found in Appendix 1.B.

Statistic	Workers	Animals	Capacity (tons)	Avg. output (tons)
N	176	178	200	200
Mean	289	103	3,494	1,703
St. Dev.	179	64	2,861	1,239
Min	5	2	30	18
Pctl(25)	167	57	1,610.2	932
Median	245	89	2,663.7	1,337
Pctl(75)	383	139	4,267.1	2,161
Max	1,038	309	15,647	6,721

Notes: Capacity estimated as maximum monthly observed output in moving period of five years (observations from year 1896 were dropped). Workers, animals, capacity, and average output correspond to mean monthly values, excluding zero output observations. *Sources:* Authors' calculations using main dataset.

Antofagasta Company) refused to report its output before 1895 (however, they did report their inputs).

Table 2.4.2 shows summary statistics for the 200 plants in our main dataset. The median nitrate plant had 245 workers and 89 animals, although there was a significant dispersion. Column 3 shows capacity, which was estimated as the maximum plant-level monthly output observed in any month of a moving 5-year interval.[21] Column 4 presents the average monthly output, conditional on plants being active. The industry presents a large amount of excess capacity, with average output doubling the average monthly output. Figure 1.5 complements Table 2.4.2 by illustrating the relationship between industry capacity and monthly output.

1.5   Reduced-form Evidence on Entry

The first step in the analysis explores the relationship between cartel episodes and the entry and exit of plants. Extensive narrative historical evidence documents a relationship between cartels and entry in this industry. For instance, the testimony of H.H. Gibbs, cited earlier, includes the following exchange:[22]

—Now you said, with respect to your nitrate of soda, that it is a bit of a monopoly?

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[21]For the estimation of capacity, we did not consider observations from the year 1896, since the rules of the Third Cartel induced abnormal levels of output in that year.

[22]Gold and Silver Commission (1887, p. 157).

Figure 1.4: New Plants per Year
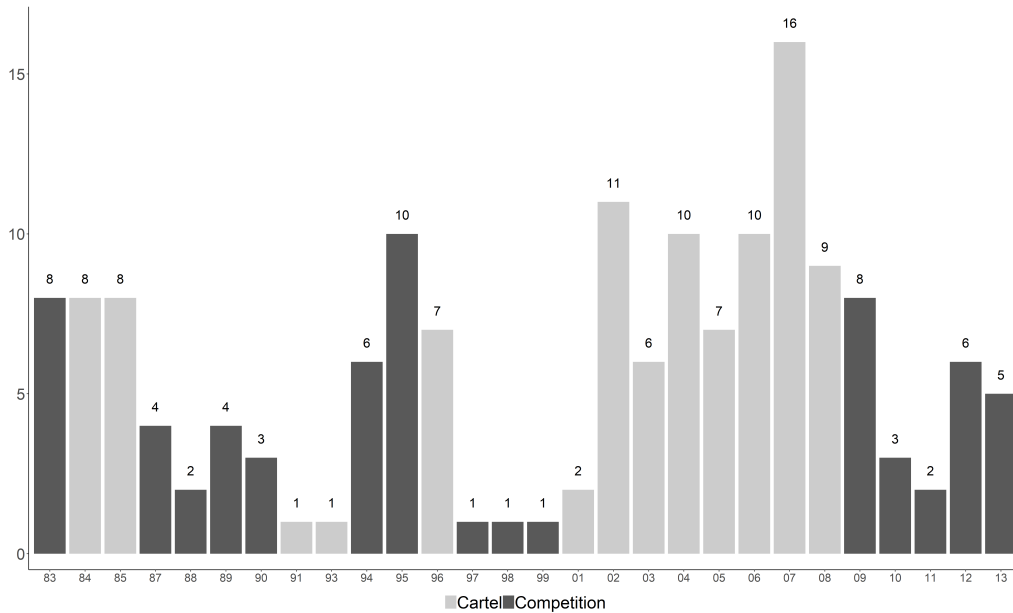
Notes: Number of nitrate plants that started operating each year. Competition (cartel) years are shown in black (gray).

—A monopoly of the province, you may say the whole of that part of Chili. Well, the effect of this stimulus given to that production is that a multitude of producers turn up.

Table 1.6 summarizes entry and exit patterns for the industry between 1885 and 1914, and shows that cartel periods are associated with a significant increase in the entry of new plants. The dependent variable in these regressions is the number of entering and exiting plants per period. We identify the entry date of each plant as the first month in which it had a positive output (the yearly entry of plants is summarized in Figure 1.4). Observations have been grouped in periods of 6 months, which are then classified as competitive or cartel periods.

The results in columns 1 and 2 of Table 1.6 suggest that even after controlling for contemporaneous nitrate price level, cartels have a significant effect on the entry of new plants,[23] and this effect has a large magnitude with respect to industry size. In a specification that uses a dummy to account for all cartels together, the effect is roughly 2 new plants per year. On the other hand, in a specification considering only the Fourth and Fifth Cartels (which are the focus of our analysis),

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[23]For a visual illustration, see Figure 1.4.1 in Appendix 1.4.

Table 1.6: Entry Regressions

	Dependent variable:	
	Entrants per period	
	(1)	(2)
Cartel	1.069**	
	(0.516)	
Cartels 4th & 5th		2.212***
		(0.591)
log(Price)	7.079***	6.437***
	(2.211)	(2.026)
Time	0.002	-0.019
	(0.016)	(0.015)
Constant	-13.863***	-11.809***
	(4.800)	(4.339)
Observations	60	60
R^2	0.228	0.328
Adjusted R^2	0.186	0.292

Notes: Robust standard errors in parentheses. Periods correspond to 6 months. *Cartel* takes the value 1 if any cartel was active and 0 otherwise. *Cartels 4th & 5th* takes the value 1 if Fourth or Fifth Cartels were active and 0 otherwise. Price is contemporaneous nitrate of soda price in UK. $^*p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

the magnitude increases further to more than 4 plants per year.

Exit patterns in our data are observed with more noise than entry patterns because of the presence of a large number of shutdowns. Particularly, it is likely that what we observe as exits in the data, near the end of our database, were instead originally intended to be temporary shutdowns that became permanent after the start of World War One. The main factor that explains observed plant exits in this industry is obsolescence. For example, approximately 30% of all exiting plants are units that were never updated to the Shanks refining method.[24]

Identification of the effect of cartels on entry relies on the fact that the competitive regime of the industry was public, and that both the competitive regime of the industry and nitrate price were exogenous from the point of view of a potential entrant. The competitive regime of the industry was exogenous because, if the current competitive regime was collusion, cartel rules implied

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[24]This refining method was the industry standard during the Nitrate Age, and was introduced only a few years before the start of our dataset.

that entry would be accommodated and the new producers incorporated into the cartel.[25] On the other hand, if the current competitive regime was competition, forming a new cartel required the approval of a large majority of producers. Since market shares in the industry were very low, it was highly improbable that the entry of a single new producer would affect the existence of such a majority. Thus, potential entrants knew that their individual entry decision was unlikely to affect the collective decision about the industry's competitive regime. Nitrate price was exogenous given the extremely low concentration of the nitrate industry, which meant that firms had a behavior consistent with perfect competition. Finally, the competitive regime was public since cartel contracts, once signed, were public and had a known fixed term.

The previous argument does not imply that incumbent producers were unaware of the fact that the existence of a cartel changed entry patterns. For instance, during the failed negotiations to form a cartel in 1909, the manager of the NPA stated:[26]

> Regarding the reduction of the [cartel] duration from 5 to 3 years, it is true that with a 5 years [contract] there is the risk that new plants will be built, since it offers a wider base for the investment of capitals . . . On the other hand, a 3 year [contract] generates another challenge, which is that one year before that period is completed the market becomes unstable, due to the uncertainty about whether a new collusive contract will be signed or not.

The nitrate industry had low barriers to entry.[27] To install a new nitrate firm, an entrepreneur needed two things: to obtain the rights to nitrate-bearing land and to install a refining facility. With respect to the refining facility, all new nitrate plants in the Nitrate Age used the Shanks Method, which was not patent protected.

Nitrate rights in private hands was abundant. An official report of the Nitrate Agency estimated in 1908 that nitrate reserves owned by private producers were more than three times larger than the total industry output in its first century.[28] Ownership of nitrate lands was very atomized, which made it impossible for incumbent producers to prevent entry by restricting access to nitrate

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[25]For an example of a cartel contract see Appendix **??**.

[26]NPA (1909), minutes from the meeting on March 23, 1909, p. 3.

[27]Low barriers to entry, defined here simply as the fact that any firm willing to pay an entry cost could become active in the industry.

[28]Bertrand (1910).

Figure 1.5: Industry Capacity and Monthly Output
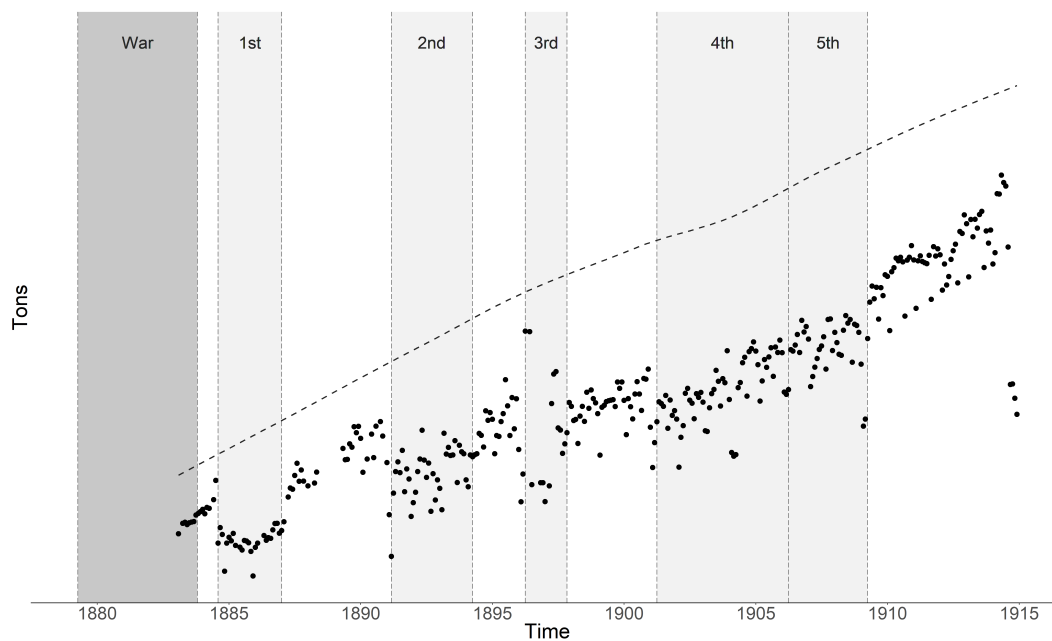
Notes: Estimated industry capacity (dashed line) and monthly industry output. Capacity computed by adding estimated individual plant capacity. Individual plant capacity, estimated as the largest observed output in 5-year intervals (the year 1896 is not considered in computation, due to exceptional output levels caused by Third Cartel rules). Cartel and War of Pacific periods are shaded. Each cartel's number by chronological order is written on its respective period.

rights.[29] H.H. Gibbs stated about the availability of nitrate land: "...the land is of no value at all, it is prairie value really until you put up a manufactory. Well, the fear of having to invest capital in that manufactory ...deters people."[30]

Contemporaneous narrative evidence shows that nitrate producers would hold on to their nitrate land, waiting for the right moment to purchase the necessary equipment to start producing:[31]

> Owners [of nitrate lands] limit themselves to keep their property waiting that more prosperous years for the industry would allow them to start obtaining commercial profits from their immobilized capital ...These legitimate aspirations have finally materialized, sheltered by the prosperity brought to the industry, thanks to the combination formed by those same owners.

Nitrate land holdings by the Chilean state were even more extensive. By 1925, the Ministry of Finance claimed that nitrate land owned by the government and still unmeasured, in terms of surface, was almost five times larger than that already in private hands.[32]

The Chilean government periodically auctioned nitrate lands in its possession (see Table 1.7). This could potentially be a threat to our identification, if the entry of new plants was induced by Chilean government auctions and land auctions coincided with cartel periods. Table 1.7 summarizes all nitrate land auctions conducted by the Chilean government during the study period. Only 3 out of 12 auctions occurred during cartels. Moreover, the amount of nitrate content transferred in those auctions was equivalent to only 6% of the reserves already in private hands (Semper et al., 1908).[33] In addition, the auctions in the period 1894-95 (competition years) were the only ones directly motivated by a desire to induce entry (Brown, 1963). Finally, from a directory that encompasses all Chilean nitrate firms in 1907 (Nitrate Credit Association, 1909), we know that out of 28 new plants built by these firms, only one can be traced directly to a recent land auction.

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[29]Patterns of nitrate land ownership across different districts are explained in Appendix 1.A.

[30]Gold and Silver Commission (1887, p. 157).

[31]NPA Quarterly Circular, Number 27, April 21, 1902, p. 4.

[32]Detailed statistics can be seen in Table 1.A.2 of Appendix 1.A. Estimation based on the minimum nitrate content required by the Shanks refining method, which was 12%.

[33]Estimation in the Nitrate Agency's annual report for 1900, p. 53. This annual report has yet to be obtained by us.

Year	Auction no.	Competitive regime	Nitrate reserves (tons)	Price (£/ton)
1882	First	Competition	30,144,060	0.21
1894	Second & Third	Competition	43,640,414	0.24
1895	Fourth	Competition	5,000,000	0.20
1897	Fifth	Cartel	1,842,000	0.16
1901	Sixth	Cartel	11,144,368	0.17
1903	Seventh	Cartel	12,559,413	0.25
1912	Eighth	Competition	8,203,185	0.50
1917	Ninth	Competition	27,686,184	0.19
1917	Tenth	Competition	30,786,675	0.33
1918	Eleventh	Competition	6,668,953	0.23
1924	Twelfth	Competition	38,046,630	0.36

Sources: Chilean Ministry of Finance (1925), p. 53.

1.6 Productivity Estimation and Dispersion

Using our detailed output and input plant-level database, we estimate the productivity of each plant in the industry. The estimated productivity distribution exhibits a large cross-sectional dispersion. We also show that plants that entered the industry during cartels had significantly lower productivity.

The production of nitrate consisted of two distinct main stages: extraction and refining. The extraction stage was the labor-intensive process by which the raw material,[34] which would later be refined into nitrate of soda, was extracted from the desert soil and transported to the nitrate plant's refining facility. The refining stage refers to the leaching process by which the nitrate of soda was separated from the other materials present in the raw material, such as diverse salts and sulfites.

In line with the previous description, we model the overall production process using a Leontief production function. At the same time, each of the main stages of production is separately assumed to follow a Cobb-Douglas production function. In the extraction stage, the relevant inputs are workers and animals used to transport the raw material. Meanwhile, on the refining stage, the relevant input is the energy used to heat the raw material during the leaching process. Finally, since most of the energy used in the extraction stage corresponds to animal traction, and the refining stage was energy intensive, it is realistic to assume that the observed energy input was only used in the refining stage. For plant i in period t, its output will be given by

$$q_{it} = \min\{\underbrace{\phi_i L_{it}^{\alpha} A_{it}^{\beta} \varepsilon_{1it}}_{\substack{\text{extraction} \\ \text{stage}}}, \; \underbrace{\theta \phi_i^{\delta} E_{it}^{\gamma} \varepsilon_{2it}}_{\substack{\text{refining} \\ \text{stage}}}\} \tag{1.1}$$

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[34]Raw material was denominated "caliche" in Spanish.

$$s.t. \qquad q_{it} \leq \underbrace{k_{it}}_{\substack{\text{refining} \\ \text{capacity}}},$$

where q_{it} is nitrate output, ϕ_i is a time-invariant TFP term, A_{it} are animals, L_{it} are workers, and C_{it} are energy (coal) units. In addition, θ is a common scaling factor and ε_{jit} are lognormal iid shocks to output with zero mean. Similarly, k_{it} corresponds to the maximum refining capacity of the plant, which is unobserved but which we can infer from the monthly output data. Notice that we observe the output of nitrate plants in physical units (tons), not in sales.

The term ϕ_i is present in both stages of the production process. Intuitively, ϕ_i is related to the geological properties of the raw material; in particular, to its nitrate grade, which should affect both stages of the production process. To illustrate, suppose one plant has a value of ϕ that is twice as large as that of a second plant. Then, the first (high-productivity plant), to produce each unit of final product, will have to extract, transport, and apply the leaching process to only half as much raw material as the second (low-productivity) plant.

During the period studied there was no significant technological change, since the Shanks method to leach nitrate, introduced in the late 1870s, remained the industry standard until the 1920s. Moreover, all new plants built during the Nitrate Age were based on this technology. At the same time, the extraction stage did not experience significant improvements (Reyes, 1994).[35]

There is ample evidence that costs—and therefore productivity—were heterogeneous across nitrate plants. The main driver of productivity differences, as the technology used by all firms was the same, was the geological characteristics of the nitrate-bearing grounds where each plant was located. Contemporaneous sources support this claim; for instance, Semper et al. (1908) state, "the cost of production varies widely depending on numerous factors. Mainly the nitrate grade, the hardness, and the specific type of raw material."[36]

We estimate the parameters of equation 1.1 in two steps. Our main dataset includes workers, animals, and nitrate output for all plants. In the first step, we use these variables to estimate the parameters from the extraction stage. We will take the following expression in log-form to the data:

$$log(q_{it}) = log(\phi_i) + \alpha log(L_{it}) + \beta log(A_{it}) + log(\varepsilon_{1it}). \qquad (1.2)$$

In the second step, we use the productivity estimated in the first step as an input to estimate the parameters in the refining stage, using the subsample of observations that include the energy variable, which corresponds to approximately 15% of the observations in the full sample.

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[35]In particular, mechanization of the extraction stage would only occur in the 1920s, with introduction of the Guggenheim method of production.

[36]Semper et al. (1908, p. 71).

1.6.1 Extraction-stage Estimates

To obtain consistent estimators in the first step, we must address two potential main concerns: simultaneity and selection. Simultaneity arises if the productivity shock ε_{1it} is observed by the firm before it makes its input decisions. Selection refers to the fact that plants choose whether to operate or not, causing the observed set of active plants to be not a random sample from the population of plants.

Notice that for simultaneity to be a problem after including fixed effects in the extraction stage, firms should be able to predict the sign and direction of the deviations from the mean and then be able to adjust the number of workers and animals accordingly.

We believe that simultaneity in this particular case is not an issue for two reasons. First, there is evidence that productivity shocks were hard to predict. Second, it was hard for firms to adjust their relevant inputs to short-term productivity shocks. In the nitrate industry, shocks to productivity correspond to deviations from the plant mean level in raw material quality.

First, because of the nature of the technology and the production process, it is unlikely that firms were able to predict deviations from mean productivity before the end of the leaching process. Historical evidence supporting this claim is found in the Antofagasta Company archives,[37] particularly in the periodic reports sent by plant managers to central headquarters. In February 1892, for example, the manager states that "last month production was only 45,890 quintals ... the result is unsatisfactory ... The first days of the month were very productive and we expected to reach a production of 55,000 quintals, but then [productivity] diminished because of the presence of sulfate and boric acid ... which prevented the cristalization of nitrate."[38] Similarly, in May 1893, the plant manager reports that "output in April was only 42,300 quintals. This reduced amount was due to the small number of leaching tanks [available], and the poor quality of the raw material whose high concentration of sodium sulfate forced us to repeat the crystallization process."[39]

Second, nitrate firms faced severe frictions in the input markets for workers and animals, which makes it less likely that they adjusted their level of inputs as a function of monthly productivity shocks even if they were able to perceive them. Since the industry was located in a previously uninhabited desert, mules had to be imported from Argentina and workers had to be brought from other regions of Chile or Bolivia. The industry suffered periodic labor shortages, which motivated the NPA to organize joint labor recruitment efforts in Central and Southern Chile. The reports of the Antofagasta Company manager illustrate the great lengths companies had to go to recruit labor:[40]

> By telegram, I was informed 247 males, 128 women, and 30 children embarked in [the province

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[37]This company was one of the largest in the industry, and company archives are preserved in the Historical National Archives of Chile.

[38]Report number 87, February 2, 1892, p. 4.

[39]Report number 224, May 2, 1893, p. 1.

[40]Report number 225, May 5, 1893, p. 1.

Figure 1.6: Plants in Shutdown
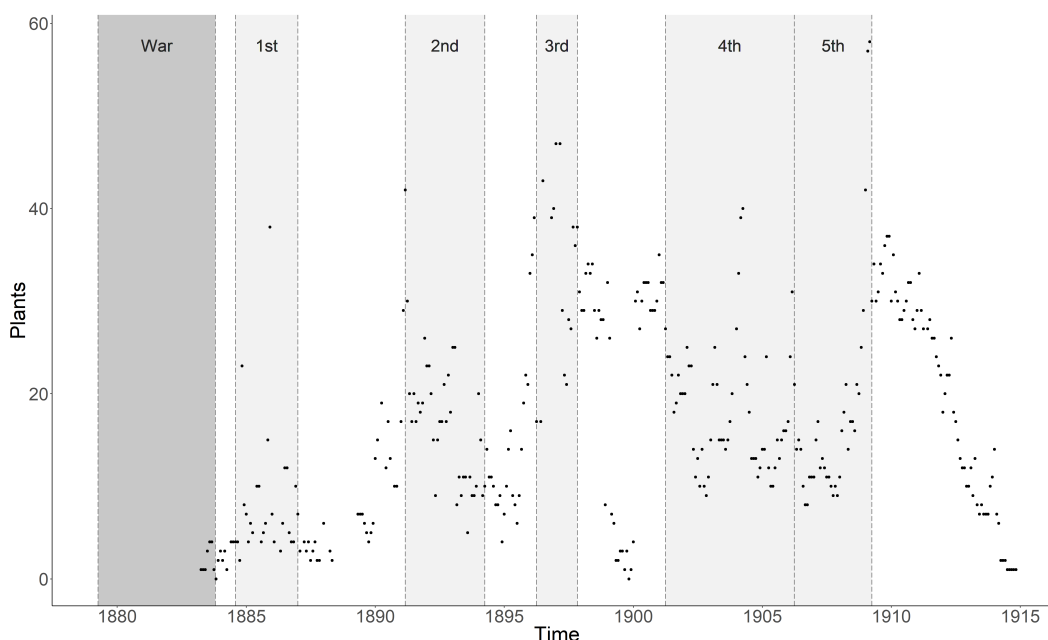
Notes: Plants in shutdown are defined as plants with zero observed current output and that have at least one positive output period later in time. Cartel and War of Pacific periods are shaded. Each cartel's number by chronological order is written on its respective period.
Source: Authors' calculations based on official publications.

of] Coquimbo bound to Pampa Central [plant].

To ensure the success of this important recruitment effort I took the following measures: The railroad will have a special service on Sunday, day of their arrival, waiting on the docks . . . Five boats will be ready to transport them to the company warehouse, . . . and the Governor will send all available police to prevent any contact with locals.

The selection problem arises in this case because there is censoring on the observed distribution of active plants. In the particular case of the nitrate industry, this problem would arise because of the large number of shutdown plants we observe in the data (see Figure 1.6).[41] Intuitively, plants that have already invested in accumulating workers and animals may decide to remain in operation, even if they have a lower productivity than a second plant that had not made those investments in the past, which introduces a bias in our estimates. To address this issue, we use the method proposed by Olly and Pakes (1996), who use a control function approach.

In this case, we augment equation 1.5 by adding a nonparametric function $\lambda(\cdot)$ of the propensity score of shutdown to control for the differential probabilities a plant had of being active given its observables. Intuitively, under mild conditions, there is a one-to-one relationship between the true selection function

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[41]Interestingly, shutdowns are far more numerous than exiting plants; see Figure 1.4.2 in Appendix 1.4.

Table 1.8: Production Function Extraction-stage

| | *Dependent variable:* | | |
| | log(Nitrate output) | | |
	(1)	(2)	(3)
log(Workers)	1.086***	0.521***	0.529***
	(0.041)	(0.040)	(0.029)
log(Animals)	0.273***	0.198***	0.186***
	(0.050)	(0.038)	(0.018)
Fixed effects	No	Yes	Yes
Adjusted Selection	No	No	Yes
Observations	10,782	10,782	8,608
R^2	0.483	0.671	0.995
Adjusted R^2	0.482	0.667	0.995

Notes: Robust standard errors in parentheses. Observations are plant-months. Nitrate output measured in tons. $^*p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

that generates the censoring and the propensity score. The new expression that will be taken to the data corresponds to

$$log(q_{it}) = log(\phi_i) + \alpha \cdot log(L_{it}) + \beta \cdot log(A_{it}) + \lambda(\nu_{it}) + \epsilon_{1it}, \tag{1.3}$$

where ν_{it} corresponds to the propensity score of *oficina i* to shutdown in period t, and the polynomial $\lambda(\cdot)$ used has four degrees of freedom and was chosen according to the BIC criteria.

The propensity score is computed using a logit regression, where the dependent variable was the shutdown choice of the firm and the independent variables are their lagged input values.[42] To compute the propensity score, several additional operations were done on the original dataset.[43]

Results from the estimation of plant-level productivity are summarized in Table 1.8. We restricted the estimation to plants for which we have at least 10 observations with positive nitrate output. Figure 1.4.3 and Table 1.9 summarize the estimated distribution of productivity, which has a dispersion, measured by the TFP 90-10 ratio, of 2.67. This value is on the same order of magnitude of the average 90-10 TFP ratio in the U.S. manufacturing sector of 1.92 (Syverson, 2004).

Since we require at least 10 data points, we do not estimate the productivity of all plants that entered

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[42]Estimation results are shown in Table 1.C.1 in Appendix 1.C.

[43]First, we removed observations in which a plant was not active, but we know from the comments on the records that the shutdown was because of force majeure. Examples include "cauldrons being repaired," "leaching tanks being repaired," and "assembling refining facility." Second, we remove observations in which there was a comment explaining the plant was only performing extraction. Third, we remove observations from periods in which exceptional circumstances may have induced additional shutdowns. These are the Chilean Civil War of 1891 and the Second Cartel, which restricted output by capping the fraction of the year a plant could produce nitrate.

Table 1.9: Summary Statistics: Plant Productivity

Statistic	Productivity
N	148
Mean	44.4
St. Dev.	15.6
Min	10.2
Pctl(25)	33.7
Pctl(75)	53.7
Max	97.1

Figure 1.7: Estimated Distribution of Plant Productivity
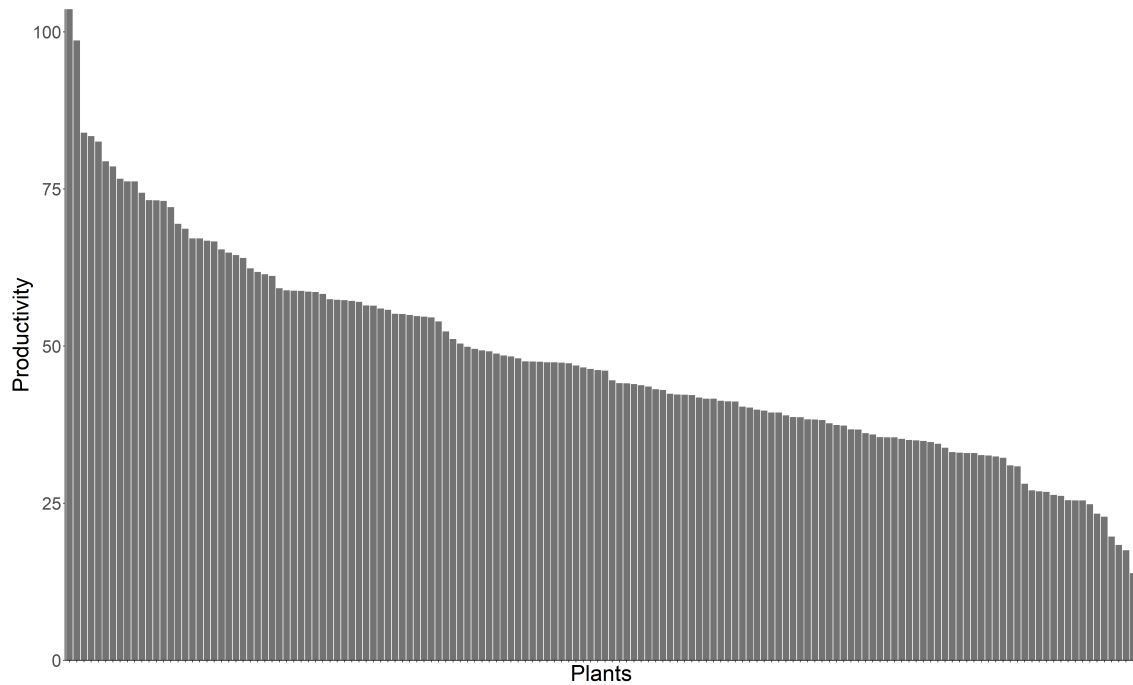
Notes: Each bar represents the estimated productivity of a nitrate plants (N=148). Values ordered in descending order.

Table 1.10: Effect of Cartels on Productivity of Entrants

	Dependent variable:	
	Productivity	
	(1)	(2)
Cartel	−10.630***	
	(3.575)	
Cartels 4th & 5th		−13.365**
		(5.705)
log(Price)	−28.425**	−27.386**
	(13.830)	(13.110)
Time	0.490***	0.924***
	(0.158)	(0.292)
Constant	108.835***	97.738***
	(30.260)	(29.631)
Observations	108	108
R^2	0.154	0.122
Adjusted R^2	0.130	0.097

Notes: Robust standard errors in parentheses. Observations are individual plants at moment of entry. Dependent variable is estimated plant-level productivity. *Cartel* takes the value 1 if any cartel was active and 0 otherwise. *Cartels 4th & 5th* takes the value 1 if Fourth or Fifth Cartels were active and 0 otherwise. Price is contemporaneous nitrate of soda price in UK. $^*p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

the industry in the period before World War One. In particular, of the 71 plants that started operating during the Fourth and Fifth Cartels, we are able to estimate the productivity of only 48 (slightly less than 70% of the total). However, since the probability of shutdown is negatively correlated to productivity, the set of plants without a productivity estimate is a negatively selected sample of the population.

1.6.2 Analysis of the Productivity Distribution

An additional question we can explore using the obtained distribution of productivity is whether cartels negatively affected the "quality" of the entrants. Intuitively, as nitrate cartels generated artificially high prices for an ex ante known period of time, some low-productivity plants, which would have not entered in a competitive environment, could have decided otherwise. Table 1.10 shows that cartels had a significantly negative effect on the productivity of new plants, even when we control for the contemporaneous nitrate price level.

Furthermore, the distribution of entrants during cartels was different than the distribution of entrants

Figure 1.8: Productivity vs Period of Entry

| | Initial | War of Pacific | Before 1st | 1st Cartel | Before 2nd | 2nd Cartel | Before 3rd | 3rd Cartel | Before 4th | 4th Cartel | 5th Cartel | After 5th |
| | 39.2 | 39.6 | 54.7 | 39.2 | 44.6 | 32.3 | 54.9 | 45.7 | 65 | 44.6 | 44.1 | 66.8 |

■ War ■ Cartel ■ Competition
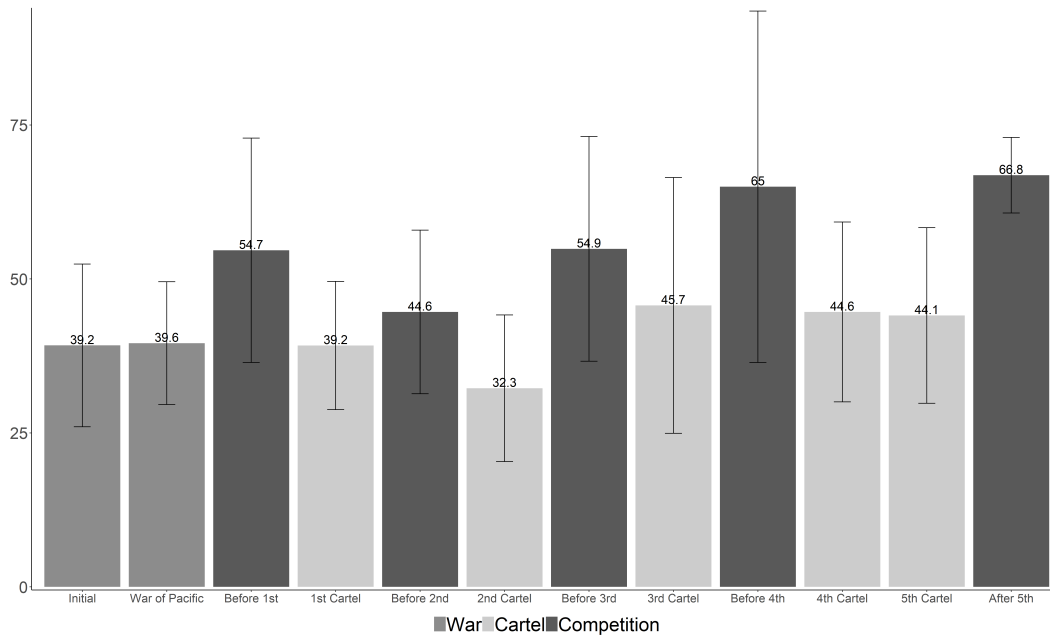
Notes: Each bar represents the mean productivity of entrants by period. Standard errors shown over the bars. Cartel (competition) periods are shown in darkest (lightest) shade.

Figure 1.9: Productivity Distributions of Entrants

□ Competition □ Cartel
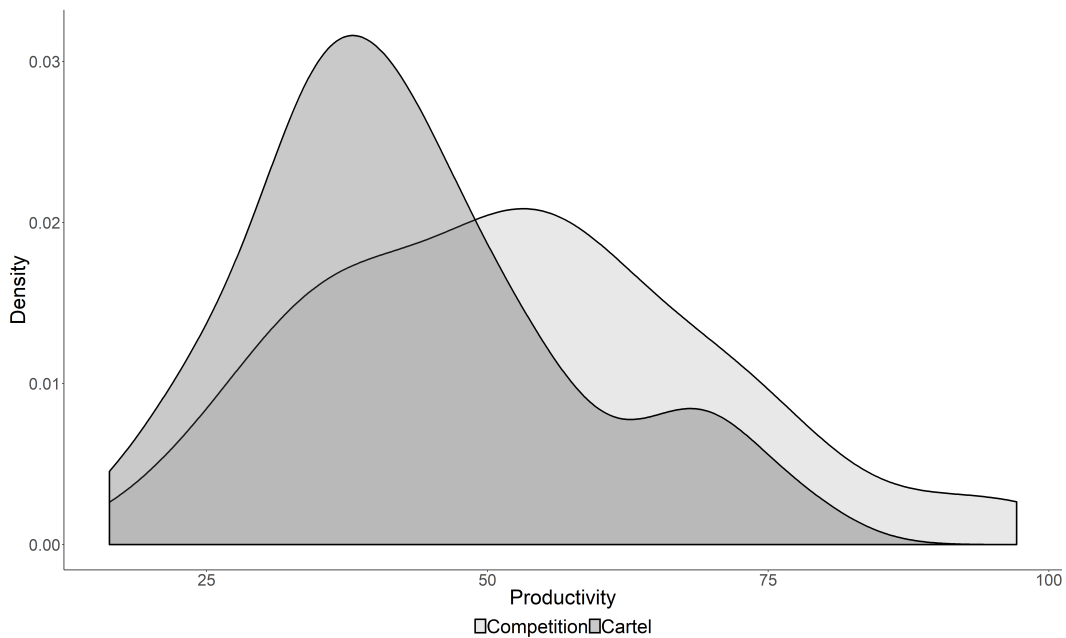
Notes: Productivity distribution of entrants during competition periods (lighter shade) and cartel periods (darker shade).

29

during competition (see Figure 1.9). A Chi-square test of the homogeneity of the distributions rejects that both distributions are the same, at levels of significance of less than 1% or 2.6%, depending on the number of categorical intervals used to split the sample.[44]

The difference in productivity is significant. The median-size plant in the industry would enjoy an additional monthly gross revenue of approximately $410,000 (in current dollars) if it went from the mean productivity of an entrant during a cartel to the mean productivity of an entrant during competition.

1.6.3 Refining-stage Estimates

Lastly, using the productivity estimates from the extraction-stage, we estimate the parameters for the refining-stage production function. The original production function equation for this stage, in logs, is given by

$$log(q_{it}) = log(\theta) + \delta \cdot log(\phi_i) + \gamma \cdot log(E_{it}) + log(\varepsilon_{2it}) \tag{1.4}$$

Since we do not directly observe plant i´s productivity term, ϕ_i, we use the estimated value obtained for the extraction stage. Thus, the equation we estimate is

$$log(q_{it}) = log(\theta) + \delta \cdot log(\hat{\phi}_i) + \gamma \cdot log(E_{it}) + log(\varepsilon_{2it}), \tag{1.5}$$

where $\hat{\phi}_i$ corresponds to the estimated productivity in the extraction stage.

An additional challenge in this case is that the Nitrate Agency's inputs data only contain energy (specifically, coal) for a subsample of the observations. Thus, we assume that the relationship between coal and nitrate output in observed plants and periods is representative of the full population.

Table 1.11 shows the results of the production function estimation. Notice that the parameter associated with $log(\phi)$, δ, is highly significant and close to one.[45]

1.7 Plant Entry Decision

In this section, we develop a simple entry model for potential entrants in the industry. We then separately estimate its building blocks: the determinants of the plants' output decision, the probabilities that ruled the transition across state variables (price level and competitive regimes), and the total cost function. Later, these pieces are combined to compute continuation values for potential entrants in the industry.

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[44]Estimation details can be found in Table 1.C.2 in Appendix 1.C.

[45]In addition, Figure 1.4.5 of Appendix 1.4 displays the relationship between energy (coal) and nitrate output.

Table 1.11: Refining-stage Production Function

	Dependent variable:
	Nitrate Output
log(Coal)	0.643***
	(0.053)
log (Productivity)	0.956***
	(0.076)
Constant	0.153
	(0.161)
Observations	2,326
R^2	0.641
Adjusted R^2	0.641

Notes: Robust standard errors in parentheses. Observations are plant-months. Nitrate output and coal measured in tons. $^*p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

1.7.1 Model of Entry

The main elements of our entry model are described next.

Time: Time is discrete and infinite. Periods consist of 6 months and are indexed by $t \in \{1, \ldots, +\infty\}$. Entry takes one period.

Plants: There is a set $I = \{1, \ldots, N_I\}$ of potential plants in the industry, which are owned by a set $F = \{0, \ldots, N_F\}$ of existing firms. We consider the entry problem of each plant independently (hence, we abstain from considering potential cost synergies across plants), so each plant is effectively treated as an independent firm.

Plants are characterized by a vector of characteristics. Thus Plant i in time t is described by characteristics

$$\tau_{it} = (\phi_i, k_{it}),$$

where $\phi_i \in \mathbb{R}^+$ is a constant productivity term and $k_{it} \in \mathbb{R}^+$ is the maximum refining capacity of the plant. We consider k_{it} to be an exogenous characteristic of the plants for now.

State space: Market conditions at any period t are summarized by a vector of state variables $\psi_t \in \Psi$, where $\psi_t = (p_t, c_t)$.

- $p_t \in \{p_1, p_2, p_3, p_4, p_5\}$ is the price of nitrate of soda in Chile. We discretize the space of prices into five intervals p_N, according to the empirically observed frequency of prices.

- $c_t \in \{c_0, c_1, c_2, c_3, \ldots, c_{10}\}$ is the current competitive regime of the industry. State c_0 corresponds

to free competition, while states $\{c_1, \ldots, c_10\}$ are cartel states. Specifically, for cartel states, their index corresponds to the number of remaining periods in collusion, as established in the current cartel contract. For instance, c_3 means that after the current period concludes, there will be two more cartel periods before competition resumes.

Plant entry decision: Current period profits for plant i of type τ_{it} are given by

$$\pi(p_t, q_{it}, \tau_{it}) = p_t \cdot q_{it} - TC_i(q_{it})$$

where p_t is the price in Chile, q_{it} is plant's i output, and $TC_i(q_{it})$ is the production cost. Notice that τ_{it} implicitly affects q_{it} and $TC_i(\cdot)$ through the productivity term ϕ_i.

Thus, a potential entrant of type τ_{it} faces at time 0 the following problem,

$$\max_{\{t_0\}} \left\{ \underbrace{\mathbb{E}_t \left[\sum_{t=0}^{\infty} \beta^t \pi(p_t, q_{it}, \tau_{it}) \mathbb{1}_{t_0} \right]}_{V(\tau_{it}, \psi_t)} - \beta^{t_0} FC(k_{it}) \right\}, \tag{1.6}$$

where t_0 is the period the firm enters; $FC(\cdot)$ is a sunk cost of entry that increases on plant size and is independent of market conditions; β is the discount factor; and $\mathbb{1}_{t_0}$ is an indicator function that takes value of 1 iif $t \geq t_0$.

Our main challenge consists in estimating the entry value $V(\tau_{it}, \psi_t)$, in order to evaluate counterfactual levels of entry in a case without cartels. In the next subsections, we detail the process of estimation by first explaining the estimation of revenue components and later the estimation of the cost function. Finally, since the nitrate industry eventually declined due to the invention of a technological substitute, a potential concern regarding our general approach is that potential entrants may have internalized in their entry decision the probability that synthetic nitrate would be invented at some point in the future. However, evidence from contemporaneous sources suggest that the invention of synthetic nitrate came as a surprise to nitrate producers. For instance, the following commentary was included in NPA's Quarterly Circular in 1904: "Happily for country and industry, there is no close danger and, even as chemists and men of science work tirelessly, it is impossible to foresee a time when nitrate has been dislodged, given the economic conditions of its production, which seldom could be matched by a different industry."[46]

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[46]NPA Quarterly Circular, Number 34, May 31, 1904, p. 10.

1.7.2 Revenue estimation

Output Determination Function

The main difficulty in the estimation of revenue is characterizing the output decisions of plants as a function of own-characteristics and market conditions. That is, we look to estimate, for each plant i, a function of the state variables, $q_i : \psi \equiv (c, p) \to \mathbb{R}^+$.

Table 1.12: Determinants of Monthly Plant Output

	Dependent variable:
	log(Nitrate Output)
log(Price)	-1.174^{***}
	(0.065)
Age	-0.020^{***}
	(0.001)
Productivity	0.031^{***}
	(0.0003)
Cartel	-0.059^{***}
	(0.011)
Number Active Plants	-0.006
	(0.005)
Time	0.025^{***}
	(0.002)
Constant	8.176^{***}
	(0.133)
Observations	21,197
R^2	0.390
Adjusted R^2	0.390

Notes: Robust standard errors in parentheses. Dependent variable is plant-month output. *Cartel* takes the value 1 if any cartel was active and 0 otherwise. *Age* is the number of periods since start of operations. *Number of Active Plants* is the number of active plants, expressed in tens. Price is contemporaneous nitrate of soda price in UK. $^*p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Notice that in the specification, we have not included any terms related to a potential strategic interaction across plants. In fact, although the operation of the nitrate market closely resembled a Cournot model, the low levels of concentration in practice caused firms to behave as in a perfectly competitive environment. Evidence supporting this statement is found in Table 1.12, in which we regressed monthly nitrate output for all plants in our dataset with respect to several potential explanatory variables. In particular, the number of plants active in the industry is not significant. Figure 1.10 further illustrates the lack of correlation between

Figure 1.10: Average Output by Productivity Type and Number of Plants
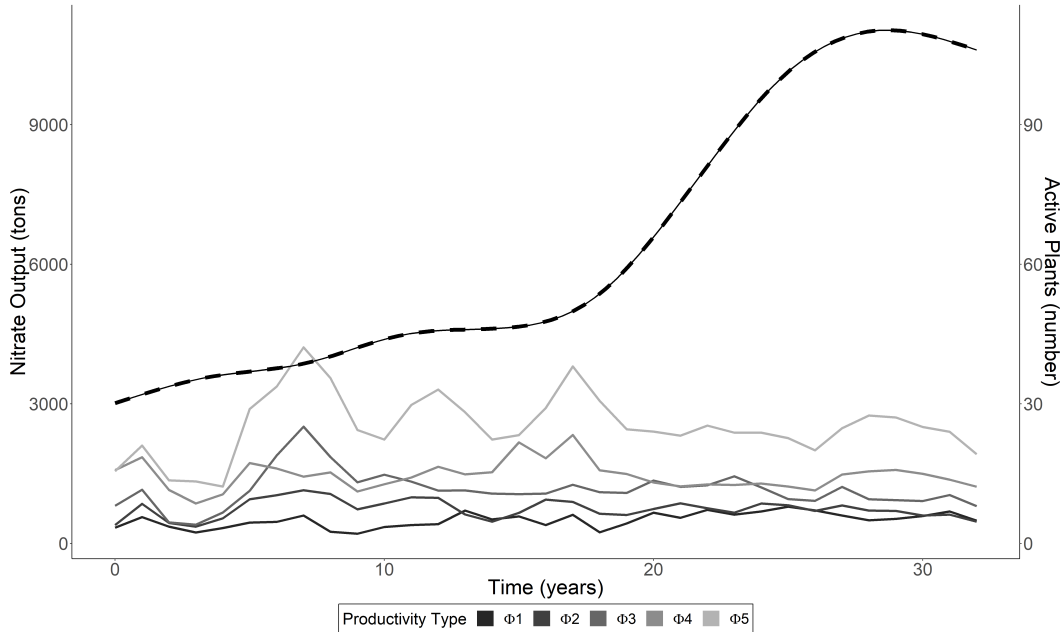
Notes: Vertical axis on the left is in tons and corresponds to monthly average plant-level output, which is indicated for each productivity type by a solid line. Horizontal axis is time in years from the beginning of our data set in 1883. Vertical axis on the right is the number of active plants in the industry, and is indicated by the dashed black line. Productivity types are described below the horizontal axis, with $\Phi 1$ being the lowest and $\Phi 5$ being the highest productivity type.

number of plants and nitrate output.[47]

To estimate the output function, we use our main dataset in a two-step approach. First, for all points in the state space ψ such that we have 10 or more observations per plant, we use the average of these observations as our estimate of $q_i(\psi)$. Second, we discretize the space of plant types τ by creating 15 cells of plants grouped according to their productivity level (5 groups) and their effective size (3 groups for each of the productivity groups).[48] The identifying assumption is that plants within the same cell should be similar enough to have similar levels of output conditional on specific values of ψ and that, by law of large numbers, deviations from the mean level of output of each cell should cancel out.

Finally, prices in Chile are directly observed from 1893 onward. We use UK prices to complete the series of prices FOB for previous dates, taking advantage of the fact that the difference between Chile nitrate prices and UK nitrate prices was extremely stable across the years.[49]

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[47]In addition, we test whether it is necessary to control for seasonality. Figure 1.4.8 in Appendix 1.4 shows that nitrate output tended to be evenly distributed across the year, and hence we do not need to consider seasonality in our estimation.

[48]Computed as their mean effective output when active, once they had been already sorted by productivity. The discretization is shown in Tables 1.3.12 and 1.3.13 of Appendix 1.C.

[49]See Figure 1.B.3 in Appendix 1.4 and Table 1.C.3 in Appendix 1.C for more details.

Transition Matrix across State Variables

We construct a transition matrix that summarizes the empirical transition probabilities across state variables observed in the data. We assume that transitions across state variables were exogenous from the point of view of each firm. We believe these assumptions are not very strong: With respect to nitrate price, as we explained in a previous section, the industry can be described as perfectly competitive. Meanwhile, regarding the competitive state of the industry, cartel rules for both the formation and dissolution of cartels did not depend on the choices of any individual firm.[50]

The procedure to compute the empirical transition probabilities consists of several steps. First, we use the discretization of the price and competition state variables to label each period t according its observed state variables (c_t, p_t). Second, we count the number of periods each possible combination of states variables was observed. Hence, we denote as $n_{(KD)}$ the number of periods where the competition state was c_K and the price state was p_D. Third, we count the number of transitions we observe from each combination of state variables (c_t, p_t) to every possible other combination of state variables. We denote as $n^c_{(KD|L)}$ the number of transitions we observe from competition state c_K and price state p_D to competition state c_L. Analogously, $n^p_{(KD|G)}$ corresponds to the number of transitions from the same combination of state variables to price state p_G. Finally, $m^p_{\{KL|D\}}$ is defined as the conditional probability of transition in one period from $(c_t = c_K, p_t = p_D)$ to $p_{t+1} = p_G$. This value is computed using the formula

$$m^c_{\{KD|L\}} = \frac{n^c_{(KD|L)}}{n_{(KD)}}, \tag{1.7}$$

similarly, $m^c_{\{KL|G\}}$ is computed as

$$m^p_{\{KD|G\}} = \frac{n^p_{(KD|G)}}{n_{(KD)}}. \tag{1.8}$$

In the case of competition states, we also assume that cartels had the same effect on the transition probabilities of the price state variable p_t, independent of the remaining duration of the cartel. That is

$$m^p_{\{KD|G\}} = m^p_{\{LD|G\}} \ , \ \forall \{c_K, c_L\} \in \{c_1, \dots, c_{10}\}$$

.

Also, notice that transitions across competition states that correspond to cartel (that is, competition states, $c_t \in \{c_1, \dots, c_{10}\}$) are trivial, since with probability equal to one, the next competition state will be equal to the current minus one (meaning that the cartel has one period fewer left before its contract

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[50]Forming a cartel required the agreement of a set of producers equivalent to at least 95% of market shares, while dissolving a cartel required a majority of 65% of market shares.

expires).[51]

1.7.3 Cost Function Estimation

To estimate the total cost function of nitrate firms, we complement the production function estimates, which were the focus of the last section, with additional contemporaneous measures of costs, summarized in contemporaneous technical sources. The total cost expression we use, divided into its components, can be written as

$$TC_i(q_{it}) = \underbrace{EC_i(q_{it})}_{\substack{\text{extraction} \\ \text{cost}}} + \underbrace{RC_i(q_{it})}_{\substack{\text{refining} \\ \text{cost}}} + \underbrace{GC(q_{it})}_{\substack{\text{tax} \\ \text{cost}}} + \underbrace{PC(q_{it})}_{\substack{\text{transportation} \\ \text{cost}}} + \underbrace{OC(q_{it})}_{\substack{\text{other} \\ \text{cost}}}, \tag{1.9}$$

where the first two components $EC_i(\cdot)$ and $RC_i(\cdot)$ correspond to extraction stage and refining stage costs, respectively. Notice these components are plant specific, since they are directly affected by the plant-specific productivity term ϕ_i. On the other hand, the terms $GC(\cdot)$, $PC(\cdot)$, and $OC(\cdot)$ are cost components common to all plants in the industry. For these components, the approach is simply the use of technical sources that describe variable costs in the industry, using what is known as the "engineering method." The main source in this case is the technical description of the industry provided by Semper et al. (1908).[52]

One of the data-related challenges for this industry is the relative scarcity of direct sources for input prices. In our computation, we use the values provided by Semper et al. (1908), who compiled cost statistics from an extensive field visit to the industry in 1901 and 1902. Additionally, when this source was translated into Spanish in 1908, the edition was augmented by adding cost data from that date. Hence, we mostly have cost data without time-series variation, although our main source centers precisely on the period of time that is our focus of interest.

Extraction-stage Costs

Extraction-stage costs are derived directly from its production function. The cost minimization problem plant i faces each period, in order to produce an output of at least q, can be written as

$$\min_{\{L_{it}, A_{it}\}} EC_i(q_{it}) = w \cdot L_{it} + c_{\text{anim}} \cdot A_{it} \tag{1.10}$$

$$s.t. \qquad q_{it} \geq q,$$

---

[51]Examples of the transition matrices can be observed in Appendix 1.C. Table **??** shows the transition matrix for competition states, when $p_t = p_1$; Tables **??** and **??** present the transition probabilities for the state variable p_t for cartel and competition periods, respectively. Transition matrices not included in the text are analogous to those shown.

[52]For a brief description of the engineering method, see Davis and Garcés (2009, p. 157).

where w is wages, and c_{anim} is the monthly cost per animal in period t.

From that minimization problem, it is easy to obtain the following cost function:

$$EC_i(q) = q^{\frac{1}{\alpha+\beta}} \underbrace{\left(\frac{1}{\phi_i}\right)^{\frac{1}{\alpha+\beta}} \left(\left(\frac{\alpha}{\beta}\right)^\beta + \left(\frac{\beta}{\alpha}\right)^\alpha\right)^{\frac{1}{\alpha+\beta}}}_{c_i} \underbrace{(w^\alpha c_{\text{anim}}^\beta)^{\frac{1}{\alpha+\beta}}}_{\omega},$$

which can be rewritten (replacing q for q_{it}) as

$$EC_i(q_{it}) = \rho_i \omega q_{it}^\psi, \tag{1.11}$$

where, ρ_i is a plant-specific cost parameter, ω is an industry-wide cost factor, and $\psi = \frac{1}{\alpha+\beta}$ is an economy-of-scale parameter.

Refining-stage costs

The estimation of refining-stage costs is done in two steps. Since we do not observe the usage of energy inputs for the whole sample, in the first step we use the estimated values of the parameters for the refining-stage production function to estimate the coal consumption of those plants with missing energy input:

$$\hat{E}_{it}(q_{it}) = q_{it}^{\frac{1}{\gamma}} \left(\frac{1}{\theta\hat{\phi}_i}\right)^{\frac{1}{\gamma}}. \tag{1.12}$$

In the second step, the refining cost $RC(\cdot)$ is estimated using the following relationship:

$$RC_i(q_{it}) = \begin{cases} c_{\text{coal}} E_{it}(q_{it}) & \text{,if } E_{it} \text{ is observed} \\ c_{\text{coal}} \hat{E}_{it}(q_{it}) & \text{,if } E_{it} \text{ is not observed}, \end{cases} \tag{1.13}$$

where c_{coal} is the price of coal in Chile.

Tax costs

The Chilean government collected a per unit export tax on nitrate of soda equivalent to approximately 2.54 pounds per ton (roughly, \$400 per ton in current dollars). This tax rate remained constant throughout the Nitrate Age. Thus, the tax cost is computed as

$$GC_i(q_{it}) = Tq_{it}, \tag{1.14}$$

where T is the nitrate tax rate.

Transportation and other costs

The final two components of the total cost function are the expenses necessary to the commercialization of nitrate that were incurred after production had concluded. Parameters for these costs were obtained from Semper et al. (1908), and when a range was provided, we use the inferior value in the interval.

First, there were costs associated with the packaging and transportation of nitrate to the port (where it was sold to nitrate traders). These costs include the cost of the sacks used to transport nitrate, c_{pack}; the railroad cost to the port, c_{rail}; and port costs, c_{port}:

$$PC_i(q_{it}) = c_{\text{pack}}q_{it} + c_{\text{port}}q_{it} + c_{\text{rail}}q_{it} \tag{1.15}$$

Second, there are others costs, which include plant administration costs c_{adm} and advertising costs c_{adv}. This last item corresponds to the mandatory contribution the NPA collected from producers to fund their joint marketing effort in the destination markets:

$$OC_i(q_{it}) = c_{\text{adm}}q_{it} + c_{\text{adv}}q_{it}. \tag{1.16}$$

Total Costs

Putting all of the cost components together, we obtain the final expression we take to the data:

$$TC_i(q_{it}) = \underbrace{\rho_i \omega q_{it}^{\psi}}_{\substack{\text{extraction} \\ \text{cost}}} + \underbrace{c_{\text{coal}}\hat{E}_{it}(q_{it})}_{\substack{\text{refining} \\ \text{cost}}} + \underbrace{Tq_{it}}_{\substack{\text{tax} \\ \text{cost}}} + \underbrace{q_{it}\left(c_{\text{pack}} + c_{\text{port}} + c_{\text{rail}}\right)}_{\substack{\text{transportation} \\ \text{cost}}} + \underbrace{q_{it}\left(c_{\text{adm}} + c_{\text{adv}}\right)}_{\substack{\text{other} \\ \text{cost}}}. \tag{1.17}$$

Table 1.11 presents estimated costs for the observations in our sample, with plants grouped for illustrative purposes according to their productivity in three groups (low, medium, and high

Figure 1.11: Total Costs by Productivity Type
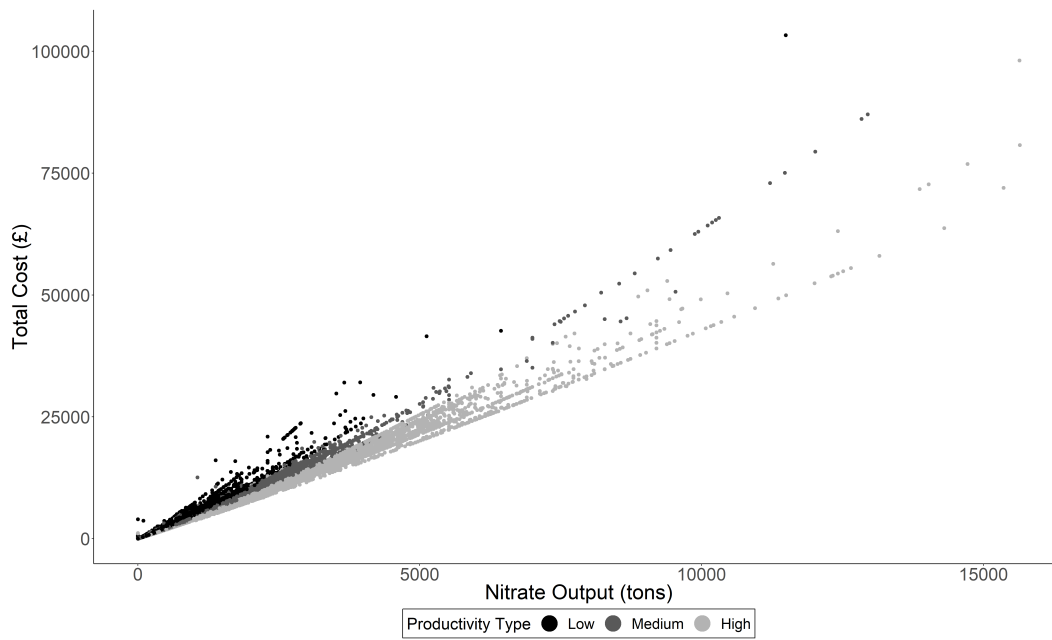
Notes: Vertical axis is total estimated cost in pounds sterling in 1900. Horizontal axis is nitrate output expressed in tons. Each point corresponds to a plant-month level observation, where coordinates are observed output and estimated total cost, respectively. Points are colored by productivity type. Productivity types are described below the horizontal axis.

Table 1.13: Summary Statistics: Estimated Plant Entry Values

Statistic	Discounted value ($£^{1900}$)	Discounted value ($\$^{2018}$)
N	148	148
Mean	306,598	45,099,752
St. Dev.	362,009	53,250,692
Min	-64,879	-9,543,475
Pctl(25)	68,754	10,113,555
Median	165,442	24,336,110
Pctl(75)	434,211	63,871,440
Max	1,944,433	286,021,351

Notes: Observations are plants. In the second column, figures presented in contemporaneous pounds sterling. In the third column, figures presented in current dollars. See main body of the text for detailed explanation of the estimation procedure.

1.7.4   Entry Values Results

The three building blocks described in the previous subsections are combined to compute the entry values of the plants observed as entrants in the data as a function of the state variables. The entry value of each plant is separately estimated using value function iteration.

Figure 1.12 shows an example of the resulting estimated values, as a function of both c_t and p_t. Plant values increase together with the competition state c_t and, conditioning on c_t, plant values are also increasing in p_t. These basic patterns are observed in the whole cross-section of estimated plant values. Moreover, plant values increase together with the TFP term ϕ_i.

Table 1.13 presents summary statistics for the estimated plant values, both in contemporaneous currency ($£^{1900}$) and present-day currency ($\$^{2018}$)[53]. The median (mean) plant in the industry had a value in present dollars of approximately 25m (45m).[54]

There is highly significant dispersion in plant values, as exemplified by the fact that the standard deviation is larger than the mean plant value. Graphically, the cross-sectional dispersion of values can be seen in Figure 1.13, which shows plant values arranged by date of entry.

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[53]Parameters used to do the conversion are found in Table 1.3.11.
[54]Estimated monthly profits, grouped by productivity groups, are shown in Figure 1.4.7 of Appendix 1.4.

Figure 1.12: Estimated Entry Values Peña Chica plant

Values Plant 1: Peña Chica
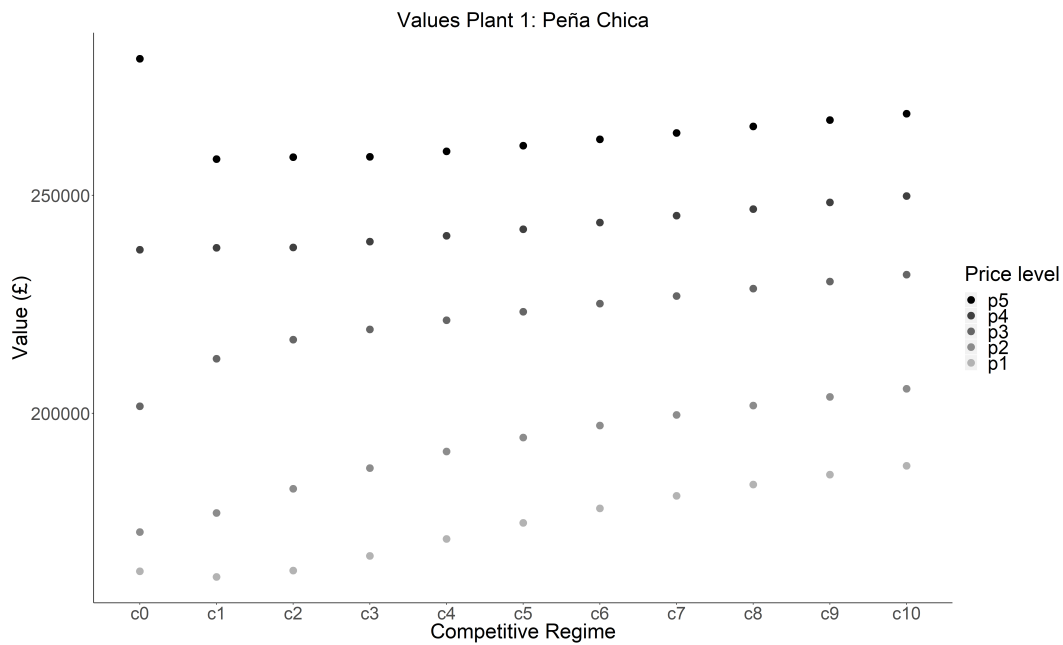
Notes: Vertical axis is the estimated entry value in pounds sterling in 1900. Values are indicated as points with other coordinates given by a combination of state variables (competitive regime and price level). Horizontal axis is competitive regime and is increasing from left to right: c_0 corresponds to competition, while the index of other competitive regimes denotes the number of periods left in the current cartel. Price level indicated by color, with p_1 being the lowest, and p_5 being the highest price interval.

Figure 1.13: Estimated Plant Entry Values
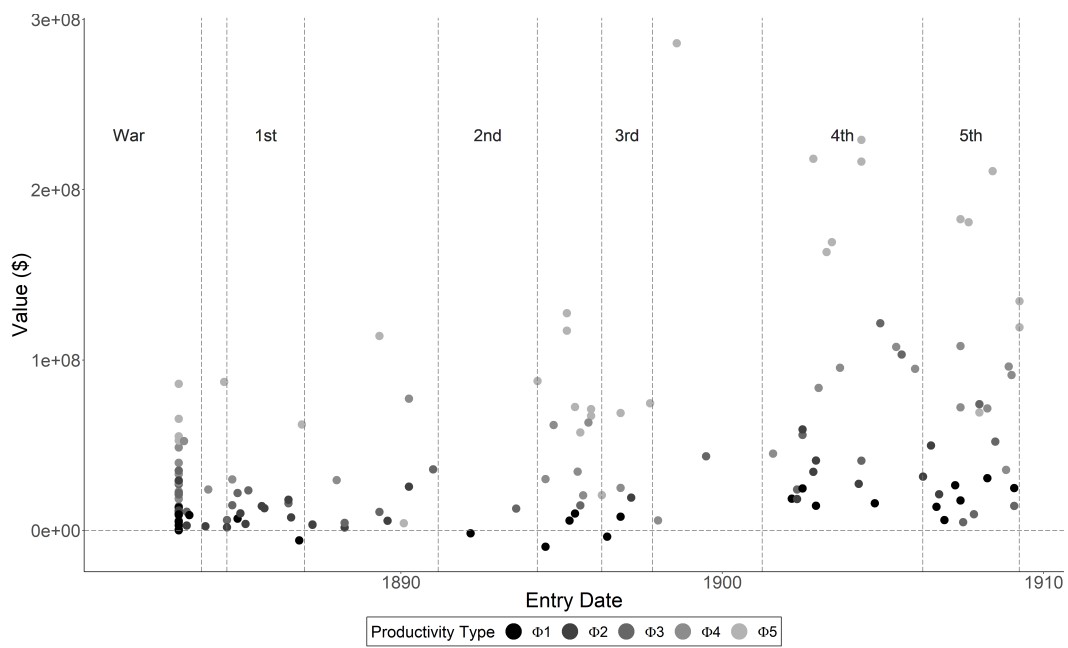
Notes: Vertical axis is total estimated cost in pounds sterling in 1900. Horizontal axis is entry date. Each point corresponds to a single plant's estimated value at the moment of entry. Points are colored by productivity type. Productivity types are described below the horizontal axis, with Φ1 being the lowest and Φ5 being the highest productivity type.

Table 1.14: Demand Elasticity Estimation

	Dependent variable:		
	log(Nitrate Output)		log(Price)
	OLS	*IV*	*First stage*
	(1)	(2)	(3)
log(Price)	−0.445*	−0.328**	
	(0.231)	(0.166)	
log(Price Last Year)			0.649***
			(0.072)
Time	0.061***	0.060***	0.006***
	(0.005)	(0.004)	(0.002)
Cartel	−0.185***	−0.194***	0.058*
	(0.048)	(0.054)	(0.035)
Constant	13.945***	13.753***	0.522***
	(0.354)	(0.268)	(0.139)
Observations	31	31	31
R^2	0.933	0.932	0.709
Adjusted R^2	0.926	0.925	0.677
F Statistic (df = 3; 27)	126.159***		21.975***

Notes: Robust standard errors in parentheses. Periods are years. Dependent variable in *OLS* and *IV* columns is log of industry output in tons. Dependent variable in *First state* column is contemporaneous UK nitrate price. Variable *Cartel* takes value 1 if a cartel was active. Prices correspond to mean period price.

1.7.5 Demand elasticity estimation

Using our data on prices and aggregate industry output, we estimate the demand elasticity for nitrate of soda, which we will use to perform counterfactual simulations.

To deal with the endogeneity of observed prices caused by the simultaneity problem, we use the lagged price of nitrate as an instrument. Our choice of this instrument is based on the specific characteristics of the nitrate market described in Section 2 and summarized in Figure 2.2.2: Demand shocks are realized once per year (in a few months of very heavy consumption); shocks can't be anticipated by producers, since they are caused by weather conditions iid across years; and consumption markets are too distant for producers to be able to react to contemporaneous demand shocks.

These facts, put together, mean that nitrate firms made a yearly output-level decision influenced by the market conditions at the end of the last consumption cycle. Since demand shocks to current year's price will be determined by current year's weather shocks, this instrument should provide

supply variation independent of contemporaneous demand shocks.

Contemporaneous discussions among producers support the mechanism proposed: "Given the news received about small existing stocks in Europe in the last few months, which created fears of reduction in consumption due to lack of supply ... a majority of the board agreed upon requesting the assembly of producers to change the [aggregate] quota to $33,000,000$ quintals."[55]

Table 1.14 shows the results obtained by using a simple OLS and implementing our IV strategy. Results show that nitrate of soda had a price demand elasticity of -0.33.

A potential issue regarding this instrument could be present if there is temporal interdependence in the consumption of nitrate—that is, if farmers could strategically postpone or move forward their consumption of nitrate given current prices and the content of nitrogen present in their fields.

1.7.6   Entry Costs

There are two main costs to enter the industry: the cost of acquiring nitrate land and the capital cost of installing a refining facility. The parameters used to estimate the entry cost of each plant are taken from Semper et al. (1908)[56]:

$$\underbrace{FC(k_{it})}_{\substack{\text{entry} \\ \text{costs}}} = \underbrace{KC(k_{it})}_{\substack{\text{capital} \\ \text{costs}}} + \underbrace{LC(k_{it})}_{\substack{\text{land} \\ \text{costs}}} \tag{1.18}$$

$FC(\cdot)$ can be written as a function only of k_{it} under an assumption that there is a function that maps refining capacity to nitrate reserves $R(\cdot)$ or, equivalently, that the amount of nitrate reserves available in the nitrate property land uniquely determined the capacity of the refining facility.

Narrative evidence suggests that the cost of nitrate land was moderate, highly variable, and increasing with time. This is consistent with a complex history of nitrate ownership rights and a large aggregate supply of nitrate-rich land. For our estimations, we use the minimum value of the range provided for nitrate land costs during the early years of the Fourth Cartel (denoted as c_l).

It is worth noting that when nitrate land was traded, its aggregate nitrate content would be measured; hence the cost of land corresponds to a price per unit of reserves.

We do not directly observe reserves, so they are estimated by adding up the nitrate output

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[55]NPA Quarterly Circular, Number 31, July 28, 1903, p. 17.

[56]Parameters are summarized in Table 1.3.10 of Appendix 1.C. It is worth mentioning that this source was written as a technical report requested by potential German investors to assess the industry's profitability.

observed in each plant. However, since the industry experienced an abrupt collapse, the amount of time we see in operation plants that entered near the end of our dataset is censored. To correct for this, we assume that each plant had reserves to operate at its mean output level for 20 years before being depleted, and apply this correction to obtain a value $\tilde{R}(k_{it})$. Hence, we compute land costs using

$$LC(k_{it}) = c_l \cdot \tilde{R}(k_{it}). \tag{1.19}$$

Regarding capital costs, Semper et al. (1908) describe a concave cost function for the capital costs that is supported with detailed itemized budgets for a plant installation. When this source was published in Spanish in 1908, the translators added an updated estimation for the capital costs of installation.[57] We assume a linear progression on time between our two cost estimates. Equation 1.20 shows the base formula used to compute capital costs, as a function of refining capacity:

$$KC(k_{it}) = \begin{cases} c_{k1} \cdot k_{it} & \text{, if } k_{it} \leq 100,000 \\ 100,000 \cdot c_{k1} + (k_{it} - 100,000) \cdot c_{k2} & \text{, if } 100,000 \leq k_{it} \leq 150,000 \\ 100,000 \cdot c_{k1} + 50,000 \cdot c_{k2} + (k_{it} - 150,000) \cdot c_{k3} & \text{, if } k_{it} > 150,000 \end{cases} \tag{1.20}$$

1.8 Counterfactual Analysis

We use the estimates obtained in the previous sections to implement two counterfactual scenarios. In the first, we compute counterfactual cartel profits under an assumption that incumbent cartel members were able to restrict entry for the duration of the Fourth Cartel. In the second, we estimate counterfactual industry levels of entry under the assumption that instead of the Fourth and Fifth Cartels, the industry remained under a competitive regime.

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[57]Itemized costs increased by 50% between 1901 and 1908.

Table 1.15: Counterfactual Fourth Cartel Profits

Case	Total Cartel Profits ($\pounds^{1900}$)	Total Cartel Profits ($\$^{2018}$)
Observed	10,175,654	1,496,813,758
Counterfactual	14,166,612	2,083,873,750
Difference (%)	-39.2	-39.2

Notes: The second column presents results in contemporaneous pounds sterling. The third column presents results in current dollars. For a detailed explanation of the computation procedure, see the main body of the text.

1.8.1 Cartel Profits with Barriers to Entry

In this section, we leverage our estimated parameters to compute the negative effect of low barriers to entry on cartel profits. The previously described low barriers to entry meant that, when a cartel was formed, producers would incorporate new entrants into the cartel. As a result, market shares for incumbent producers gradually shrank, eroding their profits as time went by. In this section, we compute the counterfactual profits incumbent firms would have achieved had they been able to completely exclude new plants from entering the nitrate industry.

We estimate plant-level profits in a counterfactual case in which cartel members are able to prevent any entry to the industry, for the case of the Fourth Cartel. This episode of collusion is especially well suited to explore this question. First, unlike previous cartels, the Fourth Cartel had both a long cartel duration (5 years) and collusive market shares, determined at the onset of the cartel, that would remain valid by contract for its entire duration. Second, our productivity estimates include the almost full population of plants present in the industry at the beginning of this cartel, meaning that we can accurately estimate aggregate cartel profits in the counterfactual case.[58] In contrast, for the Fifth Cartel (the only collusive episode after the Fourth Cartel), because less data from that period are available, there is a larger number of plants whose productivity we are still not able to estimate, which renders our potential estimation of total cartel profits less precise.

Three assumptions are made to perform the estimation. The first is that both aggregate industry output and nitrate prices would have been the same in the counterfactual case without entry. This is, cartel members would have chosen the same aggregate output levels in the absence of entry.

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[58]We have estimates of productivity for plants corresponding to 98.5% of total industry output in the year 1901.

Narrative sources from the time show that when determining cartel output levels, the main concern was to match expected consumption growth conditional on current market conditions. Moreover, individual producers could only directly affect the aggregate output decision after a proposal was first made by the NPA, based on the expertise of its permanent staff.[59] Hence, it is not obvious how the absence of potential entry would have modified the cartel decision-making process in this respect. The second assumption is that in the counterfactual case, the observed allocated collusive market shares would also not have changed, with the implication that we can use the market shares in the Fourth Cartel contract to construct counterfactual plant-level output levels. A final assumption is that plants would have had a constant monthly output level (and so we are refraining from considering, for instance, potential shutdowns).

To estimate counterfactual cartel profits, the procedure consists of two steps. First, using the already mentioned collusive market shares, we obtain annual output levels for each plant during the cartel period. Using the third assumption, we transform those into monthly output levels. Second, using the cost function estimated before, we compute counterfactual monthly costs. Finally, revenues and costs are discounted and aggregated.

The main results of this section are shown in Tables 1.15 and 1.16. Aggregate cartel profits in the counterfactual scenario would have been 39.2% larger than they were in the low-barriers-to-entry case, which translates to approximately $585m of additional profits (in current dollars). This result is generated by an increase in the median monthly plant-level profits of almost $100,000.

A potential concern in this case is that without the entry of new plants, incumbent producers may not have had enough excess capacity to supply the observed industry outputs during the rest of the Fourth Cartel. We do not find evidence to substantiate this concern. A relevant detail for this point is that the Fourth Cartel contract allocated market shares based on plant capacity. Hence, since market shares remained constant during the cartel, and these were based on individual plant capacity, and it was feasible for all plants to satisfy their allocated quota during the first year of the cartel, we only need to show that the aggregate capacity of the incumbent plants was large enough to accommodate the additional supply. In fact, Figure 1.14 shows that industry capacity at the onset of the Fourth Cartel was significantly larger than the aggregate output level chosen by

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[59]Cartel contracts also required a large majority of producers to agree in order to introduce modifications to the NPA proposal.

Table 1.16: Counterfactual Plant Profits in Fourth Cartel

Statistic	Monthly profit observed ($)	Monthly profit counterfactual ($)
N	4,070	4,070
Mean	455,751	609,454
St. Dev.	477,135	545,602
Min	$-180,587$	$-30,298$
Pctl(25)	90,790	236,998
Median	353,637	446,888
Pctl(75)	684,760	808,068
Max	3,722,985	4,605,773

Notes: Observations correspond to plant-month pairs. Figures presented in current dollars.

the nitrate producers by the end of that collusive episode.

### 1.8.2   Entry without cartels

In this section, we study what entry patterns for the industry would have been like in a counterfactual case in which the Fourth and Fifth Cartels did not occur. Intuitively, as cartels decrease aggregate output and have a known fixed-term length, potential low-productivity entrants may find it more attractive to enter the industry during cartel periods.

To estimate the effect of these cartels on the number and productivity of entrants, we use the building blocks estimated in the previous sections and follow the following procedure:

- Periods are years. The simulation covers 8 periods corresponding to the sum of the duration of the Fourth and Fifth Cartels (which were consecutive), between 1901 and 1909, plus an additional year 0 to start the simulation.

- At year 0, we start from market conditions ψ_0, observed in the period before the start of the Fourth Cartel.

- Evolution of the state variables is governed by following process:

  1. Counterfactual levels of industry output are obtained from cubic spline computed using only the values of industry output in competitive years.[60]

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[60]See Figure 1.4.10 in Appendix 1.4 for counterfactual output levels.

Figure 1.14: Industry Output and Capacity at the start of the Fourth Cartel
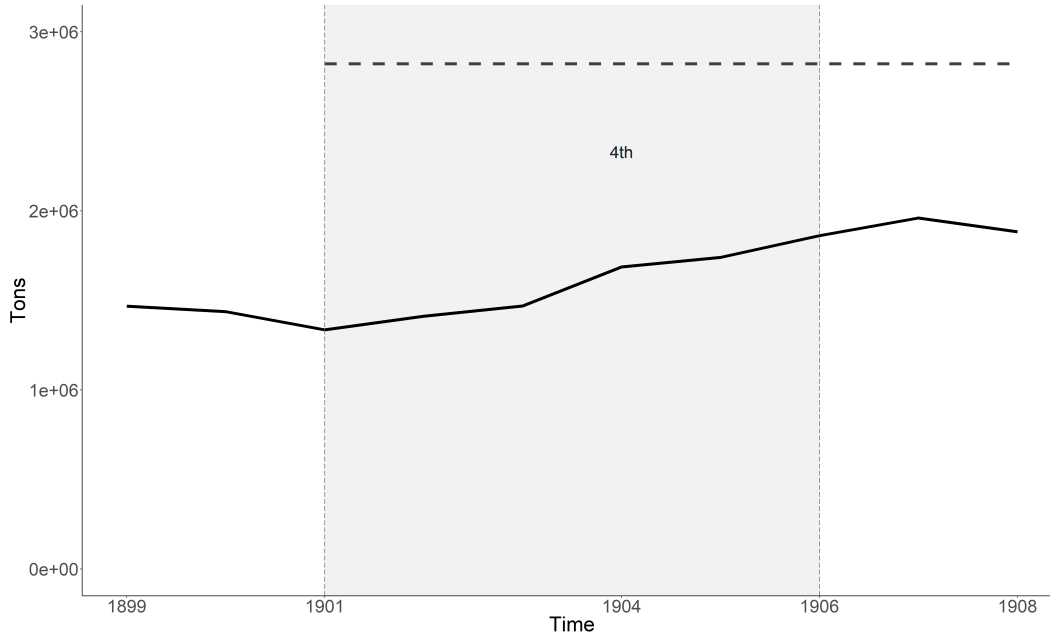
Notes: Vertical axis is tons. Horizontal axis is time in years. The black solid line is the observed industry level output, and the black dashed line is the estimated industry level capacity at the beginning of the Fourth Cartel. The time period of the Fourth Cartel is shaded.

2. Using the counterfactual level of output, we compute

$$\Delta Q_t = Q_{t,\text{count}} - Q_{t,\text{obs}}.$$

This is the difference between counterfactual and observed industry outputs.

3. We use ΔQ_t and demand elasticity η to compute ΔP_t, the difference between observed and counterfactual nitrate prices.

4. We update the counterfactual price as

$$P_{t,\text{count}} = P_{t,\text{obs}} + \Delta P_t.$$

- We construct a set of potential entrants for each year, formed by those plants that were observed entering in reality plus those plants that were potential entrants in a previous year, but decided against entering at that point.

- Entry decisions are made simultaneously by all potential entrants at the end of each period.

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Figure 1.15: Effect of Competition on Plant Entry
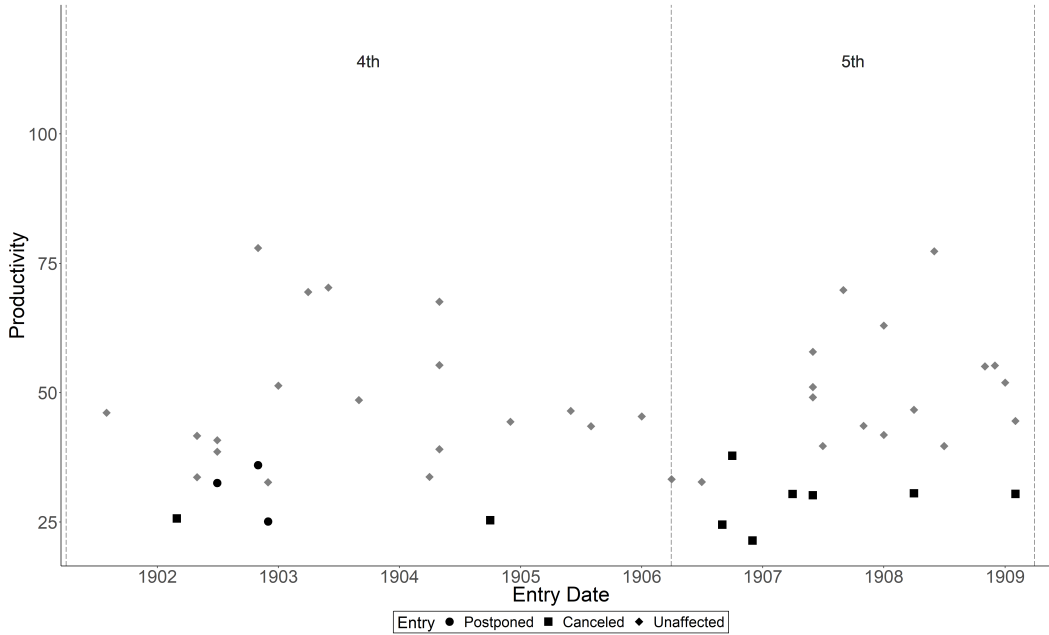
Notes: Vertical axis is total plant productivity. Horizontal axis is entry date. Each point corresponds to a single plant. Entry date is the observed moment of entry (first positive output) in the data. Shapes and colors, described below the horizontal axis, show the effect on entry decisions of the counterfactual change in competitive regime of the industry.

Firms that decide to enter are observed entering one period later. Firm i will enter in period $(t + 1)$ iff:

$$V(\tau_{it}, \psi_t) - FC(k_{it}) > 0.$$

The reason for estimating counterfactual output using a nonparametric approximation is derived from the fact that there is a subset of plants that entered the industry during these cartels, for which we do not have a productivity estimate yet (23 out of 71 plants). Hence, it is not possible to establish what their counterfactual output levels would have been without making extreme assumptions.

However, plants that do not enter into our analysis are those that accumulated very few observations during the monthly Nitrate Agency reports we collected. Since the probability of shutdown is negatively correlated with productivity, we can infer that those unobserved plants are a negatively selected subsample. Thus, we can safely interpret our results regarding entry as a lower bound of the true effects of these cartels on the number and quality of entrants.

Table 1.17: Counterfactual Industry Characteristics by end of Fifth Cartel (1909)

Case	Observed	Counterfactual	Difference (%)
New plants (number, by 1909)	48	39	-18.8%
Mean productivity entrants	44.4	48.0	+8.3%
Mean industry productivity (1909)	45.9	47.3	+3.1%
Total number plants (1909)	145	136	-6.2%
Industry monthly capacity (1909, tons)	538,280	518,443	-3.7%

Notes: New plants: defined as plants with first positive output in the period. *Industry monthly capacity:* computed from estimates in Section 4. Second and third rows are arithmetic means. Figures on first three rows referred to subsample of plants with productivity estimates.

The results of this exercise are summarized in Table 1.17. The main results indicate that out of the 48 plants in our analysis, 9 plants would not have entered by 1909 and 3 more would have postponed entry to a later moment within the counterfactual simulation (Figure 1.15). Moreover, plants that do not enter, or that postpone entry, are those with the lowest productivity levels. This translates into the mean productivity of new plants in the counterfactual case increasing by 8.3%.[61]

1.9 Final Remarks

This paper studies the interaction between cartels, productivity, and entry. As cartels temporarily increase profits, in a low-barriers-to-entry industry, more firms may decide to enter. As cartels have a greater influence on the profitability of low-productivity firms, this effect should disproportionately increase the entry of this type of firm. Over time, this mechanism may erode the industry's productivity.

To study this question, we focus on the Chilean nitrate industry as an application. We use a new dataset with rich cross-sectional variation in plant characteristics. Our analysis proceeds in several steps. First, we do a reduced-form analysis to describe the effect of cartels on the quantity of entrants. Second, we estimate plant-level productivity and compute by how much cartels reduced the productivity of new entrants. Third, we implement a simple entry model to obtain plant-level continuation values. Finally, we perform two counterfactual simulations. The first computes incumbent cartel members' profits in a case without entry. The second estimates counterfactual

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[61]Additional results can be seen in Figures 1.4.14, 1.4.11, 1.4.13, and 1.4.12 of Appendix 1.4.

levels of entry and productivity for a case in which two cartels in the study period did not occur.

Results show that cartels have a large effect on both the quantity and quality of new firms in the industry. Moreover, from the first counterfactual, we learn that low barriers to entry had a large and negative effect on the cartel profits of incumbent firms. Lastly, the second counterfactual shows that a large fraction of the least productive new firms would not have entered the industry in a case without cartels. Our results suggest that robust antitrust enforcement not only protects the short-term surplus of consumers, but may also have an important long-term effect on productivity by disciplining the quality of entrants. Furthermore, lowering barriers to entry, conditional on the absence of other negative consumer surplus effects, may be an effective tool at the disposal of antitrust agencies by severely reducing the potential profitability of cartels. A tentative application for this mechanism may be found in the wide range of professional activities that require state licensing in the United States.

Our study can be expanded in several directions. In our current period of interest, the interesting margin is the extensive one. However, in the period after the First World War, contractual innovations motivated by the declining prospects of nitrate of soda caused the intensive margin to acquire a far larger importance, giving us the opportunity the compare production efficiency under both contractual regimes. In addition, nitrate cartels used dramatically different rules of organization. This fact may allow us to enrich our current analysis by directly mapping the relationship between plant characteristics and the specific rules governing cartels.

Appendix

Appendix 1.A Nitrate Industry

### 1.A.1 Industry Location and History

The nitrate industry was located in the Atacama Desert of South America, within a narrow and long strip of land that covers a substantial fraction of the Regions of Tarapaca and Antofagasta in modern day Chile. Figure 1.A.1 describes the location of nitrate deposits within this region.

Table 1.A.1 describes the evolution of the industry before the War of the Pacific (1879-84). Before the Nitrate Age, the industry was in its early stages of development and, politically, was fragmented between Peru, Bolivia, and Chile. The presence of nitrate of soda in the Atacama Desert was known since Spanish colonial times (Cuevas, 1917), when the desertic territories, where the industry would later developed, were virtually uninhabited. Although the very first shipments of nitrate of soda to Europe date as early as the 1830s, consumption of nitrates was small, production process remained primitive and the main fertilizer exported from South America was *guano* (Bermúdez Miral, 1963). The modern phase of the industry began in 1853, when steam-based refining machines were first introduced and on-site elaboration of the product on isolated facilities became the industry norm. The following decades would witness a gradual growth of the industry and its expansion into the territories controlled by Bolivia and Chile, although the bulk of the production was still located in Peruvian territory.

Chile enters its Nitrate Age after the War of the Pacific (1884-1914). At the end of the conflict, all nitrate-producing territories of Peru and Bolivia were transferred to Chile. The evolution of industry during the Nitrate Age is described in Figure **??**.

With the breakout of the World War I, nitrate of soda gained additional importance as a major

Figure 1.A.1: Nitrate Region and Deposits
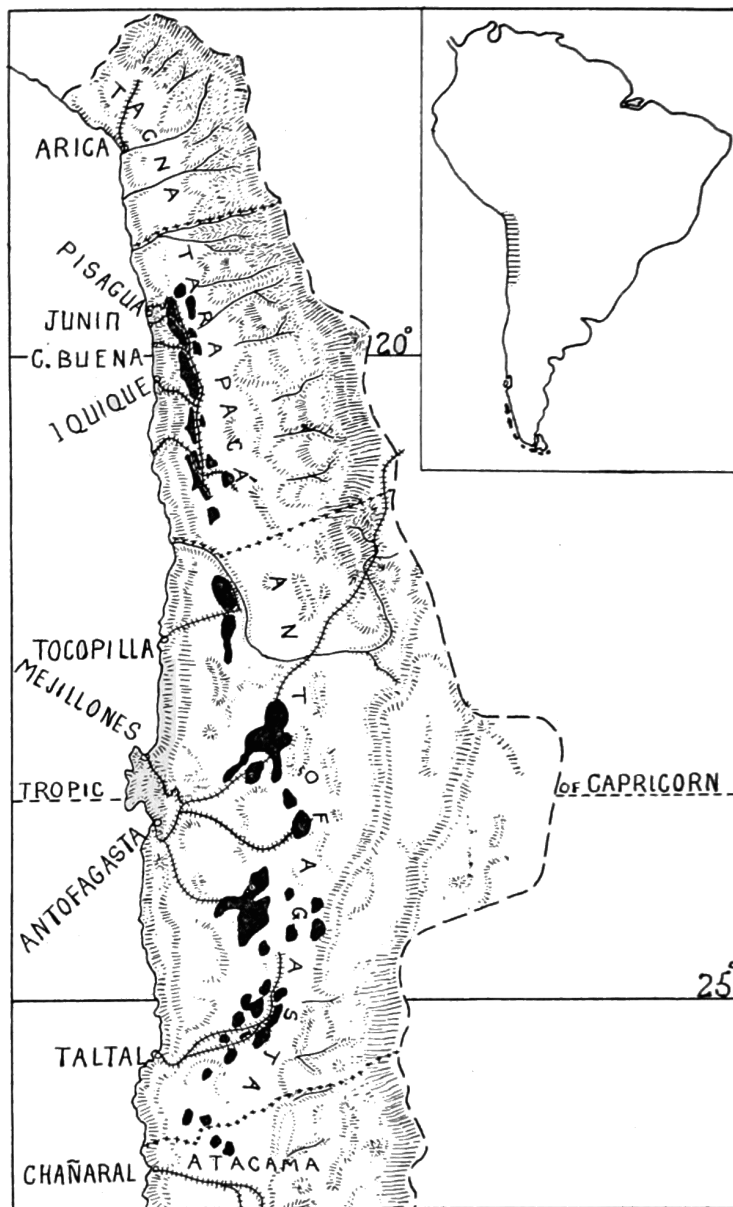
Notes: Illustration shows the northern Chilean provinces of Tacna, Tarapaca, and Antofagasta, according to their limits in 1913. Areas with nitrate deposits are marked in black. Name of ports are written to the left of the illustration. *Source:* Popular Science Monthly Volume 83, September 1913.

Figure 1.A.2: Industry Evolution during Nitrate Age (cartel periods shaded)
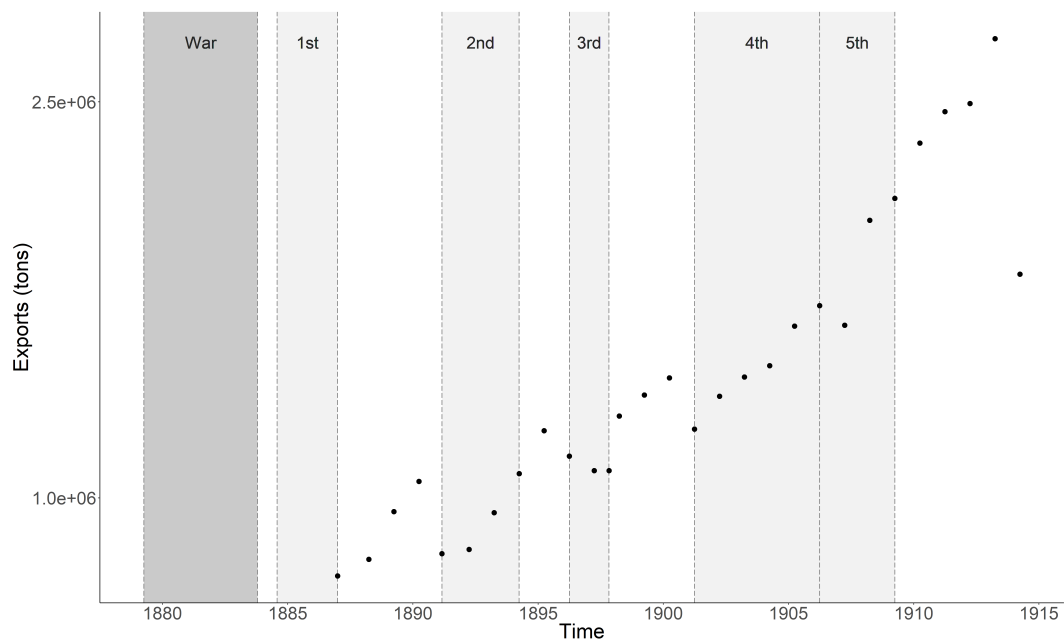
(a) Industry Yearly Exports (tons)
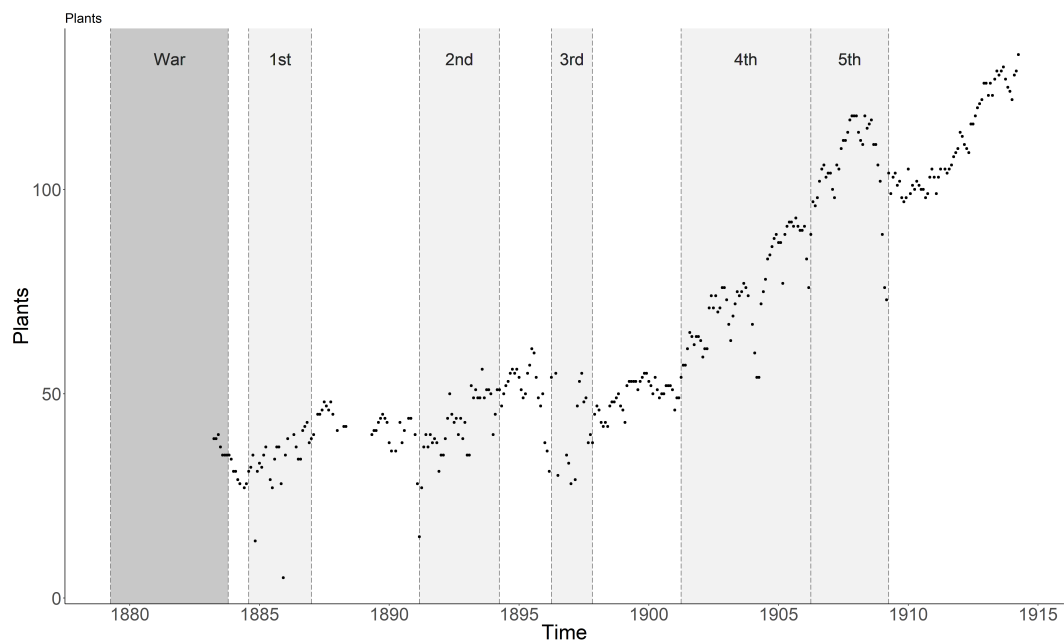
(b) Active Plants (number)

Table 1.A.1: Nitrate Exports by Country (selected years)

|	Exports (tons)			Plants (number)		
Year	Peru	Bolivia	Chile*	Peru	Bolivia	Chile
1855	51,900**	0	0	NA	0	0
1866	97,500***	0	97	NA	0	0
1872	200,943	6,164	203	18	1	0
1878	268,601	55,765	741	30	1	5

Sources: Cariola, Sunkel, and Sagredo (1991), O'Brien (1980), Lüders, Díaz, and Wagner (2016), Semper et al. (1908), and Godoy Orellana (2016).
Note: *, value for Chile corresponds to output (tons).
Note: **, average for period 1855-59.
Note: ***, average for period 1865-69.

Figure 1.A.3: HHI Nitrate Industry
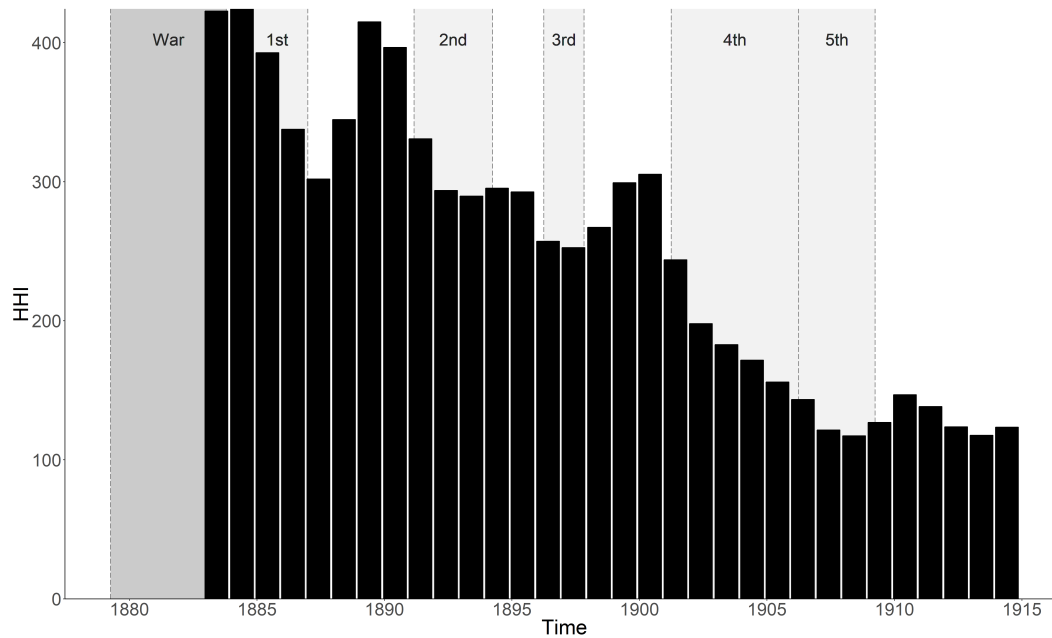
Notes: Each bar represents the HHI index of the industry for a year. Computed using total yearly plant outputs. Notice that index is computed at the plant, not the firm level. Cartels periods are shaded.

ingredient in production of munitions. The allied blockade of the Central Powers (Germany and Austria-Hungary) triggered the rapid expansion in production of synthetic nitrate of soda by those countries, using the newly invented Haber-Bosch process. As a result of this invention and the expansion of synthetic nitrate's supply, after the end of World War I Chile's monopoly had been broken and the industry's conditions had substantially changed.

1.A.2   Nitrate Lands Ownership

The history of the ownership of nitrate rights is complex and heavily dependent on which country each deposit was originally located (Peru, Bolivia, or Chile). We provide a brief summary of the main facts related to nitrate lands ownership in each of these countries.

Old Peruvian Nitrate Regions

The thin presence of the Peruvian state in the Tarapaca Province, together with the various legal sources of ownership of nitrate rights, caused nitrate rights in this region to be poorly registered and, in some case, disputed.

Mining laws of Peru descended from *Real Ordenanza Minería de Nueva España (Royal Mining Ordinances)*. Under this framework, underground resources do not belong to owner of the surface and must be adjudicated by the state. Moreover, local authorities could grant exploitation licenses, as a form to "promote industry", but these were not always officially recorded. Finally, if a concession was not being actively "used" by the owner, the state (or a third party) could claim it, according to the *despueble* clause.

In addition, the Peruvian government implemented erratic policies regarding its nitrate industry (hoping to protect its competing guano industry) which made even more difficult to account for nitrate rights by the time of the Chilean occupation of the Tarapaca Province in 1880.

In chronological order, the main policies implemented by the Peruvian government were:

- 1868: Peruvian government stops granting new concessions on nitrate lands and claims for the state all unclaimed nitrate rights.

- 1873: Peru starts a "soft" export monopoly on nitrate.

– Government sets a fixed price at which it buys nitrate.

– Private firms can still export nitrate autonomously, but paying a larger export tax.

- 1875: Peru begins the nationalization of the nitrate industry, this process also involved several options, depending on the willingness of the owner to sell:

    – Case 1: If the nitrate plant's owner was willing to sell.

        * Nitrate plants would be exchanged by bonds (*certificados*), according to price set by an appraisal committee.

        * Bonds would be paid by a loan taken by the Peruvian government in the U.K., using nitrate plants as collateral.

        * The necessary loan could not be obtained before the outbreak of war with Chile.

    – Case 2: If the nitrate plant's owner was not willing to sell.

        * Producer could still produce and sell his production, however paying a more onerous export tax.

        .

    – Case 3: Owners of inactive plants or plants in construction.

        * These plants were not considered by the appraisal committee. Subsequently, the Peruvian government announce the use of the *despueble* clause to expropiate them.

Depending on the legal situation of the original Peruvian concession, the Chilean policy was:

- Plants with outstanding bonds or *certificados* would be returned to whoever was in possession of at least 50% of the *certificados*.

    – In many cases, this was not feasible due to the dispersion of the *certificados*,since many had been "fire saled" when it became clear Peru would lose the war.

    – The Chilean government auctioned in 1882 the *oficinas* that had not been claimed, the proceeds of the auction were distributed between the owners of the *certificados*.

    – In 1887, the Chilean government paid a flat conversion rate to buy all remaining outstanding *certificados*.

- Owners of *oficinas* that had been declared in *despueble* by the Peruvian government tried to regain possession in the Chilean courts. After an initial success in 1893, the Chilean Supreme Court declared all of their property rights to be void between 1894 and 1896

As a result, the Chilean government progressively became the owner of a large fraction of the nitrate rights in the Tarapaca Province. Notice the main reason for this was that government intervention was thought to be most practical way to provide clear property right to the industry.

Old Bolivian Nitrate Regions

The Bolivian territories in the Atacama Desert were far from the center of the Bolivian nation. Communications were poor and the population of the (then called) Bolivian *Litoral Department* was small and mostly Chilean. In fact, the incipient nitrate industry in the region can be described as a Chilean-owned industry. Unlike the industry in the Peruvian Tarapaca Province, the industry in the Bolivian territory was centered around a single firm, since the Bolivian government granted a concession to produce nitrate, build a railroad, and gave tax-exempt status to the Antofagasta Nitrate Company (a Chilena-British firm). After the War of the Pacific, this company continued its operations uninterrupted.

In addition, to prevent the entry of competition to their Tarapaca Province, the Peruvian government had commissioned Juan Meiggs in 1876 to lease some nitrate rich lands in hands of the Bolivian government. After the War, Chile had to negotiate a settlement with the descendants of Juan Meiggs (since the Peruvian government had promised to Meiggs rights to extract nitrate from the leased lands). A fraction of those lands, then, were ceded to the family as part of the so called Transaction Squire of 1883.

The rest of the government-owned nitrate lands in the former Bolivian territory were transferred to the Chilean government as part of the peace treaty. As in the case of Tarapaca Province, the Chilean government then became the owner of a large majority of nitrate rights in this region.

Old Chilean Nitrate Regions

A decree from 1877, granted to the discoverer of a nitrate deposit the right to claim 3 Chilean stakes (each Chilean stake corresponds to an hectare). In most cases, entrepreneurs would then

Table 1.A.2: Status of Nitrate Lands by 1925

Status	Property	Surface (km^2)
Exploited	Private	550
Measured, not exploited	Private	5,811
Unmeasured	Public	25,000

Notes: Table shows status of nitrate lands, measured in terms of area, by 1925. Nitrate content around this period varied between 10% and 20%, hence surface area is informative about the relative amounts of nitrate contained in different categories. *Exploited:* nitrate lands already used. *Measured, not exploited* nitrate lands whose total nitrate content had been estimated in detail, and were owned by a private firm. *Unmeasured:* state lands on which nitrate presence had been established, but without detailed estimates of total content. *Sources:* Chilean Ministry of Finance (1925, p. 11).

Table 1.A.3: Nitrate Industry Ownership by Nationality

	Fraction of total industry output					
Year	Peruvian	British	Anglo-Chilean	Chilean	German	Other
1878	58	13.5	-	19	8	1.5
1884	-	20	14	36	17	13
1895	-	60	-	13	8	19
1901	-	55	-	14	15	16
1912	-	38.5	-	37	15	9.5

Sources: Cariola, Sunkel, and Sagredo (1991).

have family members or associates to petition for additional rights, until a sizable property had been acquired. In 1884, a new decree forbid new claims of nitrate rights. Finally, in 1888 the new Mining Law declared all new nitrate deposits to be exclusive property of the Chilean state. However, a sizable number of nitrate rights had been allocated under the previous liberal legislation.

As a summary, after the War of the Pacific, nitrate rights were held both by private entrepreneurs and, the largest part, by the Chilean state. Table 1.A.2 shows the estimated status of nitrate lands, according to the Chilean Ministry of Finance, by the year 1925.

Entrepreneurs from various origins were attracted by the nitrate industry, besides the native Chilean and Peruvian businessmen. Table 1.A.3 presents a summary of the ownership evolution of the industry, were firm owners have been group according to their nationality.

Nitrate tax and Government Revenues

During the War of the Pacific, the Chilean government decided to implement an export tax on nitrate of soda. The tax rate was determined as 28 pence per Spanish quintal. A pound under the Imperial System had 240 pence, and a Spanish quintal corresponds to, approximately, 101.44 pounds. Thus, the nitrate export tax is roughly equivalent in modern dollars to $400 per ton. The export tax remained constant throughout the Nitrate Age in value and accounted for a significant fraction of the price of nitrate.

In addition, the Chilean government periodically sold rights to extract nitrate in state-owned lands. However, this revenue was only equivalent to 3% of the export tax revenue (Chilean Ministry of Finance, 1925). Nitrate lands auctions seem to have been motivated by the opportunity of obtaining a good selling price, given high demand for nitrate lands, as explained on one of the bills submitted to the Chilean Congress:[62]

> It is in the interests of the [Chilean] state to dispose of some of its nitrate properties
> that can be sold under advantageous conditions, without disturbing the prosperous state
> the nitrate industry presents today . . . Making the auction of the properties referred to
> in this bill, the government has the purpose of not offering new nitrate lands for sale
> but in accordance with the interests of the industry . . . which will lead to considerable
> advantages for the state as well as for private interests.

Government attitude towards Nitrate Cartels

During the Nitrate Age there was no systematic antitrust concern on the part of the Chilean authorities. The Chilean legislation did not forbid or regulated cartels or trusts (the first antitrust legislation was not promulgated until 1959 (Bernedo, 2013). In addition, government policy regarding combinations was influenced by *laissez faire* ideology that predominated at the time among the Chilean elite. Moreover, Chilean consumption of nitrate of soda remained negligible with respect to the total volume of product sales. Hence, consumer surplus considerations were absent from the policy discussions regarding competition in this market.

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[62]Bill presented by Chilean Government on March 2nd 1902. *Proyecto de Lei que autoriza enajenación de ciertos terrenos salitrales (República de Chile, 1903)*. Bill message cited from NPA Quarterly Circular, Number 27, April 21, 1902, p. 7.

Although the use of a per-volume tax made cartels to have a negative effect on short-term tax revenues, other factors partially balanced this concern. First, the sheer importance of the industry made crisis in the nitrate sector highly damaging to the whole Chilean economy. Hence, cartels were regarded as a policy tool, that helped to ensure the stability of the wider economy. As an example, Chilean financial sector provided short and long-term finance to the nitrate industry, hence cartels were favoured by them, as decreased the risk on their loans (O'Brien, 1982). Second, during the decade of the 1900's, mode Chilean entrepreneurs became directly involved in the industry as owners. A large fraction of them were also members of Congress or held high political offices. Thus, the private interests of part of the elite partially counterbalanced the fiscal interest of the republic. As a consequence, the attitude of Chilean government towards the organization of cartels changed on time and depended of the specific short-term economic and political circumstances (Brown, 1963).

Appendix 1.B   Data

Table 1.B.1: Summary Statistics Prices UK (£/ton)

| Statistic	Nitrate of soda	Ammonium sulfate	Beet sugar	Iodine
N	407	408	408	398
Mean	10.0	12.5	12.4	1,097.9
St. Dev.	1.8	3.0	4.2	272.0
Min	6.8	6.8	5.8	587.9
Pctl(25)	8.7	11.0	9.2	881.8
Median	9.7	11.9	11.2	1,102.3
Pctl(75)	11.0	12.8	14.1	1,322.8
Max	18.7	21.8	30.2	2,131.1

Sources: The Economist, Chemical Trade Journal.

Figure 1.B.1: Coverage Main Data Sources
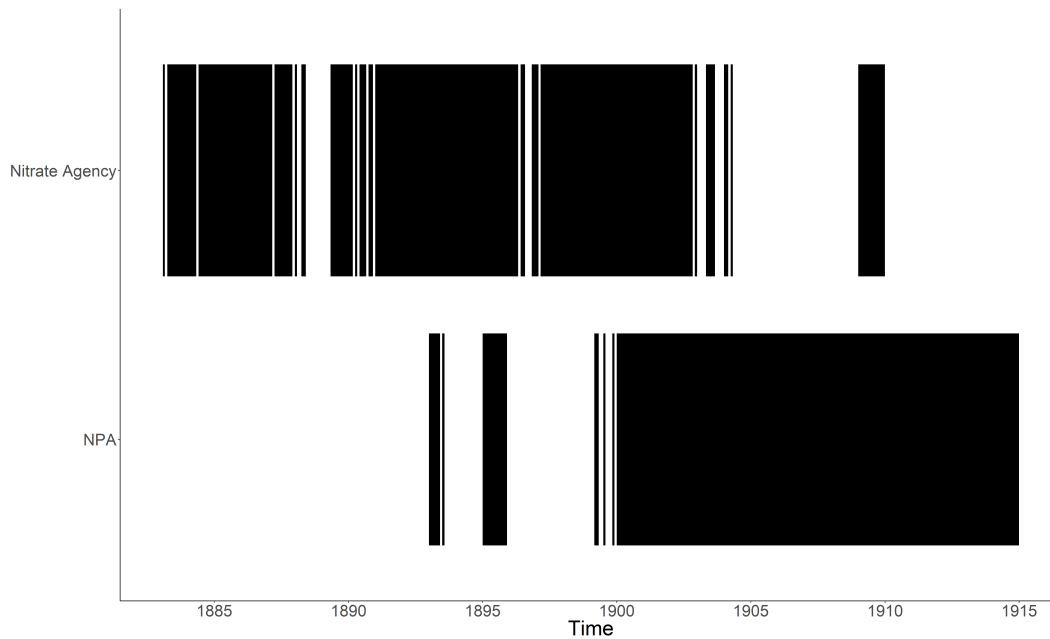
Notes: Vertical values represent the two main sources of plant-level data. Horizontal axis is time. Each black bar corresponds to a month of data.

Figure 1.B.2: Weekly Nitrate Prices in U.K. by Source
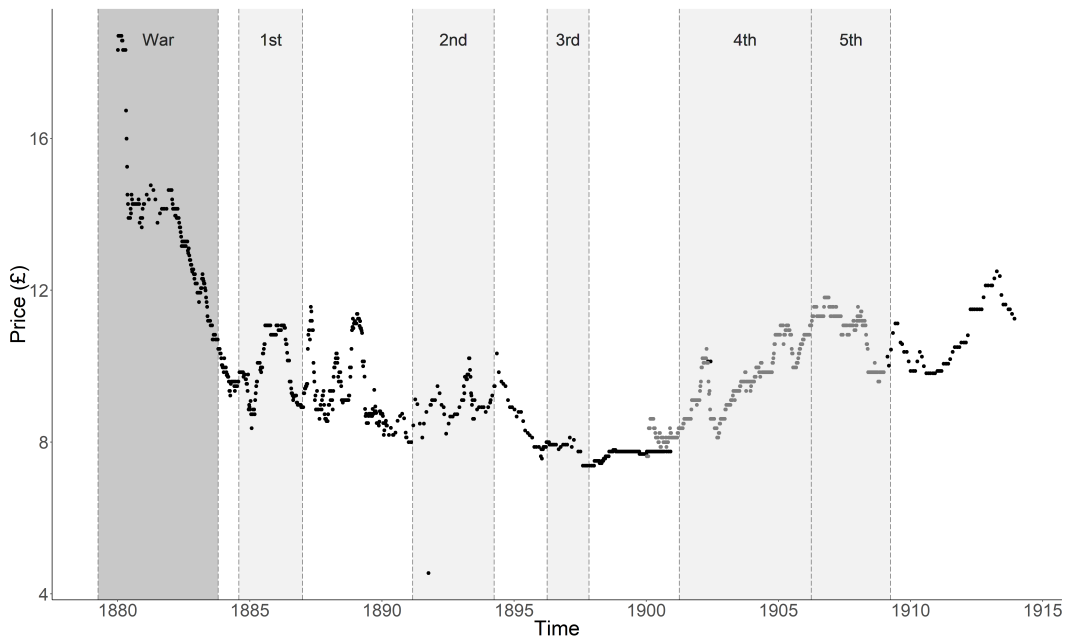
Notes: Vertical axis is prices in contemporaneous pounds. Horizontal axis is time. Observations obtained from The Economist are in black, while observations from the Chemical Trade Journal are in grey.

Figure 1.B.3: Monthly Nitrate Prices in the U.K and Chile
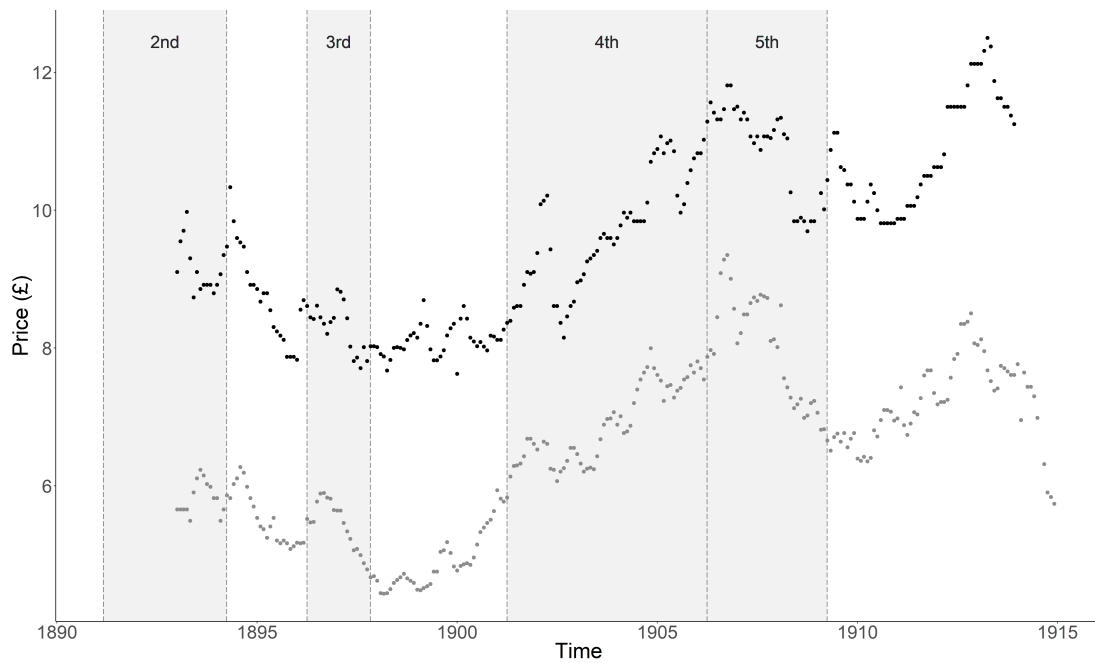
Notes: Vertical axis is prices in contemporaneous pounds. Horizontal axis is time. Prices in the U.K. arein black, while prices in Chile are in grey.

Figure 1.B.4: NPA Monthly Output Statistics (June 1900)

Notes: Periodic publication of the NPA. Each row corresponds to a nitrate plant. Output expressed in metric quintals. Obtained from the Chilean National Library, Santiago, Chile.

Figure 1.B.5: Nitrate Agency Monthly Report (November 1899)

Movimiento habido en las Salitreras de la República de Chile en el me[s]

ESPRESADO en quintales métricos

OFICINAS	OPERARIOS					ANIMALES			MOVIMIENTO DE SALITRE							
	Chilenos	Peruanos	Bolivianos	Otras naciones	TOTAL	Caballos	Mulas	TOTAL	Existencia del mes anterior Q. M.	Elaborado en el mes Q. M.	TOTAL Q. M.	Remitido al puerto Q. M.	Consumido en la oficina . Q. M.	TOTAL Q. M.	Existencia para el mes entrante Q. M.	Exist... del ... Q. M.

Tarapacá

Notes: Periodic publication of the Nitrate Agency. Each row corresponds to a nitrate plant. Output expressed in Spanish quintals. Obtained from the Tarapaca Regional Archives, Iquique, Chile.

Figure 1.B.6: Second Cartel Contract

Appendix 1.C Additional Tables

Table 1.C.1: Logit Regression Shutdown Probability

	Dependent variable:
	Plant shutdown
lagged(Workers)	-1.030^{***}
	(0.060)
lagged(Animals)	0.194^{***}
	(0.057)
Constant	2.668^{***}
	(0.171)
Observations	10,349
Log Likelihood	$-3,738.645$
Akaike Inf. Crit.	7,483.289

Notes: Robust standard errors in parentheses. Observations are plant-months. Plant shutdown takes value of 1 if the plant was inactive in a given month but is observed in operation later in the data.

Table 1.C.2: Chi-Square Test

Number intervals:	
Two	Three
8.56	7.26
(1)	(2)

Notes: Degrees of freedom in parentheses.

Table 1.C.3: Regression Prices U.K. and Chile

	Dependent variable:
	Nitrate price UK
Nitrate price Chile	0.957***
	(0.027)
Constant	3.399***
	(0.172)
Observations	250
R^2	0.809
Adjusted R^2	0.809
Residual Std. Error	0.553 (df = 248)
F Statistic	1,053.463*** (df = 1; 248)

Note:	*p<0.1; **p<0.05; ***p<0.01

Notes: Robust standard errors in parentheses. Observations are monthly prices.

Table 1.C.4: Discretization of Nitrate Price (p_t)

Interval	Lower bound (£/ton)	Upper bound (£/ton)
p1	4.44	5.32
p2	5.32	5.91
p3	5.91	6.74
p4	6.74	7.57
p5	7.57	9.35

Table 1.3.8: Summary Statistics Observed Plant Values

Statistic	Periods observed	Discounted value ($)	Mo. Profit ($)
N	148	148	28,084
Mean	214	33,802,826	378,945
St. Dev.	119	37,172,924	506,587
Min	10	-7,936,688	-6,461,858
Pctl(25)	106.5	9,364,678	0
Median	214	20,687,580	226,831
Pctl(75)	342.2	47,631,551	566,686
Max	381	224,558,616	6,274,296

Table 1.3.9: Parameters Cost Function Estimation

Variable	Description	Value	Units
ϵ	Exchange rate	16	p/CLP$
w	Monthly average wage	90	CLP$
c_{anim}	Monthly cost per animal	30	CLP$
c_{coal}	Coal price	1.55	CLP$/SPQ
T	Export tax nitrate	28	p/SPQ
c_{pack}	Packaging cost	2	p/SPQ
c_{port}	Port services cost	1	p/SPQ
c_{rail}	Railroad cost	3.5	p/SPQ
c_{adm}	Plant administration costs	1.5	p/SPQ
c_{adv}	Contribution to nitrate advertising	5/16	p/SPQ

Notes: p: pence (1900); CLP$: Chilean peso (1900); SPQ: Spanish quintal.
Sources: Semper et al. (1908).

Table 1.3.10: Parameters Entry Costs Estimation

Variable	Description	Value	Units
β	Discount factor (yearly)	0.92	
c_l	Cost nitrate reserves	2	p/SPQ
c_{k1}	Capital cost interval 1	1	£^{1900}/SPQ
c_{k2}	Capital cost interval 2	18/20	£^{1900}/SPQ
c_{k3}	Capital cost interval 3	3/4	£^{1900}/SPQ

Note 1: p: pence (1900); CLP$: Chilean peso (1900); SPQ: Spanish quintal.
Note 2: In capital cost parameters, SQP refers to monthly production capacity measured in this unit.
Sources: Semper et al. (1908).

Table 1.3.11: Parameters used for Currency Conversion

Exchange rate	Value
£^{2018}/£^{1900}	120.74
US$/£^{2018}	1.22

Sources: **boe·exchange**, **boe·inflation**.

Table 1.3.12: Discretization of Productivity types

| | Number of groups: | | | |
| | 5 groups | | 3 groups | |
Productivity group	Lower bound	Upper bound	Lower bound	Upper bound
ϕ_1	10.2	32.6	10.2	36.2
ϕ_2	32.6	39.0	36.2	50.4
ϕ_3	39.0	45.2	50.4	97.1
ϕ_4	45.2	55.3	-	-
ϕ_5	55.3	97.1	-	-

Table 1.3.13: Discretization of Capacity types (tons)

| | Capacity groups: | | | | | |
| | Group 1 bounds | | Group 2 bounds | | Group 3 bounds | |
Prod. group	Lower	Upper	Lower	Upper	Lower	Upper
ϕ_1	39.2	342.0	342.0	759.0	759.0	1217.9
ϕ_2	215.7	664.4	664.4	895.6	895.6	1439.2
ϕ_3	182.4	736.7	736.7	1221.6	1221.6	2967.8
ϕ_4	595.7	976.1	976.1	1722.4	1722.4	4033.8
ϕ_5	222.4	2032.0	2032.0	3045.3	3045.3	5605.0

1.4 Additional Figures

Figure 1.4.1: Net-entry of Plants during Nitrate Age
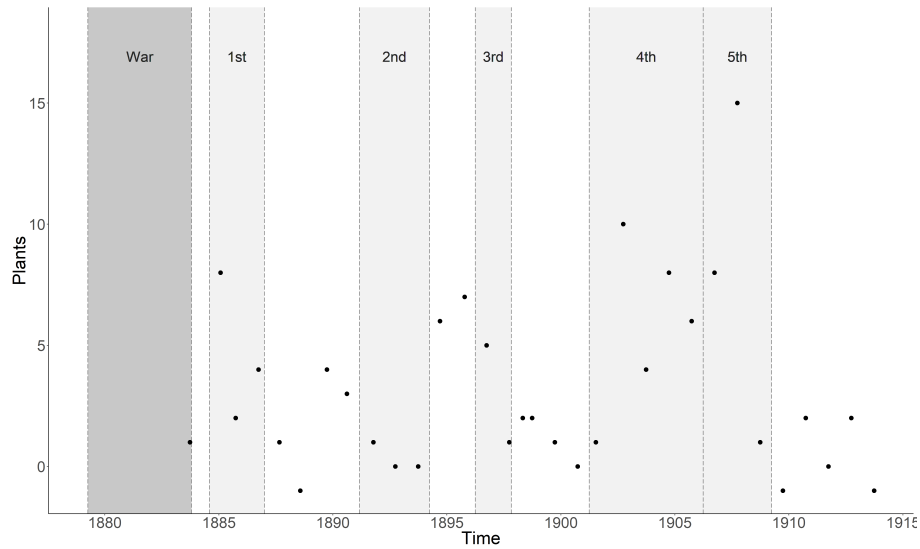
Notes: Vertical axis is plants (number). Horizontal axis is time. Net-entry computed as plants that enter minus plants that exit in a given month. Cartel periods are shaded.

Figure 1.4.2: Exiting Plants during Nitrate Age
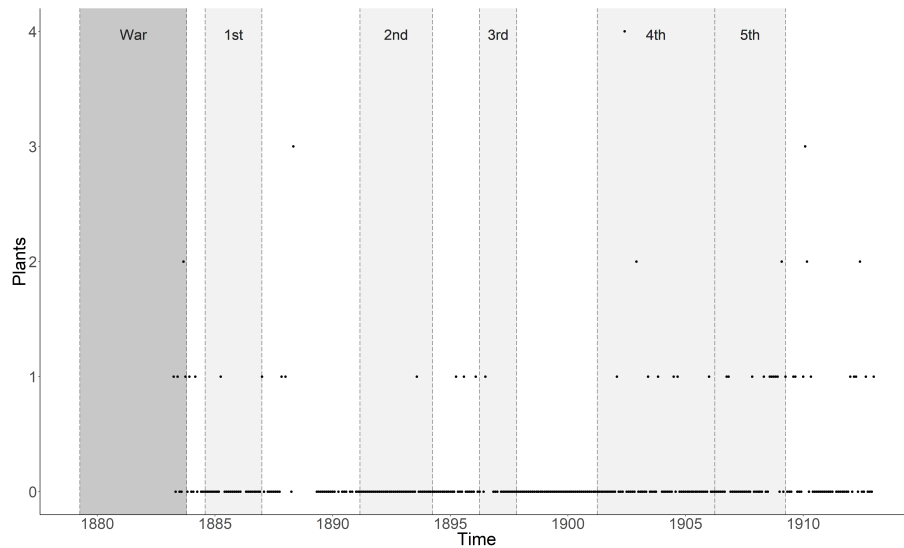
Notes: Vertical axis is plants (number). Horizontal axis is time. Exiting plants variable determined by the last observation of an establishment in the data. Cartel periods are shaded.

Figure 1.4.3: Comparison Plant Productivity Estimates
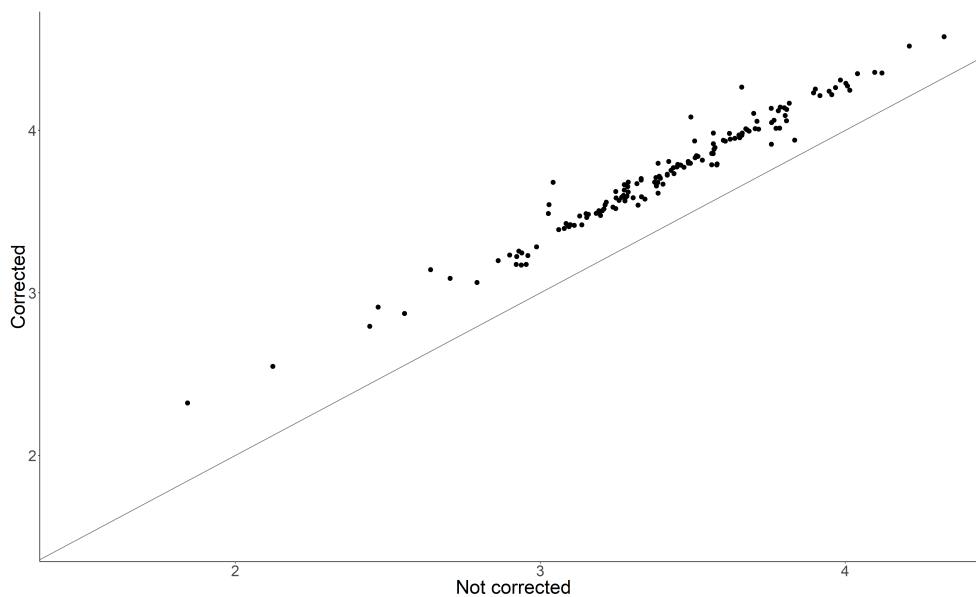
Notes: Vertical axis is productivity after implementation of correction by selection. Horizontal axis is productivity before implementation of correction by selection. Each point corresponds to a plant.

Figure 1.4.4: Productivity vs residuals (points) for Plants with more than 95 observations
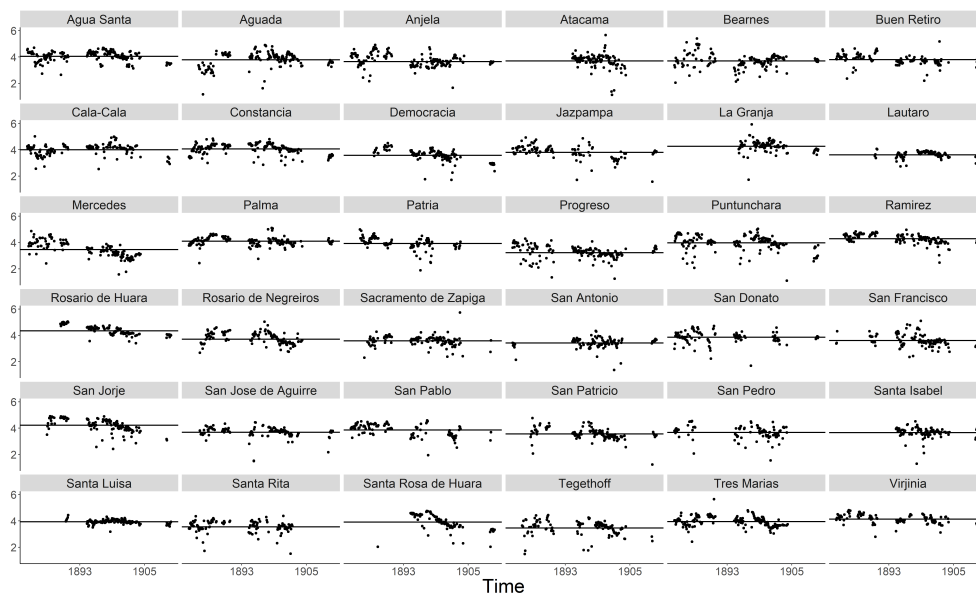
Notes: Each plot corresponds to a plant. Horizontal axis is time. Plant FE is plotted as an horizontal line. Estimated residuals plotted as points.

Figure 1.4.5: Relation between Energy Input and Nitrate Output in Refining Stage
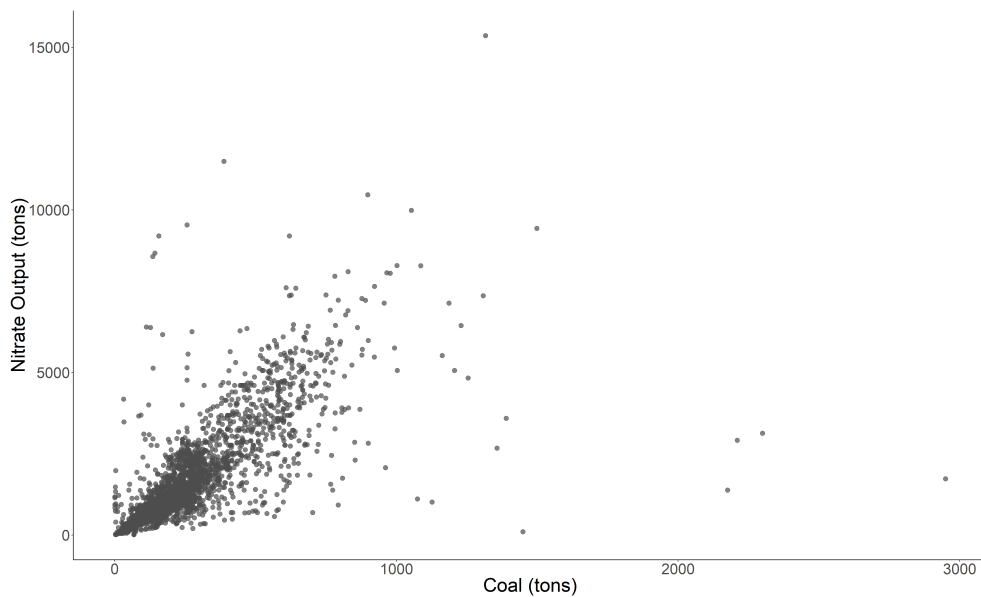
Notes: Each point is a plant-month observation. Horizontal axis is coal usage (tons). Vertical axis is nitrate output (tons).

Figure 1.4.6: Estimated Plant Productivity vs Time of Entry
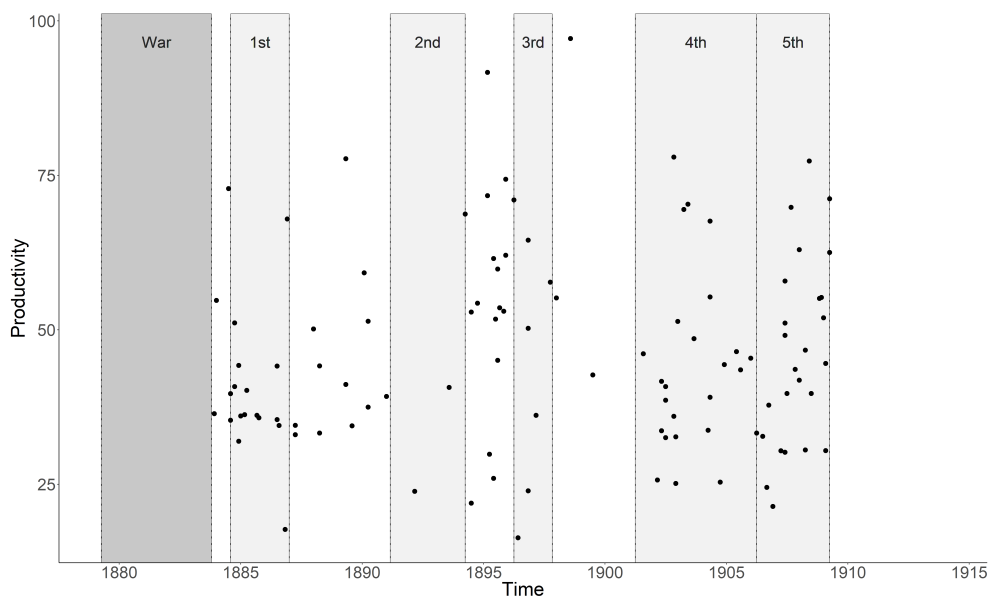
Notes: Each observation corresponds to a plant. Horizontal axis is time. Vertical axis is productivity.

Figure 1.4.7: Estimated Monthly Profits by Productivity Type
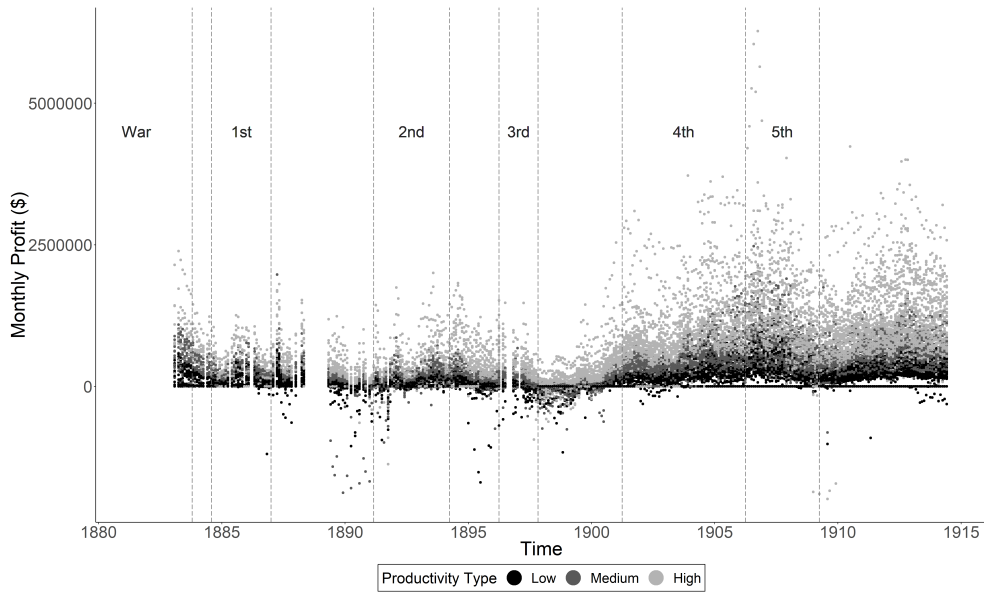
Notes: Each point corresponds to a plant-month observation. Horizontal axis is time. Vertical axis is profits current dollars.

Figure 1.4.8: Seasonality of Monthly Output by Productivity Type
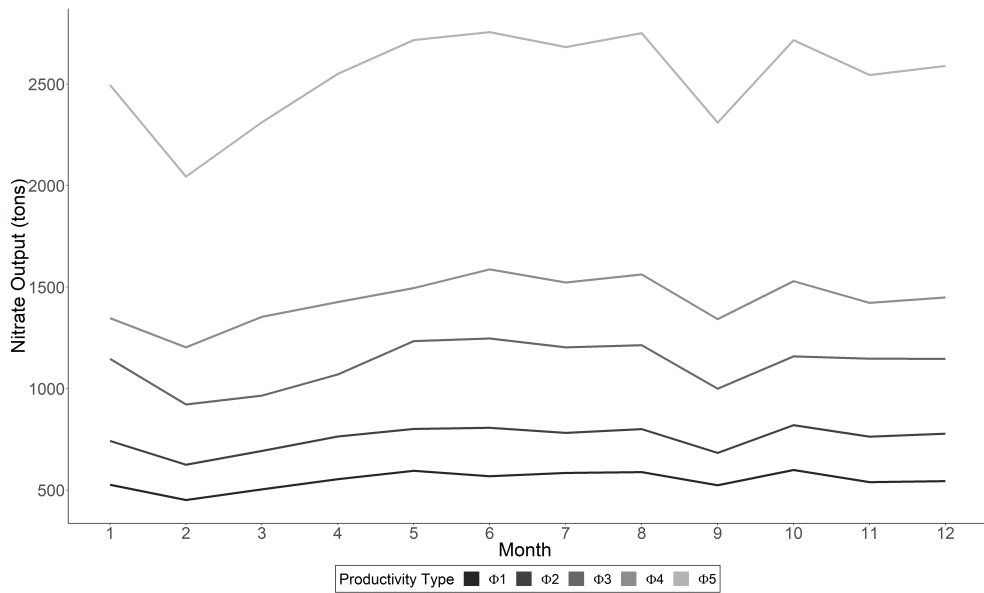
Notes: Horizontal axis are months of the year. Vertical axis is nitrate output (tons). Each line corresponds to the average nitrate output per productivity type in a given month.

Figure 1.4.9: Plant Values Net of Entry Costs: 4th & 5th Cartels
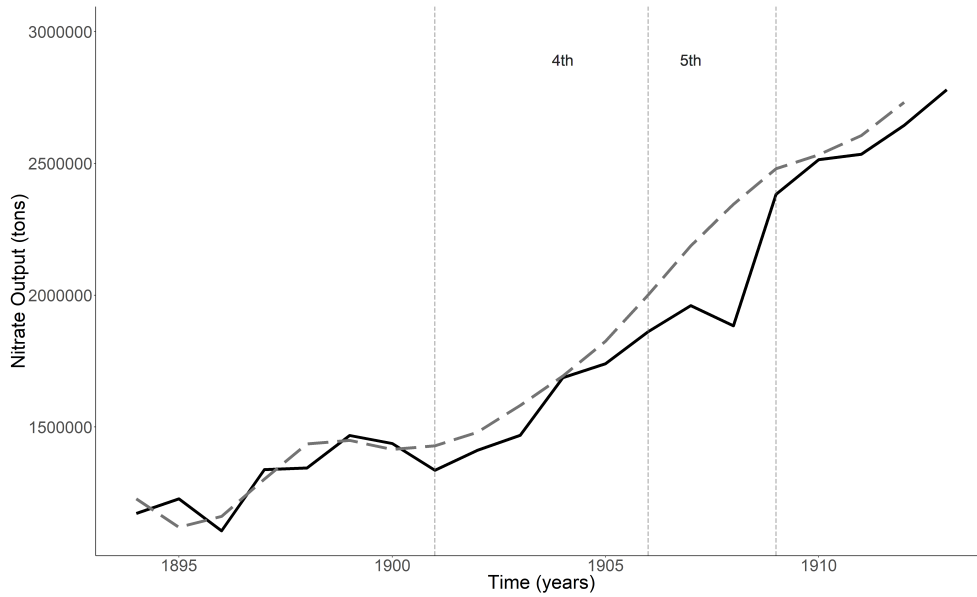
Notes: Each point corresponds to a plant. Horizontal axis is moment of entry (time). Vertical axis is estimated value in current dollars.

Figure 1.4.10: Observed and Counterfactual Industry Output
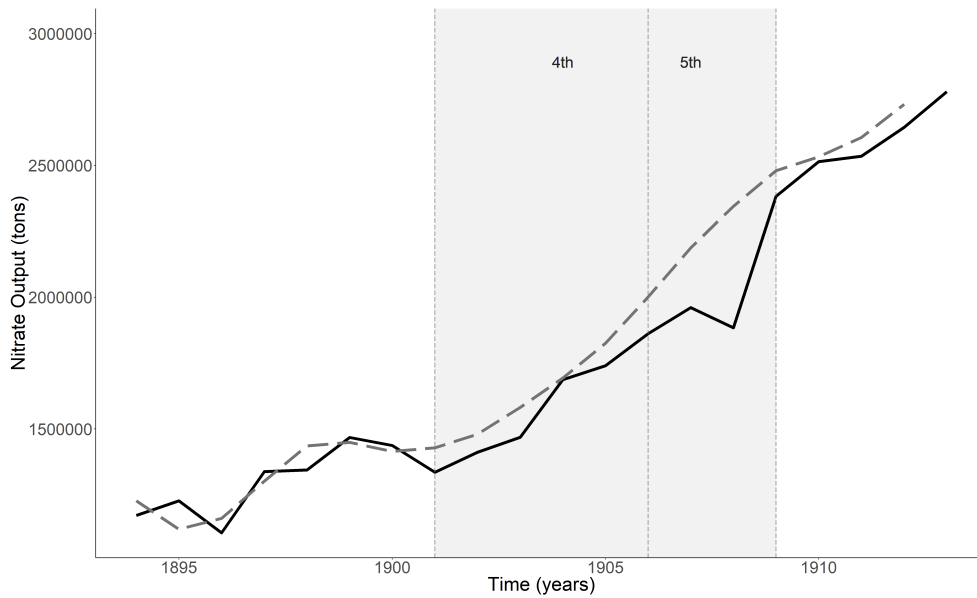
Notes: Horizontal axis is time. Vertical axis is nitrate output (tons). Continuous line is the observed industry output, while the dashed line is the counterfactual output, computed as a cubic spline.

Figure 1.4.11: Observed (continuous line) and Counterfactual Number of Plants
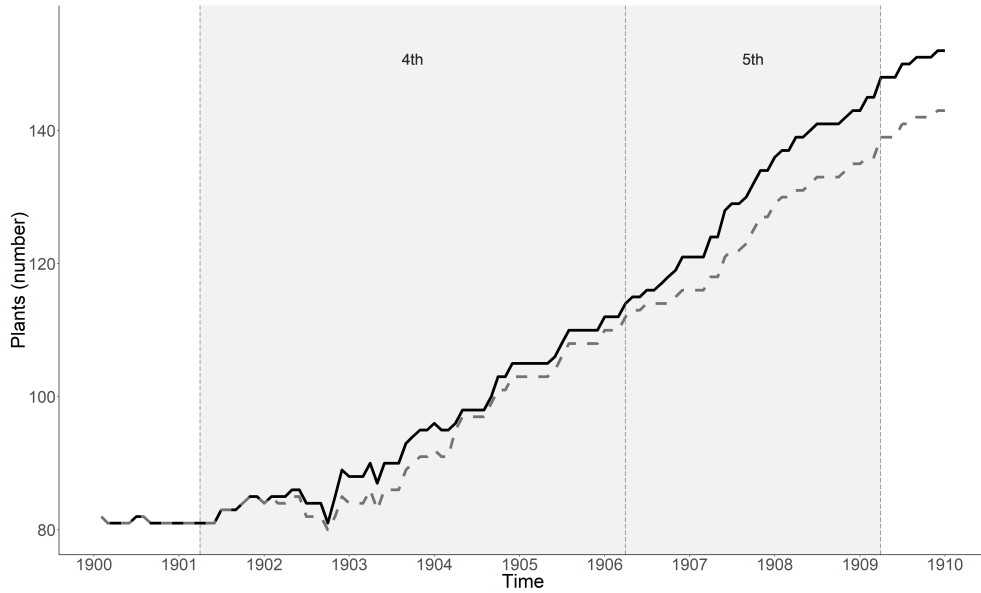
Notes: Horizontal axis is time. Vertical axis is number of plants. The continuous line represents the observed number of plants in the industry, while the dashed line represents the counterfactual number of plants.

Figure 1.4.12: Observed (continuous line) and Counterfactual Industry Capacity
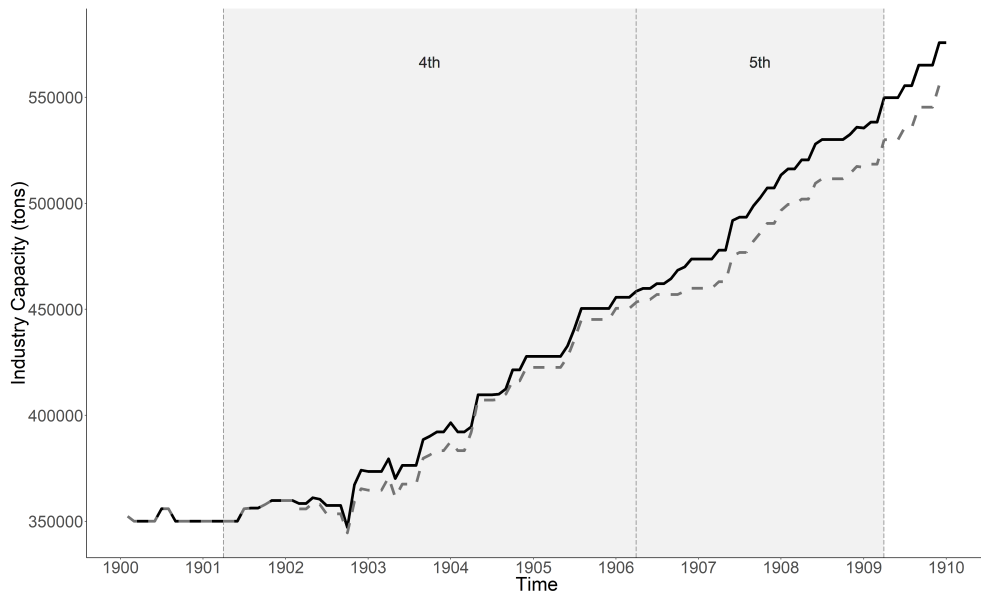
Notes: Horizontal axis is time. Vertical axis is industry capacity. The continuous line represents the observed number of plants in the industry, while the dashed line represents the counterfactual industry capacity.

Figure 1.4.13: Observed (continuous line) and Counterfactual Mean Industry Productivity
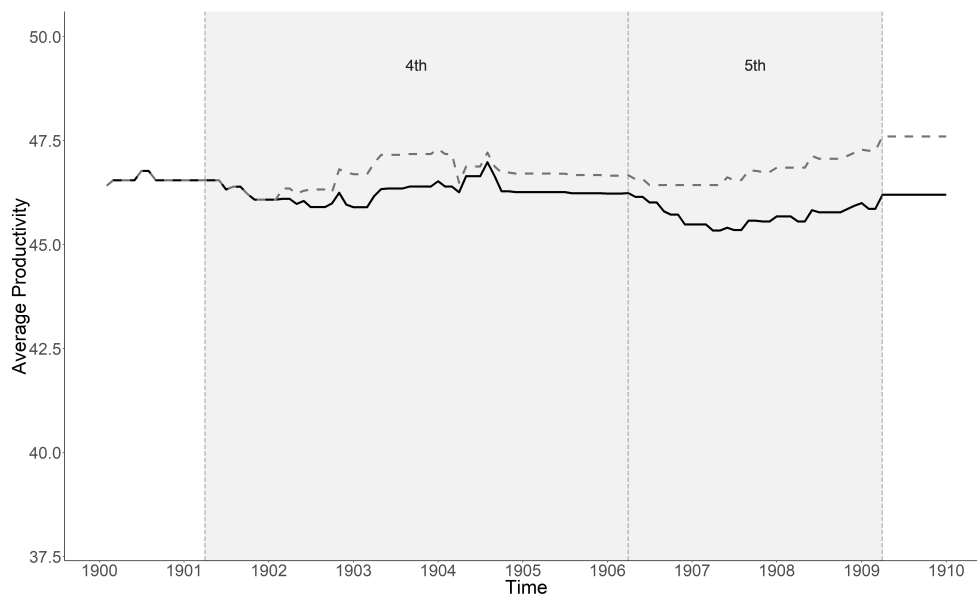
Notes: Horizontal axis is time. Vertical axis is productivity. The continuous line represents the observed mean productivity in the industry, while the dashed line represents the counterfactual mean productivity.

Figure 1.4.14: Observed and Counterfactual Productivity Distributions
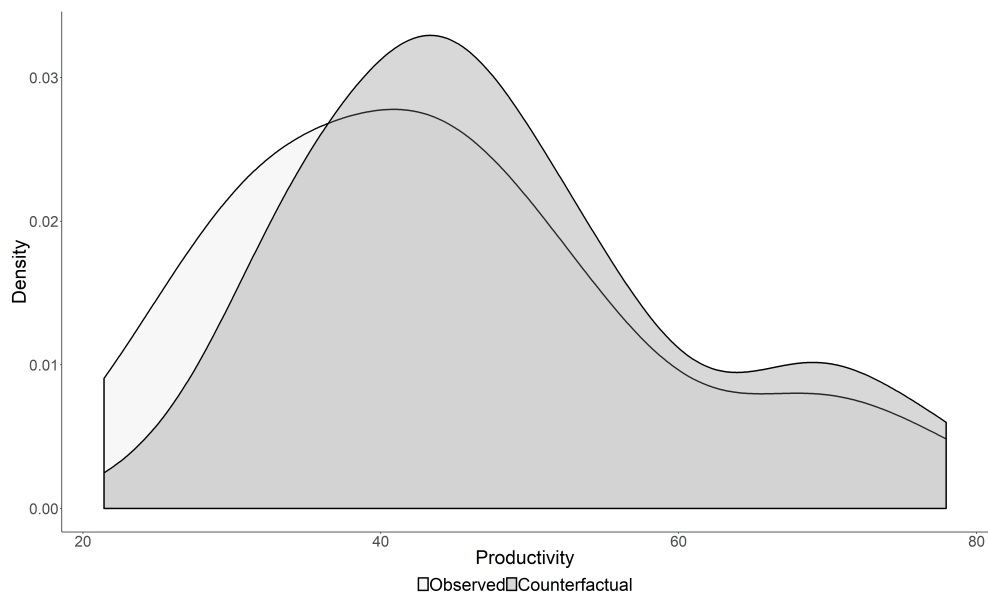
Notes: Productivity distributions of entrants during Fourth and Fifth Cartels. Observed distribution is shown in lighter shade, while counterfactual distribution is shown in darker shade.

Chapter 2

Learning-by-colluding: Experience and Efficacy of Cartels in the Chilean Nitrate Industry

This paper studies the degree to which experience helps firms to organize successful cartels. Between 1884 and 1909, Chilean producers of nitrate of soda organized cartels on five separate occasions which allow us to explore how collusive agreements evolved as producers accumulated experience in their organization. Our setting has absence of antitrust regulation and perfect monitoring, which translated in completely public cartels. Thus, unlike most of the previous literature on cartels, issues related to monitoring and enforcement were of secondary importance with respect to the challenge of allocating the collusive surplus among the colluding firms. We document that cartel contracts gradually became more complete, generated a smoother transition from competition to collusion, and that producers eventually discarded inefficient methods of market share allocation, associated to larger production costs, in favor of better alternatives.

2.1 Introduction

Although cartels are ubiquitous and very costly in terms of economic efficiency little is known about the process of cartel organization that eventually leads to the organization of successful cartels and the role of learning-by-doing in it. Do firms intuitively "know" how to optimally organize collusion once an opportunity arises? Or, alternatively, do firms learn as they go about cartel organization? Shedding light on these questions could greatly help prevention, detection, and the design of remedial measures for detected cartels.

We use the Chilean nitrate industry between 1880 and the First World War to explore this research question. Over this extended period of time nitrate producers organized cartels on five separate occasions. Moreover, collusion was both legal and public, which allow us to use sources of qualitative evidence not distorted by the fear of prosecution.

We find that collusive agreements in this industry gradually became more complex and complete, incorporating new contractual dimensions such as regulating firms' behavior during the transition to collusion. Moreover, through a process of experimentation that lasted for four cartel episodes, the producers were able to discard inefficient market share allocation methods. Furthermore, we are able to show using counterfactual simulations that the discarded methods increased production cost at least by 10%. Finally, we are able to document the process by which producers converged to a system of periodic fixed-term collusion episodes instead of organizing a permanent cartel.

Ours is, to the best of our knowledge, the first paper to document the dynamic learning process leading to the organization of a successful cartel. Our rich sources allows us to describe the evolution of producers' understanding about relevant contractual dimensions and to trace how they dealt with challenges that affected the cartel's efficacy through contractual innovations. In addition, our paper identifies a novel mechanism that hampers the organization of collusion in durable goods markets: the preemptive cheating motive. Finally, this papers contributes to our knowledge about the role of trade associations as cartel facilitators, especially in industries with a large number of producers and to explain the existence of periodic episodes of collusion, which have been observed in a wide variety of industries.

Main among the reasons for our lack of knowledge about learning in cartel organization is that cartels in most of the developed word have been illegal since about the end of WW2. Even when

a cartel is exposed, it is safe to assume that the discovered evidence has been distorted in order to limit the potential future legal liabilities, which makes very hard to address this question in a modern setting.

We are able to surpass this challenge due to the fact that nitrate cartels were legal and public, which made possible the survival of a large number of truthful qualitative sources that include full texts of the implemented collusive agreements, the minutes of producers' meetings, and the periodic publications of their trade association. We supplement this evidence with newly assembled data, including the detailed output and export statistics at the plant level.

Several features of this industry make it especially suitable for studying cartel organization. Nitrate of soda was the main fertilizer used at the time, and Chile was the sole producer. Since the domestic market for the product was negligible, every industry stakeholder in Chile was fundamentally concerned only about the maximization of producer surplus. The production process of nitrate was simple and the technology remained without significant changes. Finally, the product was completely homogeneous across firms.

The remainder of the paper is organized in the following way. Section 2.2 describes the main relevant features of the industry; Section 2.3 presents the main characteristics of the nitrate cartels and, specifically, their contract and their evolution; Section 2.4 outlines the data sources and presents summary statistics; The main aspect of learning, the allocation of collusive market shares, is explored in section 2.5; Finally, Section 2.6 describes two other important dimensions of learning: The regulation of transition from competition to collusion, and the choice of fixed-terms agreements and inter-cartel bargaining instead of permanent cartels with flexible market share allocation.

2.2   Industry Background

2.2.1   Historical development and industry characteristics

The period between the annexation by Chile of the nitrate rich territories of Peru and Bolivia during the War of the Pacific (1879-84) and the outbreak of WWI was the zenith of the nitrate of soda industry. During this period, nitrate of soda, became the main commercial fertilizer used in the world: By 1900, nitrate of soda represented two thirds of the world's total supply of commercial fertilisers (Wisniak and Garces, 2001). Moreover, nitrate of soda almost instantly turned

Table 2.2.1: Evolution of Nitrate Industry

Year	Plants (number)	Output (thous. of tons)	Workers (thous.)
1882	43	492	7.1
1887	57	713	7.2
1892	-	804	13.5
1897	42	1,187	16.7
1901	66	1,329	20.3
1906	96	1,822	-
1910	102	2,465	43,5
1914	137	2,463	44,0

Sources: Cariola, Sunkel, and Sagredo (1991), Semper et al. (1908), and Godoy Orellana (2016).

into the most important export and source of revenue for the Chilean government, accounting for approximately 65% of exports.[1] Hence, this period of Chilean history is often called the Chilean Nitrate Age.

Nitrate of soda is a natural fertilizer used to transfer nitrogen to the soil. The only commercially viable deposits in the world were found in the newly acquired Chilean provinces of the Atacama Desert (Vicuña, 1931).[2] It was an homogeneous product and its main uses were as a fertilizer, which accounted for roughly three-quarters of consumption, and as an input in the manufacture of explosives.[3] The closest available substitute during this period was sulphate of ammonia.

Nitrate was produced by private firms, in purposefully built plants located on the desert. Figure 2.2.1 shows *La Patria* nitrate plant, as a representative example. The basic configuration of a nitrate plant consisted of a central refining facility, placed in the midst of the nitrate-bearing grounds that would feed it.[4] The packaged nitrate would then be dried and stored near the refining facility, before its transportation via railroad to the nearest port. In a standard transaction, producers would sell ready for export nitrate at the port. Traders would then transport it by boat to the consuming markets of Western Europe and the United States.

The nitrate industry featured a large number of firms and experienced a constant expansion

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[1]Computed from Cariola, Sunkel, and Sagredo (1991, p. 139) as average of nitrate participation on exports in years ended with 0 or 5 during the Nitrate Age

[2]The provinces were Tarapaca (previously owned by Peru), and Antofagasta, shared between Bolivia and Chile before the War).

[3]It was sold in two versions: Ordinary (95% purity) and refined (98% purity), with ordinary constituting almost all of output.

[4]The only exception to this configuration was the Antofagasta Company before 1907, which used instead a central refining facility in the port of the same name.

Figure 2.2.1: Nitrate Plant Example: Bearnes Plant

Sources: Boudat (1889).

during the Nitrate Age. Table 2.2.1 presents basic statistics regarding the industry evolution during our period of interest. As a consequence of the large number of firms,[5] the industry had persistent low levels of concentration. For instance, in 1901 the largest firm had a market share of 6.4%, while in 1907 the largest market share was 7.6%. Firms were owned mostly by British, German, and Chilean entrepreneurs.

A distinct industry characteristic is that demand and prices were very volatile. This came as a result of three market characteristics (Bertrand, 1910). First, most nitrate was used during the European harvest season, between March and June of each year, which corresponded to about 90% of the agricultural consumption of nitrate. Second, the European demand had high variance depending on current year's weather shocks. Third, the large distance between Europe and Chile meant nitrate producers were not able to react to same-year demand shocks,[6] since nitrate production, due to economies of scale, was bound to be year-round. These patterns are summarized in Figure 2.2.2. This situation was reinforced by the fact nitrate intermediaries did minimum storage, because of the financial risks associated to its wide fluctuations in price.

The Chilean government implemented a nitrate policy based on two pillars: private-ownership of the industry with low regulation, inspired by *laissez faire* principles; and heavy taxation using a per-unit export tax of, approximately, 2.54 pounds sterling per ton exported (this corresponds to about $400 per ton, in current dollars) (Brown, 1963).[7] At the same time, the nitrate export tax became the most important source of government revenues explaining, on average, 45% of total tax revenues between 1885 and 1914 (Chilean Ministry of Finance, 1925).

The great economic and fiscal importance of the industry motivated the development of the Nitrate Agency,[8] a specialized state institution solely tasked with monitoring the industry's operation and development. Among its most important tasks, were to establish government policy

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[5]Some firms owned more than one plant. Most of the firms that entered during our main period of interest were single-firm plants.

[6]Semper et al. (1908) estimates average times of travel of 90 to 100 days for sailboats and 45 to 65 days for steamboats.

[7]Figures regarding nitrate export tax also include the export tax collected on iodine exports. Iodine is a sub-product of the elaboration of nitrate of soda.

[8]The name of the agency in Spanish was *Delegación Fiscal de Salitreras y Guaneras*. It was based on the city of Iquique, main city of the Chilean nitrate region. Immediately after the occupation of the Peruvian nitrate territories, in December 1879, the Chilean government named a general representative to the region to oversee the territory, including its nitrate industry (Ministerio de Hacienda, Chile, 1880, p. 46). A specialized General Inspectorate of Nitrate (In Spanish, *Inspección General de Salitreras*) existed by 1885 (Ministerio de Hacienda, Chile, 1885, p. 395). Finally, in 1889, the Chilean government increased the budget and rank of its nitrate agency, obtaining the name and features that would persist until 1914.

Figure 2.2.2: Industry-level Output and Consumption
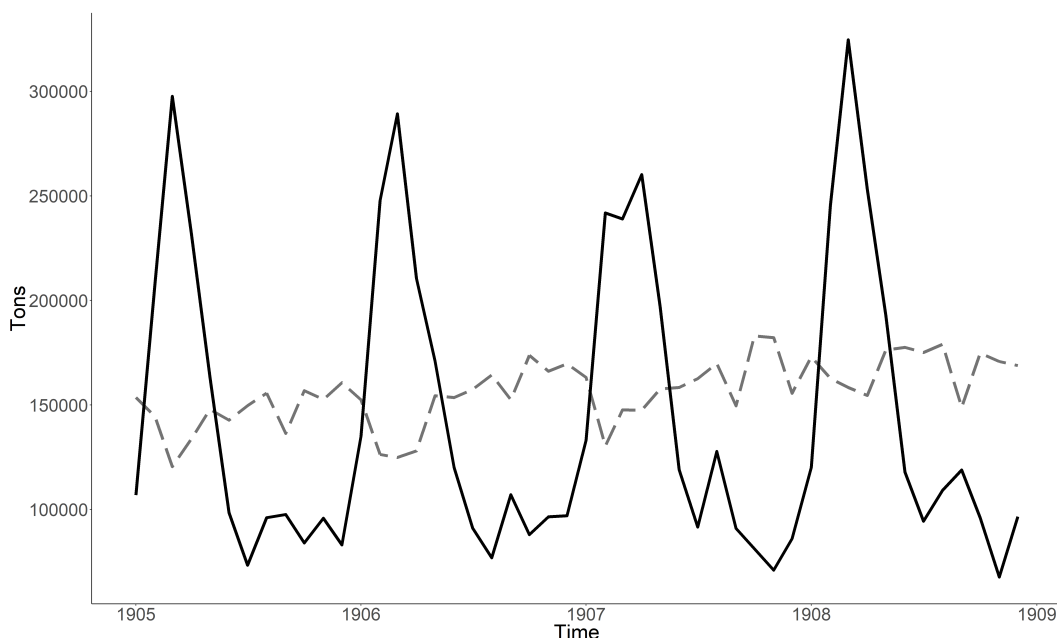
Notes: Monthly industry-level output (dashed line) and consumption (continuous line) between the years 1905 and 1908.

towards the industry, the collection of industry and plant-level statistics, and the management of government-owned nitrate assets, particularly state-owned nitrate lands.

The First World War fundamentally changed the market for nitrate of soda, [9] as Chile lost its monopoly on nitrate of soda due to the invention of the Haber-Bosch method for production of synthetic nitrate. The effects of this event for the Chilean nitrate industry were devastating, never recovering its previous levels of profitability.

2.3 Nitrate Cartels and Learning

2.3.1 General Description

Nitrate of soda producers formed cartels on five separate occasions (see Table 2.3.1) to take advantage of their joint market power in the fertilizer world market.[10] These cartels lasted from a

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[9]The breakout of the war, also greatly disrupted the industry, as the blockade of the Central Powers closed overnight some of the most important export markets at the same time as the industry experienced a positive demand shock, driven by sales to the Allied powers.

[10]For instance, during a competitive period, a nitrate producers' publication reads, "Currently, it can be said the industry is producing as much as it is allowed by the potency of the elements at its disposal . . . On the other hand, is the conviction of every and each producer that today they deliver their valuable product . . . depressed by at least a shilling in the price consumers can still pay at great advantage for their economy . . . The result, therefore, of sound

Table 2.3.1: List of Nitrate Cartels

Cartel	Start Date	End Date	Early termination
First	1884-August	1886-December	No
Second	1891-March	1894-March	No
Third	1896-April	1897-October	Yes
Fourth	1901-April	1906-March	No
Fifth	1906-April	1909-March	No

Notes: Early termination indicates whether the End Date corresponds to the original termination date agreed on collusive contract, or if an early termination clause of the collusive contract was invoked. *Sources:* Brown (1963).

minimum of seventeen months to a maximum of five years, and had almost unanimous participation among nitrate firms. Moreover, the start of the first three cartels followed drops in the nitrate price.

All nitrate cartels share some distinctive features. First, before the start of each cartel, a collusive contract would be signed by all participating producers, stipulating all the relevant rules that would govern its operation. Second, as a result of the absence of any antitrust legislation at the time in Chile, they were completely public (including their contracts) and the large importance of the industry guaranteed their actions received a great deal of attention by the press and the general public. Third, nitrate producers' limited capacity to respond to contemporaneous demand shocks, due to their long time-to-market, made unpractical for them to try to directly set the price of nitrate of soda. As a result, all nitrate cartels were limited to being quantity-setting agreements.

The management of the nitrate cartels, given their large number of firms and their geographic dispersion, required the existence of a executive body with enough power to make operational decisions in short order. The first two cartels were managed by a board of producers (denominated Nitrate Committees) elected by cartel members after the signature of the collusive agreement. In the first two cartels the group of producers that promoted their organization were heavily represented in their cartel boards. A pivotal change in the organization of the industry was the creation in 1894 of a permanent trade association, called Nitrate Propaganda Association (NPA from now on) which took over and expanded the staff and organization developed during the Second Cartel after

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advice and mere commercial foresight would be to agree on a formula under which all [producers] consulted their interests and marched together in pursuit of own and general welfare (NPA, 1899, p. 6)."

Figure 2.3.1: Industry yearly output (tons)
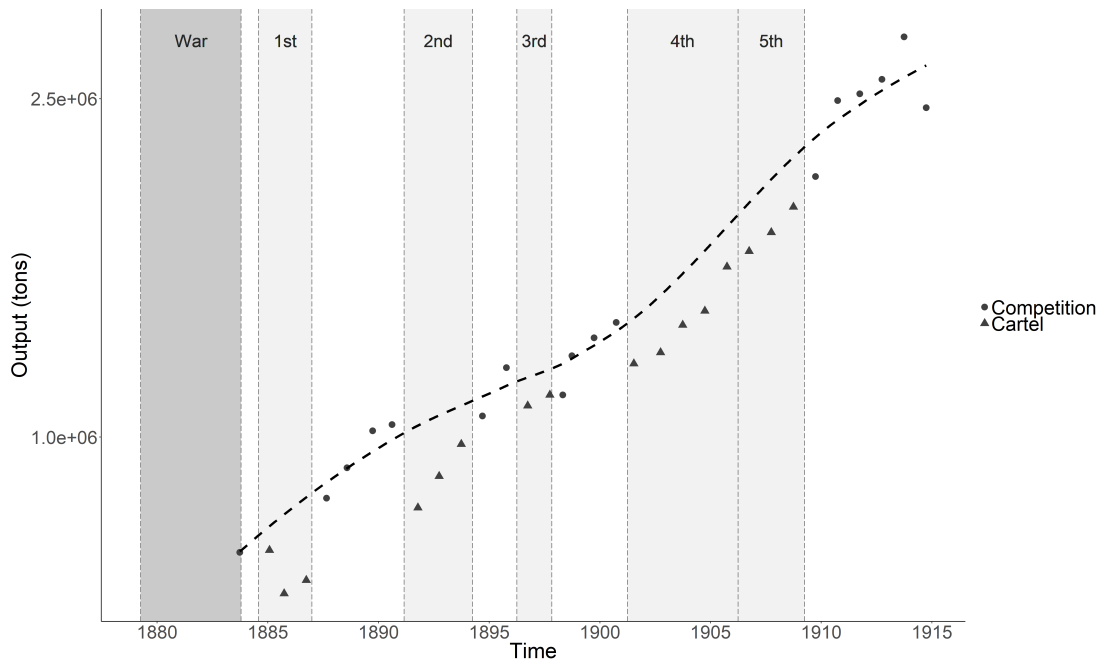
Notes: Yearly industry output shown as circles (triangles) for competition (cartel) years. Dashed line presents a non-parametric trend, computed only using industry output observed during years in competition. Cartel periods are shaded. Texts correspond to cartel number by chronological order and to the War of the Pacific period.

its conclusion in 1894. The NPA retained from the initial cartels an elected board of producers (elected for one-year terms) as its governing body but its reach was limited mostly to strategic aspects, leaving day-to-day operations in hands of its manager and a permanent professional staff. Starting from the Third Cartel, the NPA manager was the main organizer of the successive nitrate cartels.

Regarding the effects of nitrate cartels, as an illustration, Figure 2.3.1 shows the industry yearly output, together with a trend that considers only years with free competition, showing that output during cartel years were always below what it could be expected given the previous trend of output during competition.

On the other hand, Table 2.3.2 summarizes the effect cartels had on aggregate industry output. On this Table, the dependent variable is monthly industry-level output, while the main independent variables of interest are individual cartel dummies. The regression also includes dummies related to high and low-demand seasons and a time trend. The main result from Table 2.3.2 is that going from competition to cartel was correlated with an average industry output reduction of around

18%.

2.3.2 Relevant Dimensions of Learning

A successful cartel must solve four fundamental organizational issues: monitoring and enforcement, resistance from related firms and authorities, bargaining, and entry.[11]

The special characteristics of this industry's physical and institutional environment made the nitrate industry to develop in a perfect-monitoring setting. Nitrate production was the only economic activity developed in the Atacama Desert and all plants, grouped in distinctive districts, were situated nearby from each other, sharing the same railroad networks to transport their outputs to port. Moreover, the sheer importance of the industry ensured that the Chilean state developed monitoring institutions that could compile public statistics and prevent the evasion of the nitrate export tax. As mentioned above, nitrate producers followed the lead of the Chilean state and used the NPA as an statistical agency for monitoring purposes. As an example of the detailed monitoring system put in place by the NPA, Figure 2.B.1 shows an example of the Nitrate Shipment Magazine, published by the NPA from at least 1894, which contained information on all nitrate shipments made from Chile in a given month, including the firm of origin, quantity exported, name of the ship, and destination.

In addition, there is evidence that nitrate cartels had effective tools to enforce the fulfillment of their agreements. Although nitrate cartels were based on legal contracts to the best of our knowledge there is no evidence of litigation associated to contract infringements. However, there is narrative evidence that failing to comply with cartel rules would translate into a strong retaliation: [12][13]

> To a person not resident in Iquique it is difficult to realise the power which the Nitrate
> Committee possess.[14] Firstly, they have the support and are recognised ... by the
> Republic. Secondly, the object of the combination, the banking interest, and of all

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[11]McAfee and McMillan (1992). Bargaining, refers to the division of the collusive surplus among the cartel members; Entry corresponds to the presence of new producers, tempted by the large profits generated by the cartel; Monitoring and enforcement, corresponds to the mechanisms by which the cartel agreement will prevent cheating; and resistance from firms and authorities, relates to the potential actions that firms on the other side of a market and to enforcement by antitrust agencies.

[12]Russell (1890, p. 333)

[13]See additional supporting evidence related to the power cartels had in Appendix 2.B.

[14]Note: written as "Comite Salitreros" [sic] in the original text.

Table 2.3.2: Cartel Effects Regression

	Dependent variable:	
	log(Nitrate Output)	
	(1)	(2)
Cartel	−0.187***	
	(0.031)	
Cartel 1		−0.549***
		(0.084)
Cartel 2		−0.045
		(0.053)
Cartel 3		−0.019
		(0.095)
Cartel 4		−0.137***
		(0.022)
Cartel 5		−0.167***
		(0.029)
Time	0.0002***	0.0002***
	(0.00001)	(0.00001)
High season	−0.031	−0.020
	(0.051)	(0.045)
Low season	−0.042	−0.047
	(0.040)	(0.038)
Constant	16.426***	16.184***
	(0.132)	(0.145)
Observations	404	404
R^2	0.818	0.841
Adjusted R^2	0.817	0.838

Notes: Robust standard errors in parenthesis. Observations correspond to months at the industry level. *Cartel* takes the value 1 if any cartel was active, and 0 otherwise. *Cartel 1* takes the value 1 if First Cartel was active, and 0 otherwise. Additional indicator variables for individual cartels follow the same logic.*p<0.1; **p<0.05; ***p<0.01.

Figure 2.3.2: Example of Monitoring: Nitrate Shipment Magazine (February 1895)

Notes: The Nitrate Shipment Magazine (*Revista del Carguío de Salitre*) was a monthly publication of the NPA from at least 1895 until 1929. It summarized all the nitrate shipments made in Chile, including the producer of origin, quantity of nitrate, ship name, date of shipment, port of origin, and port of destination. **Source:** Vol. 2659, Ministry of Finance Collection, Chilean Historical Archives.

trade depending on the manufacture of nitrate, are so closely bound together, that a fiat issued with regard to any firm or individual who has persistently offended against the Articles of Association means to them immediate ruin. The form or individual is treated as one whose signature is not worth the paper it is written upon; he or they are in every form boycotted.

These characteristics that promoted "good behaviour" on the part of cartel members were reflected in a very small number of deviations from the agreed-upon firm level quotas. For instance, by the end of the first year of the Fourth Cartel only 5 plants had excess output over their quotas, for an amount equivalent to less than 0.15% of the total industry quota.[15] During the second year of the same agreement, the deviations were even smaller. [16]

Finally, the absence of antitrust legislation in Chile meant that the usual concerns colluding firms face when organizing collusion regarding detection and potential antitrust litigation were absent from this setting. Furthermore, local consumption of nitrate in Chile was negligible. Hence, authorities had no local consumer surplus to protect from the high prices induced by the cartel.

As a result, in contrast to a large fraction of the cases studied in the previous literature, in the nitrate cartels the challenges faced by producers were mostly related to the issues of bargaining and entry. The focus of this paper is to describe the learning process associated to bargaining problems while a companion paper[17] studies how entry affected these cartels and the solutions implemented by incumbent nitrate producers. Besides the topical differences between the two papers there is also a chronological distinction: The bulk of the learning related to bargaining occurred during the first three cartels, while the entry problem became crucial fundamentally during the last two cartels.

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[15]NPA (1902, p. 6).

[16]"The only excesses over the quotas established by the agreement were:
Output: Aguada plant, owned by Compañia Comercial y Salitrera La Aguada...1,836 Sp. quintals.
Exports: Progreso plant, owned by Evaristo Quiroga and Bro. ...1,627 Sp. quintals.
Although their insignificance suggest that these violations were involuntary errors, the producers have been fined as stipulated in articles 15 and 16 of the contract ..." NPA (1903, p. 4).

[17]Carrera and Titov (2019).

2.3.3 Evolution of Nitrate Cartel Contracts

Nitrate cartel contracts exhibited a relevant evolution.[18] As nitrate producers gained more practical experience at the organization of cartels they incorporated clauses about additional contractual dimensions, making contracts more complete. Table 2.3.3 summarizes this trend. Quantitative measures of the length of the contracts together with qualitative description of the new topics added in each of them show the collusive contracts' increasing complexity. Specifically, cartels organized by the NPA are at least twice as long as the firsts two agreements an incorporated regulations in topics that were perceived as greatly damaging to the success of previous cartels (e.g., regulation of transition to collusion). Moreover, after the success of the Fourth Cartel there was a remarkable degree of continuity in the contract used in the Fifth Cartel.

In terms of structure, the contracts also had a clear evolution: A large fraction of the First Cartel contract described the attributions and tasks of the Nitrate Committee, while at the same time setting only very general rules for the cartel itself; the Second Cartel contract reads included rules that were conditional on a satisfactory conclusion of the negotiations and left the regulation of some aspects of the cartel to a general meeting to be held *after* the agreement was signed. On the other hand, all cartel contracts negotiated under the umbrella of the NPA share a common structure.

2.4 Data and Summary Statistics

We use two main sources of data: All the collusive agreements signed by the nitrate cartels between 1884 and 1909, and a monthly plant-level panel dataset describing the output of each nitrate plant between 1883 and 1914. Table 2.4.1 describes the location of our main sources.

The cartel contracts were collected from the National Notarial Archives and other sources located in the National Library of Chile. Figure 2.4.1 presents an example of a cartel contract.

Our output data was compiled from two main contemporaneous sources. The first corresponds to monthly plant-level industry reports compiled by the Nitrate Agency, which cover the period 1883 to 1909, and include nitrate output, exports, and stocks, in addition to input data. We are able to collect spreadsheets for 228 months over this period, with 15,804 observations. The second

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[18]To see the full text of the contracts and their translation go to the Appendixes.

Figure 2.4.1: Second Cartel Contract

Sources: Chilean National Notarial Archives, Santiago, Chile. Iquique Notaries. Volume 132.

Table 2.3.3: Evolution of Nitrate Cartel Contracts

Cartel	# articles	# words	Innovations (new topics)	NPA Cartel?
First	14	781*	Allocation collusive quotas, cartel governance, transfer quotas across plants same owner, punishment of deviations.	No
Second	11	775		No
Third	14	1,811	Procedure to set industry-level quota, accommodation of entry, hiring of inspectors, small deviation leniency, upper-bounds to output, update of quotas due to investments, lower-bound to industry-level quota.	Yes
Fourth	22	2,577	Regulation of transition to collusion, transfer quotas across time for small producers.	Yes
Fifth	21	2,224		Yes

Notes: * word count excludes articles exclusively related to organization of *Nitrate Committee* (trade association). *Sources:* Prepared by authors using cartel contracts. See Section 2.4 for more details on sources and Appendixes for translation of cartel contracts.

source are plant-level output and export monthly reports produced by the NPA, which cover the period 1900-1914. In this case, records are available for 21 months before 1900 and for every month after that year, for a total of $23,518$ observations. The merged dataset has a total of $32,623$ plant-month observations.

Our quantitative sources were complemented with extensive narrative historical evidence from the nitrate producers' internal discussions, contained both in the Quarterly Circulars distributed by the NPA to its members and the nitrate producers' meeting minutes (NPA, 1909).

Table 2.4.2 shows summary statistics for the 200 plants in our main dataset. The median nitrate plant had 245 workers and 89 animals, although there was a significant dispersion. Column 3 shows capacity, which was estimated as the maximum plant-level monthly output observed in any month of a moving 5-year interval. Column 4 presents the average monthly output, conditional on plants being active. The industry presents a large amount of excess capacity, with average output doubling the average monthly output.

Table 2.4.1: Summary of Data Sources

Data	Sources
Prices UK	*The Economist, Chemical Trade Journal*
Prices Chile	Nitrate Agency, NPA
Cost parameters	Semper et al. (1908)
Plant characteristics	Narro (several issues), Boudat (1889)
1st Cartel contract	Comité Salitrero (1884)
2nd Cartel contract	National Notarial Archives. Iquique Notaries. Volume 132.
3rd Cartel contract	National Notarial Archives. Iquique Notaries. Volume 141.
4th Cartel contract	NPA (1900)
5th Cartel contract	Semper et al. (1908, p. 321)

Table 2.4.2: Summary Statistics: Nitrate Plants

Statistic	Workers	Animals	Capacity (tons)	Avg. output (tons)
N	176	178	200	200
Mean	289	103	3,494	1,703
St. Dev.	179	64	2,861	1,239
Min	5	2	30	18
Pctl(25)	167	57	1,610.2	932
Median	245	89	2,663.7	1,337
Pctl(75)	383	139	4,267.1	2,161
Max	1,038	309	15,647	6,721

Notes: Capacity estimated as maximum monthly observed output in moving period of five years (observations from year 1896 were dropped). Workers, animals, capacity, and average output correspond to mean monthly values, excluding zero output observations. *Sources:* Authors' calculations using main dataset.

Method	Description
Time	Mandatory shutdown for predetermined number of months each year.
Trial	Determination of capacity according to output during a "trial period" after negotiations.
Past-output	Determination of capacity based on previously realized outputs.
Theoretical capacity	Determination of capacity based on assessment of theoretical production capacity by experts.

2.5 Allocation of Cartel Market Shares

The allocation of collusive market shares was the main challenge that nitrate producers faced when trying to implement stable cartels. In consequence, this was the contractual aspect that received by far the most attention, as it was explicitly declared by the NPA:[19]

> "The main challenge for a cartel resides in finding an adaptable formula, permanent in a way, that allows the survival of all the plants through an agreement that limits the output of each of them in harmony with some general requirements, including those originated by the cartel's own existence. "

In particular, producers hoped to find a way of allocating production under collusion that ideally: (i) satisfied the incentive compatibility restrictions of all the producers, so that they will decide to join the cartel; (ii) was perceived as "fair"; (iii) did not introduce additional production costs (iii); (iv) did not provide incentives for new investments.

Several methods for allocating market shares under collusion were used: direct negotiation of market shares, the periodic suspension of production for a fixed length of time each year (which will be referred to as "time-method"), and three methods based on assessing the production capacity of each plant, which we collectively denominate as "capacity methods": the trial, past-outputs, and theoretical capacity methods. Table 2.5.1 and Figure 2.5.1 present a description of the methods and the cartels when they were used.

Notice that the methods tried by the nitrate producers inherently emphasize only subset of

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[19]NPA (1898a, p. 4)

Figure 2.5.1: Allocation Methods used by Nitrate Cartels
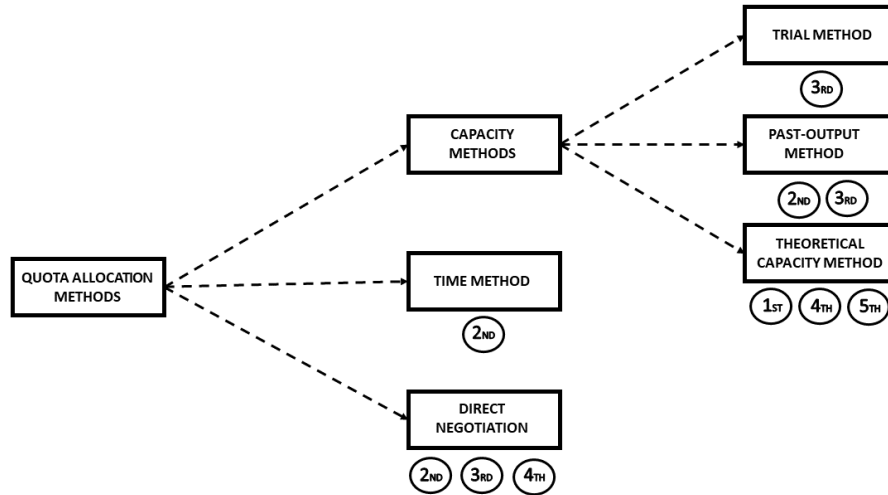
their objectives. Thus, using each method presented the producers with a different trade-off. For instance, the time method generates a perfectly proportional reduction in output across producers (maximizing the "fairness" objective) and it does not induce investments. However, imposes additional costs associated to periodical shutdowns and an inefficient scale of production.

Given that the quota-allocation method was the central feature that made each nitrate cartel unique, next we provide a chronological description of each cartel.

2.5.1 First Cartel: Early theoretical-capacity Method

The First Cartel operated between August of 1884 and the end of 1886. Its beginning is related to a sharp reduction in nitrate prices due to the end of the War of the Pacific. A general meeting of producers determined that collusive market share would be based on each plant's production capacity, which would be assessed by a committee of producers which would visit each plant shortly before the start date of the cartel. The committee, however, only had ten days to visit all the plants in Tarapaca Province, which signals a potentially shallow assessment of each facility (Comité Salitrero, 1884, p. 20).

The result of this procedure was a generalized exaggeration of each firm's production capacity.[20]

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[20]"As we all remember in the cartel from 1884 to 1887 all the plants produced following quotas based on the production capacity estimated by committees of experts and the exaggerations that were incurred caused, among

For instance, total potential output was estimated as 17,000,000 Spanish quintals when the output in the previous year had only been 12,000,000 Spanish quintals. As the British consul explained:[21] "The principle over which limitation was agreed on was a percentage of the possible output of each plant; consequently each plant claimed as large an output as possible."

Contemporaneous narrative sources emphasize the lack of fairness had very detrimental effects on the continuity of the cartel and its effectiveness. For instance, Cruchaga (1929, p. 205) claims:

> More numerous are the defects due to the bad organization. Among them is the lack of equity in the estimation of the production capacity of the plants, situation for which there is substantiated evidence to consider as true and that naturally has brought about conflict between the associates that want to take advantage of an irregular partition and those that prefer the destruction of the cartel itself before accepting the lack of proportionality.

2.5.2   Second Cartel: Time method

After the end of the First Cartel in December of 1886, the industry experience a period of free competition that lasted for 4 years. By the end of 1890, however, nitrate prices had dropped and producers started talks in order to form a new cartel. Interestingly, producers decided to use a different system to allocate collusive market shares: the time method.

The time method, instead of using fixed quotas for each plant, consists on a restriction on the amount of time each firm could refine nitrate, which was initially set at seven months of the year. In this manner, producers hoped to achieve a reduction in output perfectly proportional for every plant in the industry. Figure 2.5.2 illustrates how the system worked in practice for a subset of plants.

Compared to the earlier theoretical capacity method, the time method imposed some important trade-offs. Since each firm could produce at full capacity during the same amount of time, the allocation of production during the cartel was perfectly "fair". Also, it was not necessary to estimate production capacities and there was no distortions in the investment decisions. Finally, this method made monitoring very simple, since it was only necessary to control whether a plant was active

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other factors, the posterior disagreement."NPA (1898a, p. 3).

[21]Great Britain (1889, p. 1).

Figure 2.5.2: Time Method Examples (selected plants)
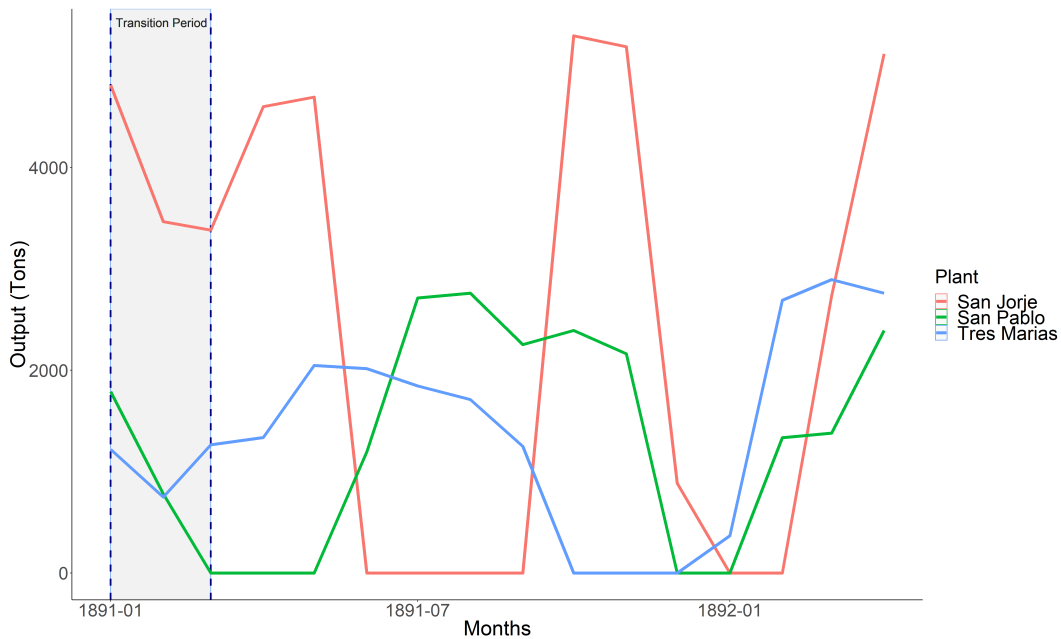
Notes: Vertical axis is output in tons. Horizontal axis is time. Transition Period is the time interval between the signature of the cartel contract and the start of collusion.

or not. However, the system also had important drawbacks. Complete shutdown of production implied that workers had to be brought back to the plant before resuming activity. Furthermore, with the time method there was no explicit aggregate production target for the industry.

To counteract the negative consequences of the time method, it was agreed that producers could opt, after the first year of the cartel, to switch to a fixed quota system.[22] Hence, during the second and third years of this cartel there were some producers using the time method while others had a fixed quota computed using the past-output method, considering output during the first year of the cartel as a reference period.[23]

Table 2.5.2 shows the results of a counterfactual simulation of the production costs the industry would have had if each plant in the industry produced its observed output in 1891, but with a constant level of output instead of using the time-method. Results indicate that the additional costs induced only by the temporal re-allocation of output within plant are very substantial (above 10%). Notice that this computation corresponds to a lower bound of the total costs, since it does

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[22]Brown (1963).
[23]NPA (1898a, p. 4).

Figure 2.5.3: Illustration of Time Method Counterfactual (Agua Santa plant)

Notes: Vertical axis is output in tons. Horizontal axis is time. Counterfactual case assumes that plants produce same total output during 1891, but that they produce it at a constant level.

not add up shutdown costs.[24] Figure 2.5.3 illustrates the re-allocation of output used to compute the counterfactual costs. Our results are further supported by the fact that in no other posterior cartel nitrate producers used the time method.

2.5.3   Third Cartel: Trial Method and Menu of Options

After the end of the Second Cartel prices of nitrate of soda experienced a sharp decline. Moreover, the existence of the NPA provided the industry for the first time with an impartial third party to lead the negotiations. Nevertheless, negotiations were long and difficult. Several drafts of the collusive agreement were circulated by the NPA before all producers could agree on a contract. The organization of the cartel could only be completed by late February of 1896, after 16 months of negotiations.[25]

The complex negotiation process translated into a collusive agreement full of intricacies and special conditions. In particular, firms could choose how to determine their collusive quotas from

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[24]However, the fact that most plants stopped operating more than once during 1891 signals that shutdown costs must have not been extremely high.

[25]NPA (1896b, p. 6)

Table 2.5.2: Counterfactual Costs Time Method

Observed costs	Counterfactual costs	Δ Costs (%)
1,831,362	1,617,994	-11.65

Notes: Observed and counterfactual costs based on cost estimations in Carrera and Titov (2019). Counterfactual costs are estimated assuming that plants produce same total output during 1891, but that they produce it at a constant level.

a menu of options:[26]

- It was established a *reference period*, going from July 1 of 1894 until July 1 of 1895.

- Plants that had been active during the reference period could opt to have their quotas set by the past-output method based on their output on that period.

- Plants that did not want to use the past-output method and new plants could use the trial method. NPA inspectors would estimate the capacity of each plant according to the output generated during a *trial period* lasting 90 days.

- Additionally, some firms decided to negotiate their quotas directly with the NPA board.[27]

- Small plants, defined as those with exports smaller than $100,000$ Spanish quintals during the reference period, would have a quota equal to their production on that period. Similarly, plants with less than $200,000$ Spanish quintals of exports during the same period would suffer only a fraction of the discount suffered by larger plants.

Interestingly, firms seem to have selected a quota allocation method in a non-strategic way. Figure 2.5.4 suggests that, at least, productivity and size are not systematically correlated to the method selected.

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[26]See Article 5 in 2.E. Appendix 2.A presents a list of the quota-allocation methods chosen by the firms.

[27]The history of the negotiations between the Lautaro Nitrate Co. (owners of the Lautaro plant) and the NPA board is illustrative. Lautaro Nitrate Co. initially demanded a quota of $1,200,000$ Spanish quintals to join the cartel. In December of 1895, after the initial demand had been accepted by the NPA, the board of this firm demanded an even larger quota of $1,500,000$ (which would be later lowered to $1,400,000$ Spanish quintals). The difference between the initial and the final demand of the company were finally absorbed as a small discount on the quotas of some other signatory firms.

Figure 2.5.4: Selection of Allocation Method in Third Cartel
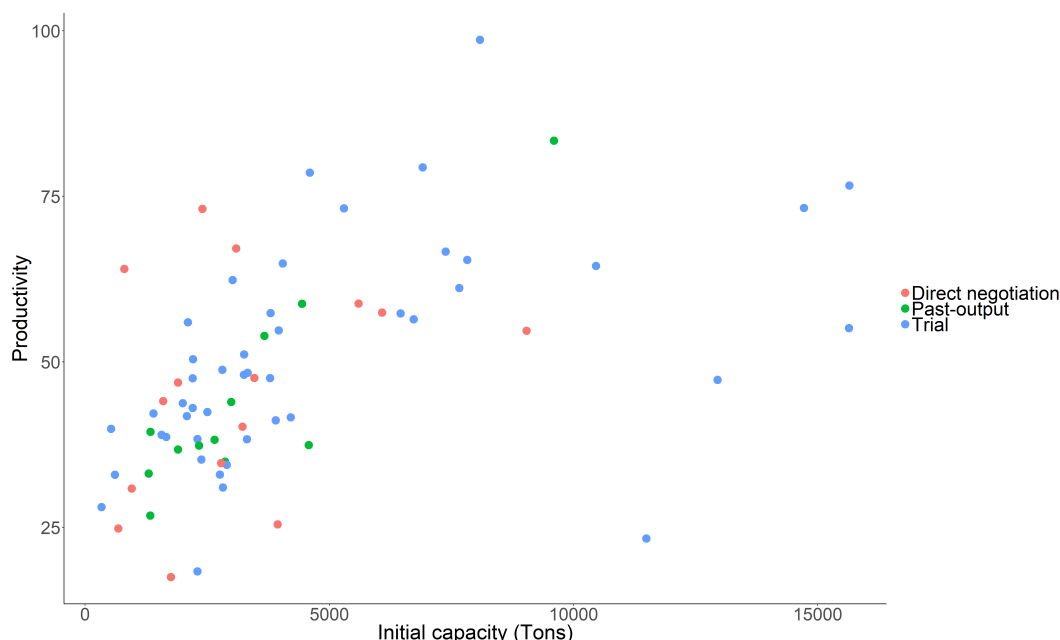
Notes: Vertical axis is productivity. Horizontal axis is the initial capacity of each plant. Productivity and initial productivity values taken from Carrera and Titov (2019).

The trial method generated an incentive for firms to produce an output as large as possible during the trial period:[28]

"Since the distribution of production quotas was to be proportional to the production capacity estimated by the work of the first three months, many plants were dragged into expanding their machinery and force production over this period of time, making crazy expenditures."

Indeed, the NPA had to quickly update its previously estimated industry wide capacity of 44, 000, 000 Spanish quintals, after the trials were conducted, to over 55, 000, 000 Spanish quintals. The surprise expressed by the NPA communications is telling about this respect:[29]

> . . . and as these figures showed production capacities largely superior to those observed
> only months ago, to the extreme of drastically changing the calculations used as refer-
> ence during the negotiations of the cartel, the [NPA] board quickly collected the new
> data, some of it truly surprising to the more knowledgeable producers of the [Atacama]
> desert, and updated its estimations to predict the export quotas during the first year

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[28]Semper et al. (1908, p. 143)
[29]NPA (1896c, p. 2).

Figure 2.5.5: Trial Method Examples (selected plants)
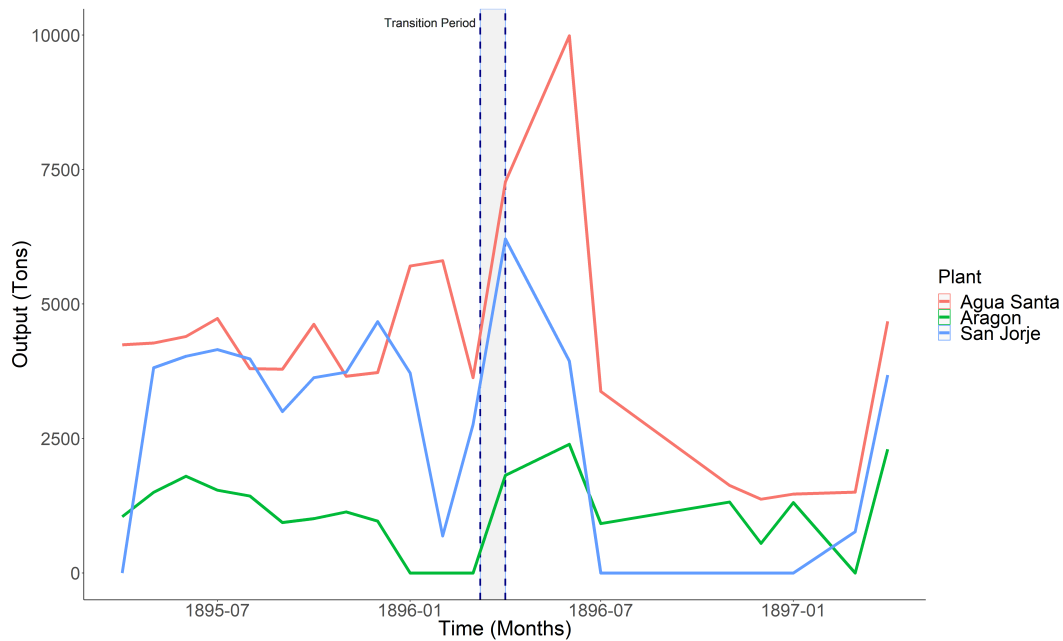
Notes: Vertical axis is output in tons. Horizontal axis is time. Transition Period is the time interval between the signature of the cartel contract and the start of collusion.

of the cartel.

One effect of the trial method was that the quotas allocated during the first year of the cartel were much smaller, as a percentage of capacity, than it was previously expected. Indeed, plants were supposed to restrict their output to only 35% of their capacity instead of the 50% of capacity that had be assumed during the negotiation of the agreement. However, since only a fraction of the firms had used the trial method, firms that had chosen the past-output method instead suffered the bulk of the reduction.

The problems described above contribute for the Third Cartel to be considered almost instantly a failure. Instead of the 3 years stipulated on the contract it lasted only for eighteen months, after an early termination clause was invoked.

Table 2.5.3 presents the counterfactual costs of the plants that used the trial method, assuming they produce the same output observed during the first year of the Third Cartel, but with a constant output level instead of using the trial method. Results show that savings of not using the trial method would have been above 20% of the observed production costs. Notice that this figure represents a lower bound, since it does not include the value of any additional investments made

Figure 2.5.6: Illustration of Third Cartel Counterfactual (Agua Santa plant)
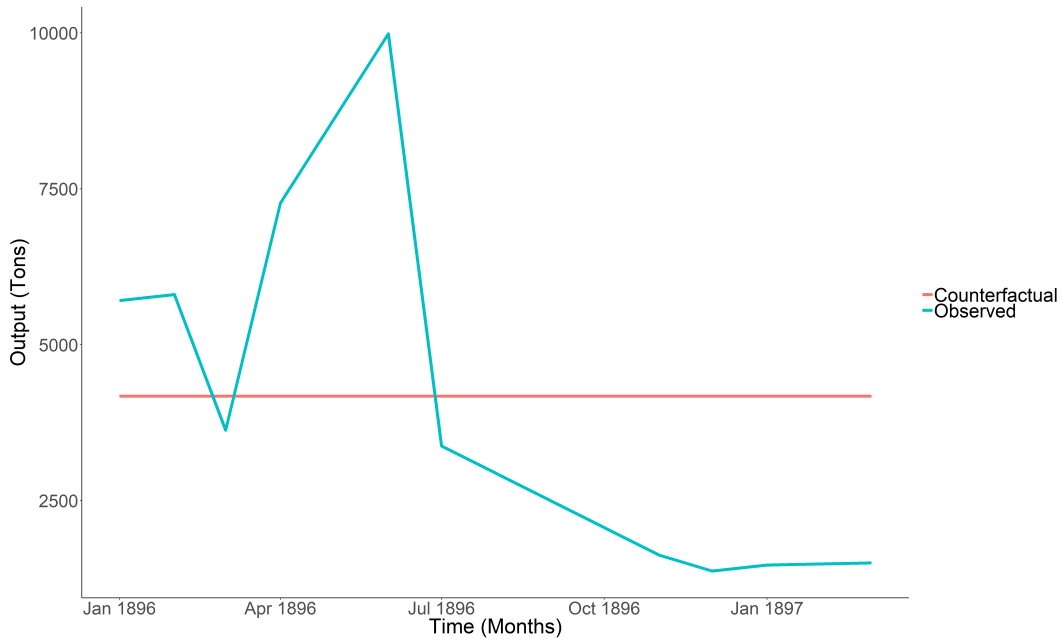
Notes: Vertical axis is output in tons. Horizontal axis is time. Counterfactual case assumes that plants produce same total output during 1891, but that they produce it at a constant level.

by the firms in order to be prepared for the trial period. Figure 2.5.6 illustrates the re-allocation of output used to compute the counterfactual costs.

Table 2.5.3: Counterfactual Costs Trial Method

Observed costs	Counterfactual costs	Δ Costs (%)
1,377,384	1,097,726	-20.3

Notes: Observed and counterfactual costs based on cost estimations in Carrera and Titov (2019). Counterfactual costs are estimated assuming that plants produce same total output during 1891, but that they produce it at a constant level.

2.5.4 Fourth and Fifth Cartels: Theoretical-capacity Method

Negotiations to resume collusion were started promptly after the collapse of the Third Cartel and a new agreement was signed in October of 1900.[30] The Fourth Cartel included several innovations.

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[30]NPA (1898b, p. 5)

The complex menu of options used in the Third Cartel was replaced by a single method for all the plants in the industry. With only a single exception, direct negotiation was abandoned as a quota allocation method, and small plants received the same proportional discount in their quotas, although they were given the chance to roll-over their quotas from one year to the next.[31]

The failure of the trial and time methods used in previous cartels motivated the re-introduction of the theoretical-capacity method in a more sophisticated version than the one used in the First Cartel.[32] The NPA board would assess the production capacity of each plant based on both its refining capacity and the nitrate content of its lands. The resulting estimation of production capacity would then remain confidential until all producers had signed the agreement. Theoretically, this procedure would force producers to only focus on the fairness of their plant's capacity assessment, instead of negotiating directly for a larger market share. On the other hand, the reputation of the NPA as a valid third party mediator would not survive if, once the market shares were finally revealed, they seemed to be arbitrary or unfair.

The Fourth Cartel was contemporaneously regarded as very successful. This is reflected in the fact that right before the expiration of the Fourth Cartel the nitrate producers agreed on extending collusion for 3 more years, in what would be the fifth nitrate cartel of this period.

Contractually, the Fifth Cartel was a continuation of the previous agreement and the main innovations regarding quota allocation were maintained and protected. In particular, when there was a risk that the negotiations of the new contract would fail, the NPA did not show any flexibility about the necessity to keep the estimated plant capacities confidential before all the firms signed the agreement and refused to negotiate directly quotas for the firms that were initially blocking the signature of the agreement.[33] At the same time, the Antofagasta Nitrate Company lost the special privilege it had during the Fourth Cartel and its quota was determined by theoretical capacity instead of by direct negotiation.

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[31]The only company that used direct negotiation was the Antofagasta Nitrate Company, which was the only company to refine the untreated nitrate ore at a central location (O'Brien, 1980).

[32]NPA (1898a, p. 4).

[33]In particular see minutes of the producers' meetings held on March 26st and 31st of 1906 (NPA, 1909)

2.5.5 Comparing Cartel Market Shares Allocation in the Nitrate Cartels

Table 2.5.4 the coefficient of variation of the ratio between the output in a reference period before the start of the cartel and the quota allocated to each plant in the industry. A higher dispersion of this ratio means that some plants were suffering a proportionally larger reduction on their output with respect to the previous competition period. In this comparison the Third Cartel has a much lower performance with respect to the theoretical-capacity method cartels, which present relatively similar levels of dispersion.

Table 2.5.4: Market Shares Allocation in Various Cartels

Cartel	Coefficient of Variation (CV)
First	0.468
Third	1.196
Fourth	0.471

Notes: Coefficient of variation is computed taking the ratio between the average output in the last year before the signature of the cartel contract and the monthly quota allocated to the plant. Computation uses a balanced panel with plants that had positive output in competitive period previous to the cartel.

2.6 Other Dimensions of Learning

This section describes other contractual dimensions over which the nitrate producers implemented innovations to improve cartel organization as they gained experience.

2.6.1 Transition to Collusion

A very acute problem that harmed the effectiveness of earlier cartels was the handling of transition from free competition to collusion. In the nitrate cartels, once a cartel contract was signed there would be a period of a few weeks or months before each firms' output had to be reduced. We will refer to this period from signature until the effective start of collusion as the *transition period.*

Their existence can be explained by the time it would take to conclude the market share allocation across producers, for the adjustments firms had to make before significantly reducing their output level, and for the already committed sales made by the colluding firms.

The existence of an unregulated transition period generated incentives detrimental for the success of a cartel. Nitrate is a storable commodity, so during the transition period consumers had an incentive to purchase the product while prices were still low. Thus, producers would be tempted to to front-load sales, causing a negative externality for the rest of the producers in the form of a reduced price effect of the cartel. We will denote this as the *preemptive cheating motive*.

The preemptive cheating motive caused the gradual introduction of transitory articles in the collusive agreements aimed at generating a smoother transition to collusion.

In the case of the First Cartel the contract did not include any clauses regarding the transition period, although they implemented a detailed procedure to verify the stocks held by each plant at the start of the cartel.[34] The result of an unregulated transition period was that producers increased their output levels in the months before the official start of the cartel. This pattern is shown in Figure 2.6.1.

Figure 2.6.2 shows the transition to collusion on the Third Cartel.[35] In this case, the preemptive cheating motive of producers was compounded by the use of the trial method that induced an additional front-loading of production. The signature of the cartel contract was immediately followed by a boom in industry output, reducing the quantity available to be allocated as export quotas, as the NPA communicated to its members:[36]

"...the excessive and anticipated exports of the month of March ...had already reduced to 20,300,000 the minimum amount of 22,000,000 [Spanish quintals], that at the time of the negotiations was expected and was used as a reference to compute the export quotas of the present nitrate year."

Interestingly, recognizing the existence of a transition problem in the First Cartel, the cartel contract had tried to solve the transition to collusion problem by fixing the total industry exports for an extended transition period that encompassed the last year of competition *before* the cartel

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[34]Comité Salitrero (1884).

[35]Notice that one of the advantages of the time method used in the Second Cartel was the absence of the need for regulating the transition period.

[36]NPA (1896c, p. 2).

Figure 2.6.1: Transition to Collusion in First Cartel
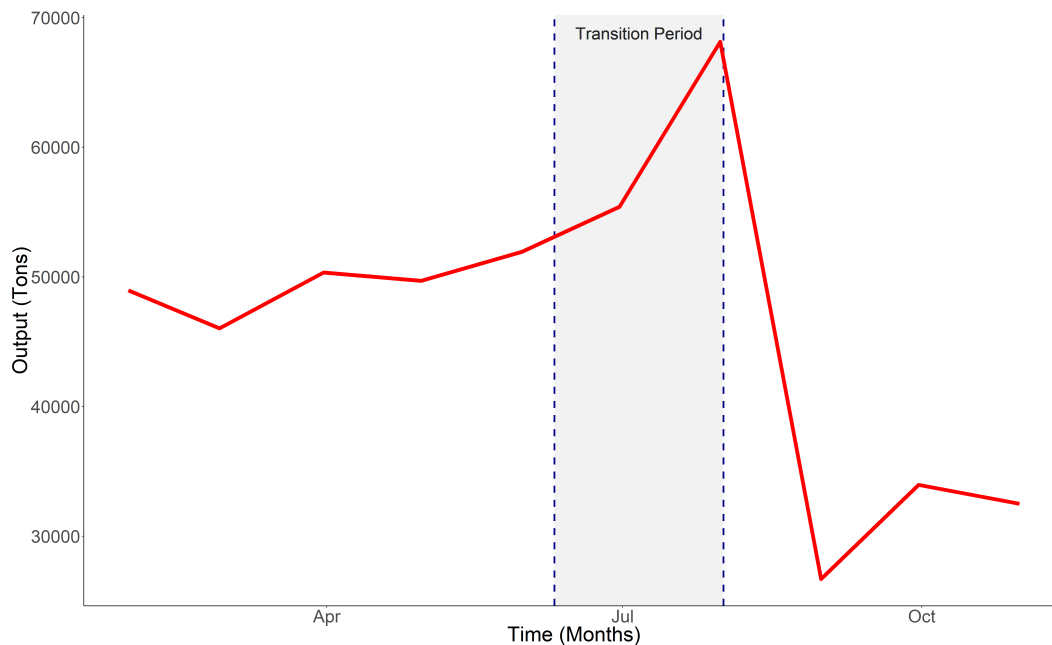
Notes: Vertical axis is output in tons. Horizontal axis is time. Transition Period is the time interval between the signature of the cartel contract and the start of collusion.

started and the first year of the cartel. However, the NPA failed to recognize that setting an aggregate upper bound did not solve the individual producer incentive problem

During the Fourth Cartel the transition to collusion problem could be handled in a more effective manner. First, the use of the theoretical capacity method had the positive feature that a larger industry output was not directly induced during the transition period as a part of the quota allocation process. Second, a transitory article in the collusive agreement established a plant-level regulation of the transition period that prevented an increase in firms' outputs. The procedure put in place consisted of three stages before the cartel became effective in April 1, 1901:

1. Plant level stocks of nitrate would be inspected on December 31, 1900. This production could be freely sold during the period from January to March (but if still unsold by April, it would be subtracted from the collusive quota).

2. Depending on the aggregate stocks resulting from the previous step, the NPA board would determined an upper bound for additional industry exports during the transition period (finally, the NPA board decided to not authorize any additional exports). This additional

Figure 2.6.2: Transition to Collusion in the Third Cartel
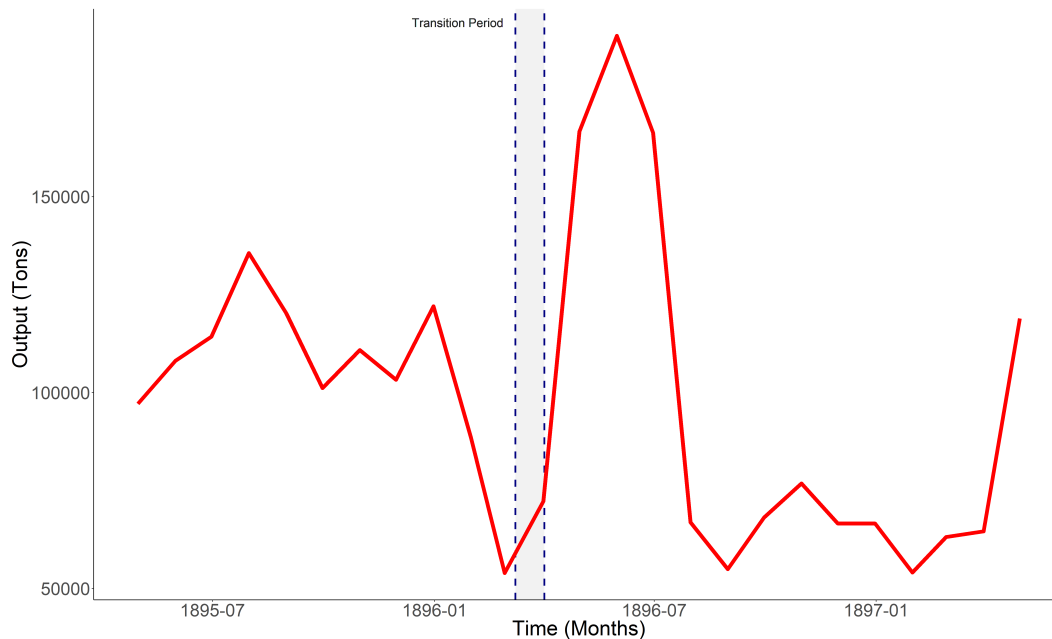
Notes: Vertical axis is output in tons. Horizontal axis is time. Transition Period is the time interval between the signature of the cartel contract and the start of collusion.

exports would be assigned to the firms based on their collusive market shares.

3. Any other amount produced by the plants during the first quarter of 1901 could only be exported after April 1 and would be counted as part of the respective collusive quota.

Figure 2.6.3 shows the industry output pattern at the beginning of the Fourth Cartel. The new mechanism implemented by the NPA that tried to fully internalized the effects of increasing production during the transition period seems to have been effective at solving the preemptive cheating motive of producers since industry output had a monotonic downward trend.

2.6.2 Flexibility For Adjustments and Duration

A long-lasting cartel, concerned about the fairness of the allocation of its collusive surplus must find a way to adjust its allocation of market shares when the relative situation of its members change with respect to their initial allocation. In the case of the nitrate cartels this challenge is interwined to the issue of cartel duration and the natural question of why nitrate producers could never implemented a permanent cartel.

Figure 2.6.3: Transition to Collusion in the Fourth Cartel
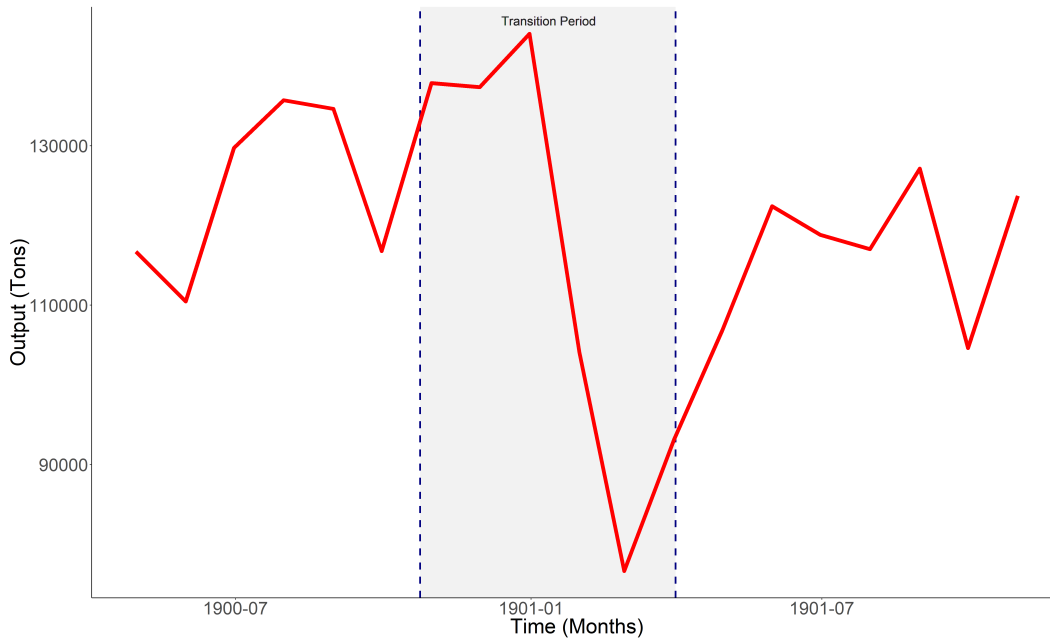
Notes: Vertical axis is output in tons. Horizontal axis is time. Transition Period is the time interval between the signature of the cartel contract and the start of collusion.

Table 2.6.1: Nitrate Cartels by Duration Characteristics

Cartel	Initial duration (months)	Effective duration (months)	Quota-allocation method (main)	Automatically renewable
First	12	29	Theoretical-capacity	No
Second	24	36	Time	No
Third	36	19	Trial	Yes
Fourth	60	60	Theoretical-capacity	No
Fifth	36	36	Theoretical-capacity	No

Cartel duration was explicitly agreed upon in the collusive contracts.[37] Table 2.6.1 presents the characteristics of the duration on the 5 nitrate cartels. Initial duration corresponds to the original duration of the agreement, effective duration is the actual time the collusion lasted, and automatically renewable refers to whether the agreement would be extended automatically and indefinitely after its initial duration had expired.

Based on this dimension of learning, we can divide nitrate cartels in two groups. The first group are the first three cartels, characterized by a slow evolution towards the establishment of a

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[37]After the Second Cartel, a specific procedure to trigger an early dissolution of the cartel was also included in the contracts. This procedure, required the agreement of an absolute majority of producers as a fraction of industry output. Only in the case of the Third Cartel, an early dissolution was discussed and approved.

permanent cartel. Earlier cartels were emergency arrangements made in order to face transitory negative demand shocks.[38] In the case of the first two cartels, duration was initially set for a short period of time (1 or 2 years) under the implicit understanding that the cartel would, at the expiration date, be renewed under the same basic collusive contract if market conditions made it desirable. However, producers were tempted by the prospect of continued cooperation and the cartel contracts they signed increasingly had the perpetuation of collusion as a concern. This trend culminated in the Third Cartel contract which incorporated a clause that made its renewal automatic (in the exact same way as the contract that created the NPA automatically renewed its charter).

On the other hand, after the failure of the Third Cartel, producers never again attempted forming permanent cartels. The last two cartels were fixed-term agreements, which implied a complete renegotiation to form a "new" cartel in case that producers wanted to extend the collusive period (as it was the case when the Fourth Cartel expired) since the default situation was the resumption of competition once their terms expired .

Moreover, the cartel duration decision is linked to the question of how to implement adjustments to collusive market shares in order to keep the allocation of surplus fair. During the first three cartels the producers were looking for adjustment mechanisms that could work in the framework of a permanent cartel, which explains in part the choices they made about what quota-allocation methods they tried: Both the time and trial methods are good solutions for keeping market shares allocation *dynamically* fair. The time method automatically transfers market shares from plants that become relatively less efficient or lose capacity to those that become more productive or increase capacity. Relatedly, the Third Cartel contract *required* that plants performed periodic trials, which would generate approximate dynamic fairness in the same manner.

On the contrary, in the last two cartels instead of having a quota-allocation method that allowed for both a fair initial allocation of market shares *and* a dynamic adjustment as conditions evolved, the NPA could now focus only on the initial allocation leaving the adjustments for the inter-cartel period (i.e., the renegotiation of the agreement). At the same time, the diminished focus on dynamic fairness allowed the producers to reduce the incentives to invest in increased capacity, by explicitly eliminating any sort of quota increases due to investments made *after* the signature of

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[38]Cruchaga (1929, p. 207) offers this interpretation for the First Cartel.

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the agreement.

2.7   Final Remarks

This paper studies whether firms learn how to better organize collusion as they gain experience. Since cartels are illegal organizations this remains an open question. To the best of our knowledge this is the first paper to be able to explore learning in relation to cartels.

To study this research question we use the case of the cartels in the Chilean nitrate industry. Between 1884 and 1909 there were five cartels in the nitrate industry. Since collusion was not illegal in Chile at the time these cartels were completely public and their rules codified in legal contracts. Moreover, there was no meaningful technological innovation in the industry. Thus, the environment where these cartels developed was static throughout the period of study.

First, a descriptive analysis of the cartels contracts show that they grew more complex and complete during the first four cartels as producers gained experience: New clauses were incorporated that addressed issues that had mined the performance of previous cartels.

We then explore the main challenge that nitrate producers faced when organizing collusion: The allocation of collusive market shares. We describe how nitrate cartels used a total of five different methods to allocate market shares and are able to show that the additional costs caused by using two methods of special interest, the time and trial methods, were very substantial and explain why they were discarded in later cartels.

Finally, we describe how nitrate cartels were able to solve the incentive problems caused by the transition from competition to collusion and the process by which the industry converged to having periodical fixed-term agreements, instead of a permanent cartel.

Our results point to a large importance of learning in the organization of cartels. Even in an advantageous setting for collusion as the nitrate industry many of the initial solutions employed by the cartelized firms were shortsighted or sub-optimal, and only through trial and error they were able to arrive to a model contract. At the same time, this paper highlights the relevance of trade associations for cartels as a repository of relevant institutional knowledge about collusion organization.

One important extension of this paper is to explore the relation between cartel leadership and

observed distortions in the allocation of collusive surplus. Specifically, exploring whether cartel organizers received a disproportionate share of collusive surplus

Appendix

Appendix 2.A   Election of Allocation Method in Third Cartel

- Past production method was used by the following plants: Cala-Cala, Carolina[39], Cruz de Zapiga, Democracia, Mercedes, Paccha, Peruana, Progreso, Rosario de Huara, San Fernando, Santa Rosa de Huara, and Sebastopol.[40]

- Quotas were determined by direct negotiations with the plants: Antofagasta, Atacama, Cholita, Julia, Lautaro, Limeñita, Paposo, Santa Ana, Santa Catalina, Santa Fe, Santa Luisa, Virginia, Vis, and Yungay Bajo.[41]

- The rest of the plants had their quotas determined by the trial method. However, some plants opted for trial method, but requested extension on the start of the trial period due to investments: Agua Santa, Angela, Aragon, Compañia, Providencia, Rosario de Negreiros, San Antonio, Santiago, Tres Marias, and Valparaiso. A second group of plants requested an extension due to other factors, which were resolved by the arbitration of mediators, as described in article 14 of the cartel contract. The plants that appealed to the resolution of the mediators in this specific case were: Aguada, Amelia, Josefina, Reducto, and Santa Isabel.[42]

- By January of 1897 the plants Agua Santa, Angela, Aragon, Compañia, Providencia, Reducto, Rosario de Negreiros, San Antonio, Santa Rita, Santiago, Serena, and Tres Marias has changes their initial capacity due to investments in refining capacity. The following plants

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[39]Note: In the text says it had been acquired by Santa Rita Company and was forming "a single plant" with Santa Rita plant.

[40]NPA (1896b, p. 6).

[41]NPA (1896b, p. 6).

[42]NPA (1896b, p. 6).

were planning on having new trial periods: Aguada, Buena Esperanza, Compañia, Jazpampa, Josefina, La Granja, Paccha, Peregrina, San Esteban, San Fernando, San Pedro, and Union.[43]

- In the fist four months of 1897, there were the following trial periods: Providencia, Serena, Reducto, San Fernando due to new investments in refining capacity, and San Jose, Santa Clara, and Puntilla de Huara as new plants starting operation. By May, the plants: La Granja, Josefina, Union, San Esteban, Aguada, and Paccha started new trial periods invoking also investments in refining facility or purchase of new nitrate lands. The plants Jazmpampa and San Pedro were about to start a new trial due to the same reason, and Huascar as a new plant.[44]

Appendix 2.B Enforcement Evidence

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[43]NPA (1897b, p. 3).
[44]NPA (1897a, p. 7).

Figure 2.B.1: Example of Threat to Intermediaries Dealing with Non-cartel Producers
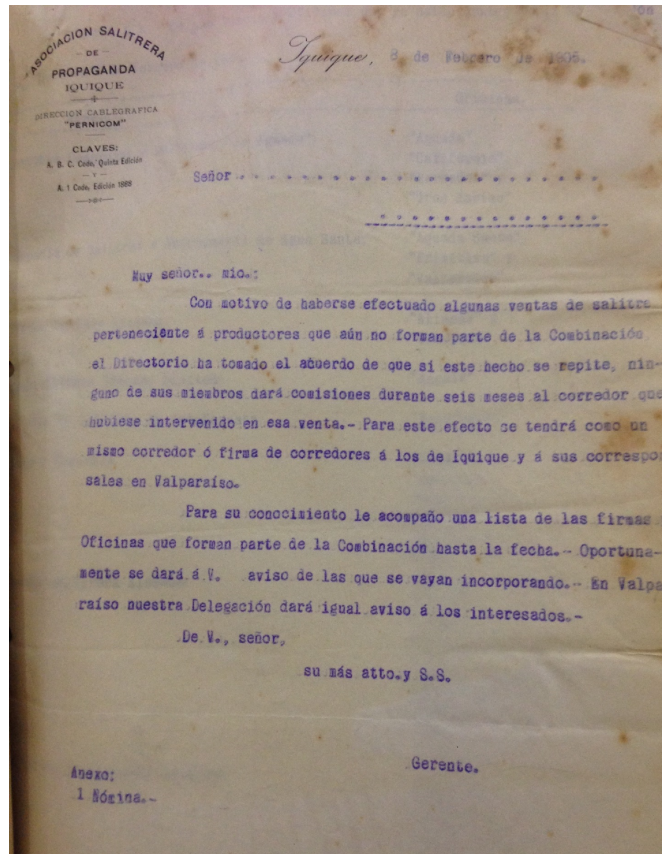
Notes: Letter dated February 8, 1905 signed by the NPA manager.
Text translation: As a consequence of some recent sales of nitrate manufactured on plants that still have not joined the nitrate cartel the [NPA] board has made the decision that, in case of this event happening again, none cartel member will do business with the broker that intervened in said sale. To this effect it will be considered as the same broker or firm both the Iquique office and its agents in Valparaiso. For your knowledge, find attached a list of the firms and plants that currently form part of the cartel. You will receive opportunely notice of those that join in the future. In Valparaiso, our representation will give the same notice to interested parties. **Source:** Vol. 96, Nitrate Collection, Chilean Historical Archives.

Appendix 2.C   First Cartel Contract

Convenio para la Formación del Comité Salitrero[45]

Artículo 1: El presente convenio tiene por objeto obligarse, por el término de un año, á [sic] no elaborar en las oficinas que en seguida se menciona i á no exportar mas [sic] cantidad de salitre que la señalada por el Comité Salitrero permanente, la cual en ningun [sic] caso podrá exceder de diez millones de quintales españoles para toda la costa.

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[45]Comité Salitrero (1884).

Los dueños de varias oficinas en actual trabajo podrán elaborar la cuota de todas sus oficinas en una sóla, pero los dueños de varias oficinas actualmente paralizadas deberán trabajar en cada una de ellas la cuota que les fuere señalada.

Es entendido que ningun elaborador podrá vender ni comprar cuota de elaboración asignada á otro.

La cuota asignada á cada oficina actualmente paralizada no se contará sino desde la fecha en que principie á trabajar.

El total de elaboración i exportación que se fijará será prorateado [sic] entre dichas oficinas, tomando por base la capacidad productora que á cada una asigna este convenio.

Las oficinas á que se refieren los incisos anteriores i su capacidad indicada son los siguientes:

(El cuadro será presentado en la reunión que tendrá lugar el próximo 10 de Junio.)

Artículo 2: Por el término de este convenio existirá en Iquique una comision [sic] de elaboradores de salitre que se denominará Comité Salitrero, con las atribuciones que mas [sic] adelante se indican.

Artículo 3: El Comité Salitrero se compondrá de nueve miembros propietarios i dos suplentes, todos esplotadores [sic] de oficinas en actual trabajo ó representantes de tales en la jestión jeneral [sic] de sus negocios.

Todas las personas que concurren á este convenio son aptas para ser miembros del Comité, sea que residan en Tarapacá, Tocopilla, Antofagasta, Aguas Blancas, Taltal ó Valparaiso.

El miembro del Comité que residiere fuera de Iquique tendrá la obligacion [sic] de atender personalmente ó de hacerse representar, en el desempeño de las atribuciones que le corresponden, por un esplotador de oficina en actual trabajo ó representante de tal en la jestion jeneral de sus negocios.

Artículo 4: Son atribuciones del Comité Salitrero:

1° Vijilar [sic] i hacer efectiva las obligaciones contraidas por el presente convenio, i representar en todo sentido los intereses de la industria salitrera.

2° Resolver, con audiencia de los interesados i previos los estudios e informes del caso, las quejas sobre falta de proporcionalidad entre la capacidad productora real de una oficina i la cuota que se le haya asignado con relacion á la cantidad total fijada para la elaboracion i exportacion, ú [sic] otras.

Si el representante de la oficina á que se refiere la resolucion del Comité sobre falta de proporcionalidad en la fijacion de la cuota, no se conformáse [sic] con ella, sin perjuicio de empezar á cumplirse dicha resolucion, podrá apelar ante la comision [sic] de peritos mencionada en el art. 7°.

No habrá recurso alguno contra la resolucion de esta segunda comision.

3° Acordar las medidas necesarias para imponer el cumplimiento de sus resoluciones i las que fueren menester para vijilar la exportacion que á cada oficina corresponda.

Las medidas de coaccion que acordáre [sic] el Comité consistirá solo en multas, que no podrán exceder de un peso por cada quintal que se exportáre [sic] de exceso sobre la cuota respectiva.

4° Fijar la cantidad con que cada oficina deba contribuir á los gastos que demande el ejercicio de sus atribuciones.

Esta contribucion [sic] se distribuirá á prorata [sic], fijándose á tanto por quintal de salitre elaborado, i no podrá exceder en ningun [sic] caso de un centavo por quintal.

El fondo para gastos del Comité se formará tambien con las multas indicadas en el número 3° de este artículo.

5° Nombrar i remover los empleados que sean necesarios para el objeto de este convenio i señalar la remuneracion [sic] que deben gozar.

6° Acordar los gastos que exija el objeto de su institucion [sic].

7° Nombrar apoderados que representen al Comité fuera de Iquique i en los lugares que sea menester que los haya.

8° Convocar á una reunion jeneral para resolver sobre los casos en los que encontráre resistencias graves en el cumplimiento de sus reglamentos i resoluciones, ó cuando la produccion [sic] de oficinas nuevas que no acepten la presente combinacion [sic] comprometan el objeto con que se forma.

9° Resolver i fijar las condiciones con que deban aceptarse las solicitudes de otras oficinas sobre ingreso á la presente combinacion.

Artículo 5: Los miembros del Comité serán nombrados, en votación secreta, por mayoría absoluta de votos, en reunion [sic] á que concurran á lo menos la mitad mas uno del total de las personas naturales ó fictícias que forman este convenio.

Su nombramiento será por un año.

Artículo 6: En la reunion jeneral del dia [sic] 10 se procederá á la eleccion [sic] del Comité permanente en la forma en que indica el artículo 5°.

En esta reunion i las demas jenerales ninguna persona podrá tener mas de dos votos, uno por sí propio i otro en virtud de un poder conferido.

Es absolutamente prohibido conferir poderes á personas que no sean salitreras ó representantes de casas elaboradoras.

Artículo 7: En la reunion indicada en el artículo anterior se elejirán ademas, á mayoría absoluta de votos, dos inspectores propietarios i dos suplentes, encargados del exámen de las cuentas i balance del fondo de gastos del Comité, i una comision de peritos compuesta de siete propietarios i dos suplentes, encargados de resolver en definitiva sobre las quejas á que se refiere el n° 2 del art. 4°.

Para la comision de peritos puede ser nombrado cualquiera que ejerza la profesion de salitrero.

En la última reunion que celebre la comision de peritos para resolver en definitiva la queja sometida á su conocimiento, tendrá voz i voto el Presidente i en su ausencia el Vice del Comité Salitrero.

Los inspectores presentarán en cada reunion jeneral un informe sobre la inspeccion que hubieren verificado.

Artículo 8: El Comité elejirá de entre sus miembros, en la primera reunion que celebre, un Presidente i un Vice-presidente que lo serán también de las reuniones jenerales i designará el órden en que deben reemplazarles los otros miembros.

Artículo 9: Toda resolucion del Comité necesita, para que se tenga por tal, que haya sido adoptada con el acuerdo uniforme de seis de sus miembros á lo menos.

Artículo 10: El plazo de un año mencionado en el primer inciso del art. 1°, solo [sic] empezará á contarse desde el dia 1° de agosto próximo.

Artículo 11: Cada tres meses, contados desde el 1° de agosto próximo, habrá una reunion

jeneral con el objeto de oir el informe de los Inspectores, deliberar sobre los asuntos que el Comité someta á su conocimiento i aprobar las cuentas del trimestre.

Artículo 12: En la reunion jeneral del tercer trimestre se deliberará sobre si se prorroga ó no por un año mas el compromiso contraido segun el presente acuerdo. El voto unánime de los asistentes á esa reunion obligará á los inasistentes.

Artículo 13: La obligación del artículo 1° con respecto á la exportacion no se refiere á la existencia de salitre que cada cual tuviera en el dia, ni tampoco á las compras á adquisiciones que se hicieren del salitre que se elabore con arreglo á este convenio.

Artículo 14: Si alguno de los que concurren al presente convenio traspasáse [sic] por cualquier causa su derecho á la oficina ú oficinas que le correspondan, el traspaso no podrá hacerse sino con la condicion expresa de que el nuevo adquiriente respetará i cumplirá las obligaciones contraidas por este convenio.

Agreement for the Formation of a Nitrate Committee[46]

Article 1: The present agreement has for object to bind [us], for the term of a year, not to produce in the plants named below and not to export a larger amount of nitrate than the one indicated by the permanent Nitrate Committee, which in any case will not exceed ten millions of quintals for all the Nitrate Coast.

The owners of several plants currently in operation will be able to produce the quotas of all of their plants in any of them, but the owners of several plants that are currently shutdown will have to produce their quotas in the same plant to which it was allocated.

It is implicit that it is forbidden to sell or buy the quota assigned to a different producer.

The quota granted to a plant currently in shutdown will not be active until it resumes operation.

The total [industry-level] quantity of production and exports that will be set, will be allocated to the plants using the production capacity estimated for each of them.

The plants alluded to in the previous subsections and their estimated capacity are the following: (The table will be shown during the meeting that will take place on June 10.)

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[46]Translated by author from Comité Salitrero (1884).

Article 2: For the duration this agreement there will be in Iquique a commission of nitrate producers, denominated as **Nitrate Committee**, with the powers stated below.

Article 3: The Nitrate Committee [board] will be composed by nine owner-members and two substitutes, all of them shall be exploiters of currently operating plants or their representatives tasked with the management of their plants [managers].
All the signatories of this agreement are fit to be members of the Committee, whether they reside in Tarapaca, Tocopilla, Antofagasta, Aguas Blancas, Taltal or Valparaiso.[47]
A member of the Committee that resides out of Iquique will be bound to attend in person or to name a deputy for the performance of his responsibilities, among the plant owners or managers.

Article 4: The attributions of the Nitrate Committee are:

1° To monitor and to make effective the commitments contracted through this agreement, and to broadly represent the interests of the nitrate industry.

2° To adjudicate, after having an audience with the interested parties and using prior studies and reports regarding the case, complaints about lack of proportionality between the true production capacity of a plant and its quota. If the representative of the plant declared his disagreement with the ruling, he will be able to appeal before the commission of experts mentioned in article 7. The ruling of this commission will not be subject to any instance of appeal.

3° To agree on the necessary measures to enforce implementation its resolutions and to monitor the exports of each plant to ensure quotas are respected. The coercitive measures will be limited to fines, which will not be larger than one Chilean peso per quintal of excess exports over the respective quota.

4° To set the amount with which each firm must contribute to finance the operation of the Committee. The contribution will be allocated proportionally, on the basis of output and it will not be larger in any case than one cent per Spanish quintal. The expense fund for the

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[47]Tarapaca, Tocopilla, Antofagasta, Aguas Blancas and Taltal correspond to localities or districts of Northern Chile where nitrate deposits are found. Valparaiso was the main commercial and financial city of Chile at the time.

Committee will also receive the fines included in section 3 of this article.

5° To name and to remove the required personnel for the objectives of this agreement and to set their wages.

6° To determine the necessary expenses for the fulfillment of its mission.

7° To name agents to represent the Committee outside of Iquique in the cities where this is required.

8° To convene a general meeting on cases in which the Committee finds resistance to its regulations and resolutions, or when the entry of new plants which refuse to join the cartel threatens the fulfillment of its objectives.

9° To decide and to set the conditions on which the applications of other plants to join the cartel will be resolved.

Article 5: The members of the Nitrate Committee [board] will be elected by secret ballot in a meeting with the presence of an absolute majority of the signatories.

They will hold office for a period of one year.

Article 6: The election of the Nitrate Committee will be done using the procedure described in article 5 during the general meeting on the 10 [of June].

On said occasion, and more generally at any general meeting, no person will be able to have more than two votes, one for his own firm and one as a representative of a second firm.

It will be absolutely forbidden to name as a representative a person that is not an owner or a manager.

Article 7: In the general meeting mentioned above will also be elected, by absolute majority of votes, two owner-inspectors and two substitutes, which will be tasked with monitoring an adequate use of the expense fund of the Committee, and a commission of experts formed by seven owners and two substitutes, charged with resolving as last instance the complaints mentioned in number 2 of article 4.

Any person with practical experience can be nominated to be part of the commission of experts.

In the meetings when the commission of experts resolve about complaints put in front of them, the President of the Committee will have voice and vote (the Vice-president in case of absence of the President).

The inspectors will present on each general meeting a report about their activities.

Article 8: The Committee will select from among its members, during its first meeting, a President and a Vice-president who will preside the general meetings and will decide the order in which the other members of the Committee will substitute them in case of absence.

Article 9: All the resolutions of the Committee will need an agreement of at least six of its members to be approved.

Article 10: The one year term mentioned in the first paragraph of article 1 will start on August 1.

Article 11: Every three months, counted from August 1, there will be a general meeting with the object to receive the report from the inspectors, discuss issues put forward by the Committee and approving the expenses of the period.

Article 12: In the general meeting of the third quarter will be discussed the extension of the present agreement for one more year. The unanimous vote of the presents will bind those that do not attend the meeting.

Article 13: The commitment made regarding the nitrate exports in article 1 do not refer to the nitrate stocks that each producer has on that day, nor to the purchases of nitrate manufactured according to the rules of this agreement.

Article 14: In the event of transferring for any reason their rights to the plant or plants they operate, the signatories of this agreement will clearly stipulate that the new owner will comply and respect all the obligations originated on this agreement.

Appendix 2.D   Second Cartel Contract

Convenio de Combinación Salitrera[48]

Los infrascritos, todos productores de salitre, convienen en formar parte de una combinacion salitrera, por el término de dos años, contados desde el 1° de Enero de 1891, con arreglo a las siguientes estipulaciones:

Artículo 1: Cada uno de los firmantes de este convenio, en el caracter [sic] en que comparece o por la sociedad que representa, conviene con los demas [sic] otorgantes, en no trabajar en sus respectivas oficinas salitreras sino siete meses en el año 1891 i [sic] se obliga del mismo modo, a suspender por completo la elaboracion [sic] por cinco meses en el mismo año en la forma siguiente: Cada productor podrá elejir [sic] los siete meses de elaboracion [sic] que le conviniese, dando un aviso anticipado por escrito de quince dias a lo menos, al consejo directivo de la combinacion, cada vez que principie o suspenda el trabajo; no pudiendo hacerse éstas operaciones sinó el 1° o 15 de cada mes. El productor que elijiere en la forma dicha los siete meses de trabajo que le convenga, deberá suspender por completo la elaboracion durante los últimos cinco meses del presente año.

Artículo 2: El número de meses que durara la elaboracion en 1892, será fijado por el Consejo Directivo de la combinacion, i sujetándose aesta fijacion, cada productor podrá elejir los meses de elaboracion en la forma y condiciones estipuladas en el artículo 1°.

Artículo 3: La suspension de trabajo se refiere únicamente a la elaboracion de salitre, pudiendo en consecuencia, extraerse y acumularse caliche durante la paralizacion de las oficinas.

Artículo 4: Los firmates de este convenio pagarán al Consejo Directivo, la cuota que este juzgue necesaria para atender a los gastos de propagación de consumo de salitre, y a los que demanden el sostenimiento y la administracion de la combinacion; no pudiendo dicha cuota exceder de medio centavo por quintal de salitre embarcado.

Artículo 5: Cualquier productor que elabore salitre fuera de los períodos a que tenga derecho segun este convenio, pagará por cada dia de esceso [sic] una multa cuyo monto será fijado en los estatutos y que ingresará a fondos comunes de la combinacion, sin perjuicio de obligarsele a

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[48]Combinación Salitrera (1891).

paralizar la elaboracion por el tiempo que corresponda.

Artículo 6: Los estatutos que por lo demas han de rejir la combinacion, serán acordados por mayoria absoluta de votos en reunion jeneral, que se celebrará con los que asistan el dia que señale el Consejo Directivo provisorio i en el local que éste determine, prévio aviso de quince dias que se publicara en dos periodicos de Iquique. Los que no asistan a esa reunion por sí o por apoderado, se obligan desde luego a someterse a los Estatutos que apruebe la mayoría de los que concurran.

Artículo 7: Los parecientes nombran a los señores J. Dawson, W. Patterson Roberson, F.G. Lomax, P.G. Pascal, J. Vernal y B. Domínguez como propietarios y el señor H.W. Sillem como suplente, teniendo cada uno facultad para hacerse representar por un reemplazante, para que desde luego compongan el Consejo Directivo provisorio de la combinacion, cuyas funciones durarán hasta que se elija el Consejo Directivo definitivo, una vez aprobados los estatutos. Se faculta a los miembros del Consejo Provisorio para que conjunta y separadamente representen a todos y a cada uno de los otorgantes judicial y extrajudicialmente, en todo lo que tenga por objeto hacer cumplir las estipulaciones de este convenio; pudiendo delegar la representación judicial, poner posiciones, decir de nulidad, constituir compromisos, nombrar árbitros y arbitradores, percibir y transijir y jurar de columnia, por sí o por el delegado.

Artículo 8: Si alguno de los que concurren al presente convenio transfiriese por cualquiera causa su derecho a la Oficina ú oficinas que les corresponda, o la diese en arrendamiento, uso, comodato, etc., o celebrase otro contrato semejante, deberá en él estipular de una manera espresa, con el nuevo adquiriente que éste respetará y cumplirá las obligaciones del presente convenio. De no hacerse así, quedará aquel personalmente obligado.

Artículo 9: Este convenio dejará de ser obligatorio desde el momento que la comision a que se refiere el artículo 10° comunique al Consejo Directivo que no ha podido llegar a un acuerdo con las compañias Agua Santa, Antofagasta, Banco Mobiliario y los señores Pedro Perfetti y José Devescovi; fijándose como plazo para este objeto hasta el 31 del presente mes.

Artículo 10: Se nombrará una comision compuesta por los señores Pedro Pascal, E.W. Vincent, Alfredo Quaest Faslem y F.G. Lomax, para que trate con los productores de salitre mencionados en el artículo anterior.

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Artículo 11: Este convenio se reducirá a escritura pública una vez que se haya llegado a un acuerdo con los productores a que se refiere el artículo 9°.

Prórroga de la Combinación Salitrera[49]

Reconvienen en continuar i formar parte de la asociacion o combinacion salitrera que fué reducida áescritura pública, el ocho de Julio de mil ochocientos noventa i uno, quedando ahora dicho convenio constituido por las estipulaciones i cláusulas que mas adelante se insertan i el cual rejirá desde el primero de Enero de mil ochocientos noventa i tres hasta el treinta i uno de de Marzo de mil ochocientos noventa i cuatro.

Artículo 1: Cada uno de los firmantes de este convenio, en el carácter en que comparece ó por la sociedad que representa, conviene con los demas otorgantes en no trabajar en sus respectivas oficinas salitreras, desde el primero de Enero de mil ochocientos noventa i tres hasta el treinta i uno de Marzo de mil ochocientos noventa i cuatro, sino en conformidad á las reglas i con las limitaciones que siguen.

Primero: Durante la vijencia de este convenio i de acuerdo con sus estipulaciones, cada productor de salitre podrá optar entre trabajar por tiempo, suspendiendo la elaboración en algunos meses del año, ó trabajar por cuota, limitando la producción á una cantidad fija de quintales españoles de salitre.

Segundo: El Directorio ó Consejo Directivo de la Combinación fijará el número de meses ó tiempo en que no pueda elaborarse salitre en las Oficinas en que se trabaje por tiempo, en mil ochocientos noventa i tres, i su fijación se tendrá desde luego como parte integrante de este convenio. Cada productor por tiempo podrá elejir los meses de elaboración que le convenga, no excediendo del número de los fijados por el Directorio, debiendo dar á este un aviso por escrito con anticipacion de quince dias á lo menos, cada vez que principie o suspenda el trabajo, sin que puedan hacerse estas operaciones sino el primero ó el quince de cada mes. El productor por tiempo que no diese aviso para el principio i continuacion de la elaboración estará obligado á paralizar luego que se complete el tiempo fijado por el Consejo para la elaboración. Esta suspension no implica la extraccion i

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[49]Combinación Salitrera (1892).

acumulación de caliche u otras obras que no sean de elaboración.

Tercero: Durante la vijencia de este convenio la elaboracion por cuota se fijará como sigue, i de acuerdo con los datos de la misma combinación, previamente comprobados.

1° Para el que hubiere trabajado por tiempo en el año de mil ochocientos noventa i dos se tomará la cantiddad elaboró durante los seis meses de trabajo del mismo año.

2° Para el que tiene cuota basada sobre el trabajo por tiempo de mil ochocientos noventa i uno se tomará la cantidad que elaboró en ese año, mas un diez por ciento; debiendo determinarse la cuota por los datos de la misma Combinación previamente comprobados. Esta cuota ó número de quintales de salitre se entenderá aumentada ó disminuida en la proporción que el Directorio aumentare ó disminuyere el número de meses ó parte de un mes de elaboración para los productores por tiempo.

El productor por cuota no tendrá derecho para elaborar en una sóla oficina, las cuotas de dos ó mas. Unicamente podran variarse las bases establecidas en este inciso mediante el acuerdo unánime de todos los miembros de la Combinación, sin perjuicio de lo establecido por el inciso segundo del mismo artículo.

Cuarto: La eleccion á que se refiere el párrafo primero de éste artículo debera hacerse, para mil ochocientos noventa i tres, antes del treinta i uno de Marzo del mismo año, por medio de una carta dirijida i entregada al Directorio de la Combinacion; entendiendose que los que no llenen éstos requisitos optan definitivamente por la produccion por tiempo.

Quinto: Una vez elejido por el productor espresa ó tácitamente el sistema de cuotas ó el de tiempo, no podrá hacer nueva elección. Pero el productor que hubiese trabajado por sistema de cuotas durante el año mil ochocientos noventa i dos, podrá elejir el de tiempo para mil ochocientos noventa i tres, i vice versa, siempre que la eleccion la haga antes del primero de Abril de mil ochocientos noventa i tres. Para hacer uso de ésta facultad, el que haya trabajado por cuota durante el año mil ochocientos noventa i dos, deberá haber dado los avisos de paralizacion i de principio de trabajo correspondientes á los tres meses anteriores al primero de Abril de mil ochocientos noventa i tres.

Sesto: Los productores por cuota podrán trabajar en la forma que mas le conviniese, sin ser limitados a periodos señalados anticipadamente.

Artículo 2: Los firmantes de este convenio pagaran al Consejo Directivo, hasta un centavo por quintal español de salitre embarcado, para que atienda á los gastos de propagación de consumo del salitre i á los que demanden el sostenimiento i la administración de la Combinación.

Artículo 3: Cualquier productor por tiempo que elabore salitre en contravencion al presente convenio ó á los acuerdos que se tomen en conformidad a él, pagará una multa de mil á quince mil pesos diarios, segun lo determine el Directorio en atención á la importancia de la Oficina; i si el infractor fuere productor por cuota, la multa será de tres pesos por cada quintal español que elaborare en exceso sobre la cuota que le corresponda, todo lo cual se entiende sin perjuicio de obligarles á cumplir el convenio. No obstante, si hubiere exceso en la elaboración de una oficina que trabaja por cuota no se impondrá multa sino cuando el exceso sea mayor que un cinco por ciento de la cuota correspondiente al año. En el caso de un aumento dentro de éste límite, se computará como parte de la elaboración del año siguiente; i solamente entonces podrá embarcarse. De igual manera, si resultare deficit en la elaboración, siempre que no pase de cinco por ciento con relación á la cuota corespondiente, habrá derecho para elaborarlo en el año siguiente. Las multas se impondrán por el Directorio, i su valor ingresará á los fondos comunes de la Combinación, principalmente con el objeto espresado en el artículo precedente. Por toda otra infraccion en las estipulaciones del convenio ó de los acuerdos debidamente tomados por el Directorio o juntas jenerales, el infractor estará obligado á una indemnización proporcionada á los perjuicios que su falta ocasionare á la asociacion; i la falta como tambien la cantidad que por ella haya de satisfacerse, será resuelta en un arbitraje de amigable composicion constituida en conformidad con las reglas establecidas en el reglamento.

Artículo 4: Si alguno de los que concurren al presente convenio trafiriese por cualquiera causa su derecho á a Oficina ú oficinas que le corresponda ó le diese en arrendamiento, uso, comodato, etcétera, ó celebrase otro contrato semejante, deberá en él estipular de una manera espresa, con el nuevo adquiriente, que este respetará i cumplirá las obligaciones del presente convenio. De no hacerse así quedará aquel personalmente obligado.

Artículo 5: Forman también parte integrante de este convenio el reglamento que mas adelante se inserta i los acuerdos que celebre el Directorio ó Consejo Directivo, como los que se tomen en

juntas jenerales, siempre que unos i otros esten conformes con las estipulaciones de esta escritura i reunan la mayoría de votos convenida.

Nitrate Cartel Agreement[50]

The undersigned, all nitrate producers, agree to be part of a nitrate cartel, for a term of two years, starting from January 1, 1891, in accordance with the following stipulations:

Article 1: Each one of the signatories agree to operate in their respective plants for seven months in the year 1891 and, at the same time they commit to completely suspend the production in the same year according to the following rules:
Each producer will be able to choose the seven months of production that are more convenient to him, giving advance notice of at least fifteen day to the board of the cartel each time that production is resumed or suspended; The only days when it will be possible to change the operational status of a plant will be the 1 and the 15 of each month. The producer that does not select in this manner seven months of production, will have to stop working during the last five months of the year.

Article 2: The number of months each plant will be able to have active production during 1892 will be set by the cartel board and, subject to that decision, each producer will be able to choose his months of operation in the same manner outlined in article 1.

Article 3: The suspension of operations refers only to the refining of nitrate. Thus, extraction and accumulation of nitrate ore is allowed during the shutdown period.

Article 4: The signatories of this agreement will pay to the cartel board the fees that the board deems necessary to promote the consumption of nitrate and to pay for the expenses caused by the administration of this agreement. This fee will no exceed half a cent per Spanish quintal of exports.

Article 5: Any producer that produces nitrate outside of the periods when he is authorized according to this agreement will pay a fine for each day of excess production whose amount will be set in the statutes. These fines will enter a common fund of the cartel and the producer will have

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[50]Translated by author from Combinación Salitrera (1891).

to suspend production to compensate for the unduly time of work of his plant.

Article 6: The statutes that are to rule the cartel will be approved by absolute majority of votes in a general meeting that will be celebrated on a day and location chosen by the provisional cartel, after a fifteen days notice that will be published in two Iquique newspapers. Producers that do not attend the meeting will have to accept the statutes that are agreed upon the assistants.

Article 7: The signatories name the Misters J. Dawson, W. Patterson Roberson, F.G. Lomax, P.G. Pascal, J. Vernal y B. Domínguez as owners and Mister H.W. Sillem as alternate, having each one of them the ability to be represented by a substitute, to compose the provisional cartel board whose functions will last until the election of a definitive cartel board once the statutes have been approved. The members of the provisional cartel board will have, jointly and separately, ample powers of legal and administrative representation.

Article 8: In the event of transferring for any reason or in any form their rights on the plant or plants they produce, or to give them in lease, use, loan, or to celebrate any other similar contract, the signatories of this agreement are expressly obligated to clearly stipulate with the new owner that he will inherit all the obligations originated on this agreement and to produce the export quota corresponding to each plant in the same plant. In contrary case the original owner will be personally liable.

Article 9: This agreement will stop being valid in the moment the commission refereed to in article 10 communicates the board that the negotiations with the companies: Agua Santa, Antofagasta, Banco Mobiliario and the Misters Pedro Perfetti and Jose Devescovi. The deadline for achieving this objective will the 31 of the present month [January].

Article 10: A commission composed by the Misters Pedro Pascal, E.W. Vincent, Alfredo Quaest Faslem y F.G. Lomax will be tasked with negotiating with the companies mentioned in article 9.

Article 11: This agreement will be transferred to a public deed as soon as a consensus has been reached with the firms mentioned in article 9.

Appendix 2.E   Third Cartel Contract

Convenio de la Combinación Salitrera[51]

Artículo 1: Los que suscriben convienen en no exportar ni elaborar Salitre de la Oficina ú [sic] Oficinas que actualmente poseen ó explotan y de las que poseyeren ó explotaren después de esta fecha y durante la vigencia del presente Convenio, sino en la cantidad ó cuota anual que le corresponda á cada Oficina en conformidad á las reglas y con las limitaciones que á continuación se expresan.

Artículo 2: El presente Convenio regirá desde el 1° de Enero de 1896 hasta el 31 de Marzo de 1899, pero si ninguno de los Asociados, diese aviso por escrito al Gerente de la Asociación, antes de seis meses de su término, que desea retirarse, continuará en vigencia por otro año y así, sucesivamente, hasta que se cumpla esa condición y así lo acordase la mayoría de las tres cuartas partes de los Asociados en Junta General convocada especialmente para ese fin.

Artículo 3: Tanto la fijación y distribución, como las modificaciones en las cuotas que correspondan anualmente á cada Oficina, serán establecidas por el Directorio de la Asociación Salitrera de Propaganda con sujeción á las prescripciones de este Convenio; y la cifra que se señale á cada Productor se tendrá como parte integrante del mismo Convenio.

Artículo 4: Se conviene con todos los Productores en que la exportación desde el 1° de Abril de 1895 hasta el 31 de Marzo de 1897 no excederá de 49.000.000 de quintales españoles; pero en el caso de que el precio del Salitre en la Costa suba á más de 6 chelines por quintal español, ley de 95 por ciento, el Directorio queda facultado para aumentar la exportación del segundo año en la cantidad que juzgare conveniente.

Será atribución exclusiva de dicho Directorio fijar la exportación en los años siguientes y modificarla según las circunstancias del mercado, pero en ningún caso podrá limitarla á menos de 23.500.000 quintales españoles en cada año.

El Directorio fijará la cantidad de la exportación de cada año á más tardar en el primer trimestre, esto es, entre el 1° de Abril y 30 de Junio y las modificaciones que acordare antes del 30 de

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[51]NPA (1896a).

Septiembre.

Artículo 5: Se tomará como base para las cuotas de embarque de cada Oficina la cifra que se acuerde para la exportación del año, de conformidad con el artículo anterior; y el Directorio distribuirá anualmente esa cantidad entre todos los Productores según las reglas siguientes:

A. Las Oficinas que hayan elaborado los doce meses comprendidos entre el 1° de Julio de 1894 y el 1° de Julio de 1895 podrán tener en el primer año la cuota proporcional por sus embarques efectivos hechos durante ese mismo período, según total comprobado por la Asociación Salitrera de Propaganda.

Las Oficinas que no se conformasen con la cuota que les correspondiere por este inciso tendrán derecho á que se les fije la que resultare después de someterse al período de prueba de la que habla el insciso siguiente.

B. Las Oficinas que no hayan trabajado durante todo el período antedicho ó que hayan comenzado á elaborar después, pero antes del 1° de Enero de 1896, tendrán en el primer año la cuota que les corresponda por la producción calculada en un período de prueba de 90 días contínuos de trabajo, debiendo paralizar después dos meses seguidos para verificar las existencias.

Este término de prueba puede ser escogido dentro del período de seis meses comprendido entre el 1° de Octubre de 1895 y el 1° de Abril de 1896, de modo que dicho término de prueba deberá terminar para todas las Oficinas, á más tardar, el 30 de Junio de 1896.

Es entendido que el término de prueba á que se someta cualquiera Oficina, sea de las comprendidas en este artículo ó en otro de este Convenio, se contará de fecha á fecha, días seguidos, sin lugar a reclamos por interrupciones en la elaboración, salvo que ésta deba suspenderse por causas de fuerza mayor, cuya calificación corresponderá al Directorio.

Para establecer la cifra de producción y la cuota de embarque á que tendrán derecho se procederá como sigue:

Antes y después de la prueba, el Directorio, por medio de Inspectores, tomará razón de las existencias de Salitre en esta forma:

Antes de la prueba:

Existencia á bordo de buques á la carga.

Existencia en bodega en puerto.

Existencia en camino al puerto.

Existencia en canchas y bateas.

Después de la prueba:

Cantidad embarcada en los cinco meses.

Cantidad adicional á la anterior sobre la cual se ha pagado flete por ferrocarril.

Cantidad en camino al puerto.

Cantidad en canchas y bateas.

Cantidad gastada en el consúmo de la Oficina.

Deducida la partida "*Antes de la prueba*" de la que resulte "*Después de la prueba*", la cantidad que quede será la elaboración total de los 90 días y, descontando de ésta la duodécima parte, se tendrá la producción neta ó efectiva para servir de base á la fijación de la cuota anual. (Ejemplo: Supóngase que en los 90 días resultaran 400.000. Deducida la duodécima parte, 33.334, quedan 366.666 ó sea 1.466.664 de producción anual; por consiguiente, la cuota de embarque será la proporcional entre esa suma y la que se fije para la exportación del año.)

C. Las Oficinas que comiencen á elaborar después del 1° de Enero de 1896 deberán someterse á un término de prueba de 90 días contínuos á contar desde dos meses después de la fecha en que principien á trabajar; y para fijar la cifra de su producción y la cuota de sus embarques en el primer año, se procederá como queda determinado en el inciso anterior.

D. Las Oficinas cuyos embarques totales en los doce meses comprendidos desde el día 1° de Julio de 1894 hasta el 1° de Julio de 1895 han sido menores de 100.000 quintales españoles, tendrán una cuota igual á la cantidad embarcada.

Las que en el mismo período han embarcado más de 100.000 quintales españoles y menos de 150.000 tendrán una cuota igual á la cantidad embarcada rebajada en el 50 por ciento de la reducción general.

Y las que en el igual período antedicho embarcaron más de 150.000 y menos de 200.000, su cuota será la cantidad embarcada reducida en un 75 por ciento de la reducción general. Las cuotas de estas Oficinas en los años siguientes serán fijadas de acuerdo con lo establecido en este inciso y con relación á lo embarcado en el año anterior.

E. Las Oficinas que por sus contratos actualmente vigentes con el ferrocarril estan obligadas á bajar una cantidad mínima de salitre y las que se hallan en condiciones tales que les impiden formar parte del Convenio, según sus estipulaciones generales, tendrán la cuota que les acuerde el Directorio por el voto unánime de todos sus miembros. A este efecto cada uno de los firmantes del presente Convenio faculta ampliamente al Directorio para fijar dicha cuota y arreglar las bases de la adhesion de ellas por convenios especiales.

F. Las Oficinas que hagan mejoras que aumenten el poder productivo de sus máquinas ó adquiriesen nuevos terrenos tendrán derecho á exigir que se constate la mayor producción, sujetándose al mismo período de prueba de que habla el inciso B de este artículo, y á que se aumente en proporción la cuota que podría corresponderles.

Artículo 6: Ninguna Oficina podrá elaborar en caso alguno más de quince por ciento en exceso de la cuota de embarque que le haya correspondido en cada año; y este exceso deberá quedar en la Costa como existencias de la respectiva Oficina para el año siguiente.

Artículo 7: Toda Oficina está obligada á someterse á un nuevo término de prueba después de cada dos años de trabajo, á contar desde el 1° de Enero de 1896 y las cuotas serán rectificadas de conformidad con el resultado de cada nueva prueba.

Artículo 8: El productor que es actualmente dueño de varias Oficinas no podrá elaborar en cualesquiera de ellas la cuota de una ó de todas sus demás Oficinas, sino la de aquella en que haya elaborado después del 1° de Enero 1894; y perderá este derecho si la máquina de la Oficina que paralice sufre despúes cualquier modificación que disminuya el poder productivo que tenía cuando dejó de elaborar y si no suspende en absoluto la extracción de caliche desde el momento mismo en que decida hacer uso de esta facultad que le otorga este inciso, según aviso que deberá dar por escrito al Gerente de la Asociación.

La Oficina que paralice á virtud del inciso anterior deberá comenzar la nueva prueba de que habla el artículo 7°, á más tardar, el 1° de Marzo del año que corresponda.

Artículo 9: Cualquier productor que exporte ó elabore en exceso de la cuota anual que le corresponda por los artículos 5° y 6° de este Convenio pagará una multa que impondrá el Directorio de la Asociación Salitrera de Propaganda de tres pesos mínimum por cada quintal español de exceso y su valor ingresará á los fondos comunes de este mismo Convenio.

Sin embargo, no habrá lugar á multa si el exceso no es mayor de 2.5 por ciento de la cuota correspondiente al año, pero este aumento se descontará de la cuota del año siguiente.

Artículo 10: Queda autorizado el mismo Directorio para nombrar los Inspectores que creyere necesarios y asignarles sueldos convenientes.

Los firmantes de este Convenio tendrán la obligación de dar a dichos Inspectores libre acceso á sus Oficinas á cualquier hora y con todas las facilidades posibles para el debido cumplimiento de su misión.

Los Inspectores ejercerán sus funciones de conformidad con el Reglamento que dictará el expresado Directorio.

Artículo 11: Para los gastos que origine este Convenio los Asociados se comprometen á pagar una contribución especial que no excederá de tres octavos de centavo por quintal español esportado y será cobrada mes á mes por la Asociación Salitrera de Propaganda.

Artículo 12: En caso que cualquier productor nuevo haya principiado á elaborar sin haber dado previamente su entera adhesión á este Convenio, el Directorio tendrá la facultad de declarar desahuciado el Convenio por la mayoría absoluta de todos sus miembros.

Artículo 13: En caso que cualquiera de los firmantes transferiese por cualquier motivo ó en cualquier forma sus derechos en la Oficina ú Oficinas en que elabora ó la diese en arrendamiento, uso, comodato ó celebrase otro contrato semejante, deberá en él expresar claramente con el nuevo adquirente que éste se obliga a cumplir las obligaciones de este Convenio y a trabajar la cuota que le correponda á cada Oficina en la misma Oficina. En caso contrario quedará aquel personalmente responsable.

Artículo 14: Toda divergencia sobre infraccion de las estipulaciones de este Convenio y toda otra dificultad cuya resolución no estuviese prevista en él será resuelta en arbitraje de amigable composición constituido en conformidad de las reglas que establecen los Estatutos de la Asociación Salitrera de Propaganda.

Nitrate Cartel Agreement[52]

Article 1: The subscribers agree not to export or produce nitrate from the plant or plants they currently own or exploit, and from those they will own and exploit after this date and during the term of this agreement, but in the amount and annual quota that to each is allocated according to the the rules detailed below.

Article 2: The present agreement will be valid from January 1, 1896 to March 31, 1899, but if none of the signatories declares in writing his desire to withdraw from the agreement in six months period before right before its conclusion, the agreement will be extended for an additional year. After this extension, the agreement could be likewise extended indefinitely for one year increments every time, if no notice of the type described above is given and three quarters of the signatories reunited in a special general meeting approve it.

Article 3: The export quotas of every plant will be set, allocated, and modified by the Nitrate Propaganda Association [NPA] board according to the rules of this agreement, and the quota that will be allocated to each producer will be considered as an integral part of this contract.

Article 4: It is agreed by all signatories that the industry export from April 1 1895 to March 31 1897 will not exceed 49,000,000 Spanish quintals. However, in the case that the nitrate price in the Nitrate Coast surpasses 6 shillings per Spanish quintal of 95 percent purity, the NPA board will have the power to increase the amount to be exported during the second year in the quantity that it deemed convenient.

The total export on each nitrate year of the agreement will be set by the board which is also authorized to modify it as a function of market conditions, as along as it is never smaller than 23,000,000 Spanish quintals.

Total exports on each nitrate year during the duration of this agreement will be determined by the

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[52]Translated by author from NPA (1896a).

board and notified to the producers during the first quarter, this is, between April 1 and June 30. Any modifications to the total exports figure will be communicated before September 30.

Article 5: To obtain the export quotas of all the plants in the agreement, the annual industry exports figure will be allocated to the producers according to the following rules:

A. Plants that have operated in the twelve months between July 1 of 1894 and July 1 1895 may choose to have during the first year of the agreement an export quota proportional to their shipments made during the same period, according to total verified by the NPA.

The plants that are not satisfied with the quota they would obtain in this manner, will have the right to obtain a different export quota by using the trial period described in the next subsection.

B. Plants that not have operated during the entirety of the period described above or that started operations afterwards but before January 1 1896, will have during the first year an export quota based on a trial period of 90 continuous working days, having to completely stop production for two consecutive months so that their nitrate stocks are verified.

When the trial period will be, can be chosen by each firm within the six months period between October 1 1895 and April 1 1896, so that the trial periods for every plant has concluded by June 30 1896.

The trial period for all plants, be those included in this article or in any other article of this agreement, will be counted using consecutive days without any kind of exceptions for interruptions in the production unless reasons of force majeure, which will be qualified exclusively by the NPA board.

To compute the production figure and the export quota the procedure will be the following:

Before and after the trial period, the board through its inspectors will verify the nitrate stocks:

Before the trial period:

Stocks on board of cargo ships being loaded.

Stocks in warehouses at the port.

Stocks on the way to the port.

Stocks in crystallizing tanks and drying floors.

After the trial period:

Nitrate production shipped during the five months.

Production (in addition to the shipped quantity) for which the railroad fee has already been paid.

Stocks on the way to the port.

Stocks in crystallizing tanks and drying floors.

Nitrate production used as input in the plant itself.

Deducting from the "*After the trial*" the "*Before the trial*" number it is obtained the total production during the trial period. Discounting from this last number the twelfth part, the resulting figure will be the effective or net production that will be used to compute the export quota of the plant.

(Example: suppose that the resulting number for the 90 days was 400,000. Deducting the twelfth part, 33,334, the resulting figure is 366,666 or 1,466,664 of estimated annual production; therefore the the export quota of this plant will be the ratio between this last figure and the total industry exports for the year.)

C. Plants that start operations after January 1 1896 will be subject to a trial period of 90 days continuous no later than two months after the date when they began operating. Its annual production and export quota will be determined using the rules described in the previous subsection.

D. Plants whose total shipments in the twelve months between July 1, 1894 and July 1, 1895 were smaller than 100,000 Spanish quintals will have an export quota equal to the quantity shipped.

Similarly, plants whose total shipments in the same period were between 100,000 and 150,000 Spanish quintals will have an export quota equal to the quantity shipped minus a deduction equivalent to 50 per cent of the general reduction.

Finally, plants whose total shipments in the same period were between 150,000 and 200,000 Spanish quintals will have an export quota equal to the quantity shipped minus a deduction equivalent to 75 per cent of the general reduction.

The quotas of these plants will be set in subsequent years according to the rules on this article and in relation to the quantity shipped in the previous year.

E. Those plants whose currently valid contracts with the railroad force them to ship a minimum amount of nitrate, and those whose current circumstances prevent to join the cartel under its general rules, will have an export quota agreed upon the NPA board by unanimous vote of all of its members. To this effect, each of the signatories agree to empower the board to set those quotas and to arrange the incorporation of these firms to the cartel using special agreements.

F. Plants that during the term of this agreement make investments in their refining facility or purchase new nitrate lands, will have the right to request a trial period, with the same characteristics as the one described in subsection B, to verify their increased annual production and to obtain a proportional increase on its export quota.

Article 6: Plants will not produce more than 15% in excess of their export quota in any nitrate year. Any production above the effective export quota of the plant will be exported in the following nitrate year.

Article 7: Starting on January 1, 1896, all plants will be forced to have a new trial period every two years of operations, and the export quotas will be rectified according to the results of each test.

Article 8: A producer who owns several plants will be able to produce their quotas in any of them, as long as the recipient plant has been operative after January 1, 1894. However, he will

lose this benefit if the refining facility of the plant that shutdowns suffers any reduction on its production capacity or if the extraction of nitrate ore is not completely stopped from the moment on which it decides to transfer its quota, by giving notice in writing to the manager of the NPA. The plant that shutdowns as part of the previous subsection must start the new trial period described in article 7 on March 1 of the respective year, at the latest.

Article 9: Any producer who exports or produces in excess of his annual quotas determined according to articles 5 and 6 of this agreement will pay a fine that will be determined by the NPA board, of a minimum of 3 Chilean pesos for each Spanish quintal of excess which will enter the common funds of the cartel.

The fine will be waived if the excess is not greater than 2 1/2% of the export quota of the respective year, but the excess exports will be deducted from the quota of the following nitrate year.

Article 10: The NPA board of directors is authorized to hire inspectors when it deems necessary and to assign them the salaries it deems appropriate.

The signatories of this agreement will be bound to give inspectors free access to their plants at any time and to provide any additional information they may require for the proper fulfillment of their mission.

The inspectors will perform their duties according to the regulations issues by the board of directors.

Article 11: For the expenses caused by this agreement, the associates commit to pay a special fee, which will not exceed three eighths of a cent per Spanish quintal exported and will be charged month by month by the Nitrate Propaganda Association.

Article 12: If any new producer starts operating without first declaring his full adhesion to this agreement, the board may declare the present agreement terminated by the absolute majority of its members

Article 13: In the event of transferring for any reason or in any form their rights on the plant or plants they produce, or to give them in lease, use, loan, or to celebrate any other similar contract, the signatories of this agreement are expressly obligated to clearly stipulate with the new owner that he will inherit all the obligations originated on this agreement and to produce the export

quota corresponding to each plant in the same plant. In contrary case the original owner will be personally liable.

Artícle 14: Any disagreement over any potential infringements of the clauses of this agreement and any other conflicts over issues not explicitly contained within this agreements will be resolved in friendly arbitration by mediators appointed in conformity to the rules established by the Nitrate Propaganda Association Statutes.

Appendix 2.F   Fourth Cartel Contract

Escrituras Públicas de la Combinación Salitrera de 1901 a 1906[53]

Artículo 1: Los que suscriben convienen en no exportar ni elaborar salitre de los terrenos que actualmente poseen ó explotan y de los que poseyeren y explotaren después de esta fecha y durante la vigencia de este Convenio, sino en la cantidad y cuota anual que, con sujeción á [sic] las reglas que se expresarán á continuación, fijará el Directorio de la Asociación Salitrera de Propaganda.
El Directorio de la Asociación Salitrera de Propaganda lo será á la vez de la Combinación Salitrera establecida por el presente Convenio en virtud de lo autorizado en el inciso IV del artículo 2° de los Estatutos de esa Asociación.
Dicho Directorio deberá ser nombrado anualmente, procediéndose á su elección conforme al artículo 9° de los Estatutos mencionados y debiendo tener lugar la primera elección en la primera Junta General ordinaria de la Asociación Salitrera.

Artículo 2: El presente Convenio regirá por cinco años forzosos desde el 1° de Abril de 1901 hasta el 31 de Marzo de 1906, salvo lo dispuesto en lo números 5° y 6° del artículo 12.

Artículo 3: La exportación total del primer año salitrero será la que señala el cuadro general de que se habla en el artículo 6°.
La exportación total en cada uno de los años salitreros siguientes será fijada por el Directorio y avisada á los productores á más tardar el 15 de Mayo de cada año; sin embargo podrá ser modificada, á más tardar, en la primera semana de Julio de cada año, si así lo acuerda un número

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[53]NPA (1900).

de asociados que represente á lo menos el sesenta y cinco por ciento (65%) del total de las cuotas de las Oficinas según el cuadro mencionado en los artículos 6° y 7°, debiendo el Directorio convocar á Junta General extraordinaria con ese fin.

Artículo 4: La exportación de cada año salitrero siguiente al primero de este Convenio no podrá fijarla el Directorio en cantidad menor que la del consumo total en los doce últimos meses comprendidos entre el 1° de Mayo y 30 de Abril.

Artículo 5: El Directorio tendrá la facultad para fijar, á más tardar, el 15 de Mayo de cada año la proporción de lo que convenga exportar en los nueve meses de Abril á Diciembre á partir desde el de 1901, pero no podrá reducirla á menos del 75% de la exportación total del año salitrero respectivo.

Artículo 6: La cuota anual de exportación que corresponde á cada Oficina en el primer año de este Convenio será asignada en el cuadro general de todas las Oficinas que se suscribirá en escritura pública adicional, la cual será considerada como parte integrante de este mismo Convenio.

Artículo 7: Dicho cuadro servirá de base para la fijación de las cuotas de exportación á cada una de las Oficinas en los cuatro años siguientes de este Convenio, salvo las modificaciones que únicamente pueden introducirse en él por la construcción de nuevas máquinas ó por el ingreso de nuevos productores conforme á lo dispuesto en el segundo párrafo del artículo 10 y á lo prescrito en los artículos 11 y 12.

Artículo 8: Tanto la fijación y distribución, como las modificaciones en las cuotas que, conforme al cuadro de que hablan los dos articulos anteriores, corresponda anualmente á cada Oficina, serán señaladas por el Directorio.
La relación ente cada cuota y el total que suma el cuadro de que habla el artículo anterior da [sic] el porcentaje que corresponde á todas y cada una de las Oficinas, sin excepción, en la cifra de la exportación general fijada conforme á los artículos 3° y 4°. (Ejemplo: Si la cuota de una Oficina es de 500.000 y el total del cuadro es 30.000.000, esa Oficina tendrá el 1.6666% como cuota en la exportación que se fije.)

Artículo 9: No se concederá durante la vigencia de este Convenio aumento de cuotas por

mejoras ó aumento de máquina, ni por mejora en la ley de los caliches, ni por la elaboración de nuevos terrenos en la máquina ó máquinas existentes, ni por construcción de nuevas máquinas en terrenos que sean propiedad de un productor al tiempo de firmar este Convenio y que hayan sido consideradas parte integrante de la Oficina al asignarse la cuota de la Oficina.

Durante la vigencia de este Convenio será prohibido en absoluto disminuir el número y cubicaje de los cachuchos, bateas y calderos de la máquina que existía al asignarse la cuota de la Oficina.

Artículo 10: El productor asociado que durante la vigencia de este Convenio adquiriese terrenos de persona que no forma parte de la Combinación y quisiera trabajarlos en una de sus Oficinas no tiene derecho para pedir nueva ó mayor cuota para la misma Oficina.

Si dicho productor construye máquina en terreno no considerado en la cuota de que goza, la de la nueva máquina se fijará como lo determina el artículo 11, pero sólo comenzará á regir desde el mes siguiente al en que se compruebe que la máquina está concluída [sic] definitivamente. El salitre que haya elaborado hasta ahora formará parte de la cuota.

Artículo 11: En el caso contemplado en el artículo anterior la cuota de exportación de la Oficina será establecida por una comisión de tres salitreros prácticos nombrados por el Directorio, los que no procederán á la apreciación sin exigir previamente del productor que señale el terreno que va á explotar.

Si el productor no acepta la cuota dentro de quince dias, ésta será fijada por un tribunal arbitral compuesto de peritos salitreros nombrados uno por cada parte, los que de común acuerdo designarán un tercero de igual categoría para que, en caso de discordia, éste falle en última instancia sin ulterior reclamo de ninguna clase. Los peritos nombrados quedarán obligados á presentar su fallo dentro de quince días, á más tardar, de recibir los datos.

Artículo 12: El Directorio tendrá la facultad de hacer arreglos con los productores nuevos que instalen Oficinas después de entrar en vigencia este Convenio, bajo las siguientes bases:

1° Cuando según el estado de adelanto de la construcción de la maquinaria lo juzgue conveniente, el Directorio nombrará una comisión compuesta de tres salitreros prácticos para que, en vista de los planos de la máquina, la parte ya instalada, estudio de los terrenos, etc., determine la cuota de exportación aproximada que debe señalarse á la nueva Oficina.

2° Si el productor nuevo declara su entera adhesión al presente Convenio y acepta dicha cuota, quedará ésta [sic] como definitiva si la máquina ha sido concluida á juicio de la misma comisión ú [sic] otra en su defecto, nombrada también por el Directorio, con arreglo á los planos estudiados previamente.

3° Si el productor nuevo declara su entera adhesión al presente Convenio y no acepta dicha cuota dentro de los quince días de habérsela comunicado en carta certificada, se someterá la cuota á arbitraje constituido conforme al artículo 11, una vez concluida la maquinaria de la Oficina.

4° La cuota del productor nuevo comenzará á regir desde el mes siguiente al en que se compruebe por la comisión del inciso 2° que la máquina está terminada definitivamente. El salitre que se haya elaborado hasta entonces formará parte de su cuota.

5° Si el productor nuevo se niega á declarar su entera adhesión al presente Convenio y á aceptar la cuota ó el arbitraje dentro de los quince días de habérsele comunicado en carta certificada la cuota señalada por la comisión, el Directorio podrá declarar desahuaciado el presente Convenio por la mayoría absoluta de todos sus miembros, previa consulta de los Asociados en Junta General convocada al efecto.

6° Si el productor nuevo se negara á entrar en arreglos ó permitir las funciones de la comisión pericial, el Directorio, previa las formalidades prescritas en el inciso 5° anterior, podrá declarar desahuciado este Convenio por la mayoría absoluta de todos sus miembros.

Artículo 13: La Oficina que no elabora su cuota ó parte de ella en el primer año salitrero pierde todo derecho de elaborar la cuota de ese año ó esa parte en el año siguiente y así sucesivamente. Sin embargo, el productor propietario de varias Oficinas podrá trabajar la cuota que les corresponde en cualquiera de ellas bajo la condición de que ninguna de las Oficinas produzca mayor cantidad que la del total de su cuota en los años de vigencia de este Convenio. Para hacer uso de esta facultad, el productor deberá dar aviso por escrito al Gerente de la Asociación, á más tardar, el 1° de Abril de cada año, de la forma como [sic] distribuirá el trabajo de sus cuotas en sus diversas oficinas.

Asimismo, las Oficinas con cuotas anuales de 90,000 quintales o menos podrán acumular sus cuotas de dos ó más años. Para hacer uso de esta concesión el productor deberá declarar por escrito al

Gerente de la Asociación, á más tardar el 30 de Junio de cada año, si opta por trabajar en el año ó acumular para el siguiente. En los años que tengan dos ó más cuotas acumuladas y que opte por trabajar, deberá expresar además el total de cuotas que elaborará en el año salitrero respectivo. Tanto en el caso del productor propietario de varias Oficinas que trabaje la cuota de una de ellas en otra, como en el caso de las Oficinas con cuotas acumuladas, no habrá derecho á elaborar en el año siguiente la parte de cuota dejada de producir en el año que haya expresado la declaración dada por el productor en cumplimiento de lo prescrito en los dos incisos anteriores.

Artículo 14: La Oficina que no exporte íntegramente su cuota en el año salitrero podrá embarcar el saldo en el año siguiente, pero sólo en el caso que lo haya elaborado en el año anterior.

Artículo 15: Ningún productor podrá elaborar en caso alguno en el año salitrero más de 15% en exceso de su cuota anual de exportación, sin incurrir en una multa de seis peniques esterlinos por cada quintal español de exceso.
Tanto dicho 15%, como lo producido de más, no podrán exportarse en dicho año y se computarán como parte de la cuota del año salitrero siguiente. El salitre usado para pólvora y consumo propio de la Oficina no forma parte de dicho 15%.

Artículo 16: Cualquier productor que exporte en exceso de la cuota anual que le corresponde pagará una multa de diez y ocho peniques esterlinos por cada quintal español de exceso, y la cantidad exportada de más se le descontará de la cuota del año salitrero siguiente.
Sin embargo, si el exceso no es mayor del 2.5% de la cuota de exportación podrá saldarse, sin incurrir en multa, por traspaso de otra Oficina que haya producido el salitre dentro de su propia cuota y no lo haya exportado, debiendo dicho transpaso ser indicado á la Gerencia de la Asociación de común acuerdo entre los interesados. Las multas expresadas en este artículo y el anterior serán impuestas por el Directorio y sus valores ingresarán á los fondos comunes de la Combinación.

Artículo 17: El Directorio nombrará comisiones que verificarán las existencia de salitre tanto en las Oficinas como en camino y en los puertos al fin de cada año salitrero.
Queda autorizado el Directorio para nombrar Inspectores cuando lo creyera necesario y asignarles los sueldos que estime conveniente. Los firmantes de este Convenio tendrán la obligación de dar á

dichas comisiones e Inspectores libre acceso á sus Oficinas con todas las facilidades posibles para el debido cumplimiento de su misión.

Los Inspectores ejercerán sus funciones de conformidad con el reglamento que dictará el Directorio.

Artículo 18: Tanto los acuerdos de las Juntas Generales como las proposiciones que el Directorio someta á la aprobación de los productores, serán obligatorios para todos los miembros de la Combinación, siempre que sean aceptados por un número de Asociados que represente, á lo menos, el 80% del total de las cuotas de las Oficinas, según el cuadro mencionado en los artículos 6° y 7°.

Artículo 19: Para los gastos que origine este Convenio, los Asociados se comprometen á pagar una contribución especial que no excederá de un cuarto de centavo por quintal español exportado y será cobrada mes á mes por la Asociación Salitrera de Propaganda.

Artículo 20: Los firmantes de este Convenio se obligan expresamente, en el evento de transferir por cualquier motivo ó en cualquier forma sus derechos en los terrenos que poseen ó exploten, ú Oficinas en que elaboran, ó de darlos en arrendamiento, uso, comodato, ó de celebrar otro contrato semejante, á estipular claramente con el nuevo adquirente que este tomará á su cargo todas las obligaciones del presente Convenio; y para que esta cláusula surta todos los efectos legales y obligue á terceros, aun [sic] cuando no se estampe tal condición en dichos contratos, los firmantes facultan para que de esta cláusula se tome razón en los Conservadores de Bienes Raíces y de Minas correspondientes como una limitación a su dominio.

Artículo 21: Todas divergencia sobre infracción de las estipulaciones de este Convenio y toda otra dificultad cuya resolución no estuviera prevista en él, será resuelta en arbitraje de amigable composición de árbitros arbitradores nombrados de entre los miembros de la Combinación uno por el Directorio y otro por el Productor divergente, y estos dos árbitros designarán de común acuerdo un tercero de igual categoría para que, en caso de discordia, éste falle en última instancia sin ulterior recurso de ninguna clase.

Artículo Transitorio

A. El Directorio de la Asociación Salitrera de Propaganda hará tomar las existencias de salitre

de todas y cada una de las Oficinas el 31 de Diciembre de 1900. Dichas existencias serán de libre exportación durante los meses de Enero á Marzo de 1901.

Es entendido que el todo ó parte de la cantidad que cada Oficina haya podido embarcar y no la haya exportado antes del 31 de Marzo de 1901, quedará por cuenta de la cuota de la Combinación de la Oficina respectiva en el primer año de este Convenio.

(Se calcula que si la exportación de los meses de Junio á Diciembre de 1900 llega a 21.000000 de quintales españoles, quedará como existencia en la Costa el 31 de Diciembre de 1900 del mismo año de 7.000.000 á 8.000.000 para exportarse libremente de Enero á Marzo de 1901, conforme con el inciso precedente.)

B. El mismo Directorio podrá disponer que se exporte durante los meses de Enero á Marzo de 1901 la mayor cantidad que estime por conveniente en vista de las necesidades del mercado. Esta mayor cantidad será señalada por el Directorio, á más tardar, en la segunda quincena de Enero de 1901, una vez conocidas las cifras de las existencias en 31 de Diciembre de 1900 y se distribuirá entre todas las Oficinas a prorrata de la cuota de exportación fijada á cada una de ellas en el cuadro de que habla el artículo 6° de este Convenio.

C. El salitre que produzcan las Oficinas en los meses de Enero a Marzo de 1901 no podrá exportarse sino después del 1° de Abril de ese mismo año y por cuenta de las cuotas de la Combinación, salvo lo prescrito en el inciso B anterior.

D. Las existencias de salitre que tengan en cualquier forma las Oficinas en la Costa el 31 de Marzo de 1901, menos las que estén á bordo de buques despachados de aduana, aunque no zarpados, formarán parte de la cuota de exportación que corresponda á cada Oficina desde el 1° de Abril de ese mismo año.

Public Deed Nitrate Cartel from 1901 to 1906[54]

Article 1: The subscribers agree not to export or produce nitrate from the grounds they currently own or exploit, and from those they will own and exploit after this date and during the term of this agreement, but in the amount and annual quota that, subject to the rules detailed below,

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[54]Translated by author from NPA (1900).

will be set by the board of the Nitrate Propaganda Association.

The board of directors of the the Nitrate Propaganda Association [**note:** NPA] will serve simultaneously as the board of the nitrate cartel established by this agreement in virtue the authorization in paragraph IV of article 2 of the statutes of that Association. Said board shall be appointed annually, its election proceeding according to article 9 of said statutes. The first election shall take place during the first ordinary general meeting of the Nitrate Association.

Article 2: The present agreement will last for five years from April 1, 1901 to March 31, 1906, except as provided in Numbers 5 and 6 of Article 12.

Article 3: Total exports during the first nitrate year[55] of this agreement will be given be the figure shown on the table mentioned in article 6.

Total exports in each of the following nitrate years will be determined by the NPA board and notified to the producers no later than May 15 of each year; however, this figure may be modified at the latest in the first week of July of each year, if so agreed by a number of producers equivalent to at least sixty-five percent of total market shares according to the table mentioned in articles 6 and 7. The board will have to convene an extraordinary general meeting for that end.

Article 4: The export of each of the successive nitrate years after the first year of the agreement will not be set by the board in a smaller quantity than that of the total consumption in the last twelve months between May 1 and April 30.

Article 5: The board of directors will have the power to set, at the latest on May 15 of each year, the fraction of the output that will be exported in the nine months from April to December of each year, beginning in 1901, but this fraction will not be smaller than 75% of the total exports of the respective nitrate year.

Article 6: The export quota of each plant in the first year of this agreement will be the one shown on the table attached to this public deed. Said table will be considered as an integral part of this agreement.

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[55]The nitrate year corresponded to the twelve months starting in April 1 and ending in March 31. The use of this specific year was given by the period of peak demand before the European harvest season from March to June of each year.

Article 7: This table will be the basis to determine plant-level export quotas for the following four years of this agreement, changes to the quotas will occur due to the construction of new plants or the entry of new producers, according to the provisions of the second paragraph of Article 10 and as prescribed in Articles 11 and 12.

Article 8: The values of the initial plant-level quotas as their annual updates due to entry, will be opportunely communicated to each firm by the board of directors.

The relation between each plant's initial quota and the total sum of initial quotas on the table previously mentioned gives the percentage [**note:** market share] that corresponds to every plant in the cartel, according to Articles 3 and 4.

(Example: If a plant's initial quota is 500,000 quintals and the total sum on the table is 30,000,000, that plant will have an export quota equivalent to a market share of 1.6666% over the industry-level quota determined by the board.)

Article 9: During the term of this agreement, quota increases will not be granted for improvements or investments in a refining facility, nor for an increase in the nitrate content of the nitrate ores, nor for the use of new lands in the existing plant or plants, nor for the construction of new plants in lands that were already owned by the producer at the time of signing this agreement and were accounted as a part of an existing plant when the quotas were determined.

During the validity of this agreement it will be completely forbidden to reduce the number and cubic capacity of the leaching tanks, crystallizing tanks and boilers of the refining facility that existed when the plant's quota was assigned.

Article 10: The associated producer that during the validity of this agreement acquired nitrate land from a person that not part of the cartel and would like to extract its nitrate ore to refine it in one of its plants, will not have the right to request a larger quota for said plant.

If a producer builds a new plant on newly acquired land which was not considered as part of any of his plants when quotas were determined, the new plant will have its quota determined as specified in Article 11. This quota will become active one month after the plant's construction has been verified as completed. The nitrate produced until that moment will be deducted from the plant's quota.

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Article 11: In the case described in the previous article, the export quota of the plant will be determined by a commission of three members with practical experience in the industry, appointed by the NPA board of directors, which will not start their assessment until the producer specifies the nitrate land to be exploited.

If a producer does not accept the quota allocated to one of his plants within fifteen days, the quota will be set by an arbitral tribunal composed by three nitrate experts. Each of the partied will appoint one expert, and then the third expert will be nominated by mutual agreement of the initial two, so that in case of a disagreement, he will make the final determination. There will not be any further appeals of any kind. The appointed experts will submit their decision within fifteen days, at the latest, after receiving the data.

Article 12: The NPA board will have the power to sign agreements with new producers who install plants after the cartel contract enters into force, under the following procedure:

1. When, given the progress in the construction of the new plant the NPA board deems it convenient, the board will appoint a commission of three expert nitrate producers to estimate using the plant's blueprints, the progress on its installation, an assessment of the quality of its nitrate lands, etc., the approximate export quota that probably will be allocated to the new plant.

2. If the new producer declares his conformity with both the cartel agreement and its the preliminary quota, the preliminary quota will be understood as the plant's definitive quota after it is ratified when the plant's construction has been concluded by the same or a new commission (also named by the board) which will use as inputs the studies previously enumerated.

3. If the new producer declares his full adhesion to this agreement but does not accept the preliminary quota within fifteen days of being notified by official letter, then the plant quota shall be submitted to arbitration according to Article 11, once the plant has been completed.

4. This quota will become active one month after the plant's construction has been verified as completed by the commission described in number 2. The nitrate produced until that moment

will be deducted from the plant's quota.

5. If the new producer refuses to declare his full adhesion to this agreement and to accept the quota or arbitration within fifteen days of being notified by official letter, the board may declare the present agreement terminated by the absolute majority of its members, after consulting all signatories in a special general meeting convened for that purpose.

6. If the new producer refuses to enter into arrangements or to allow the inspection of the commission of experts, the board, after following the procedure described in number 5 above, may declare this agreement terminated by the absolute majority of all its members.

Article 13: The plant that does not produce its quota, or part of it, in the first nitrate year of the agreement will not have the right to produce the missing quantity in the following year. The same will apply in the successive years of the agreement.

However, a producer who owns several plants will be able to produce their quotas in any of them, under the condition that none of the plants produce a quantity greater than its total quota during the duration of this agreement. To make use of this clause, the producer must give written notice to the manager of the association, no later than April 1 of each year, describing how his firm will allocate the production of their quotas among its plants.

In addition, plants with effective quotas of 90,000 quintals or less may accumulate their quotas for two or more years. To make use of this clause the producer must communicate in writing to the manager of the association, no later than June 30 of each year, if he chooses to work during the current year or to accumulate for the next. In the years a producer will produce two or more accumulated quotas, he must also express the total number of quotas that will be used in current nitrate year.

Article 14: The plant that does not fully export its quota in a nitrate year will be able to export the balance in the following year, on the condition that the nitrate was produced in the preceding year.

Article 15: Plants will not produce more than 15% in excess of their annual export quota in any nitrate year. Each Spanish quintal of excess production over this threshold will be fined with

six pennies sterling.

Any production above the export quota of the plant will be exported in the following nitrate year and deducted from that nitrate year's export quota. The nitrate used to manufacture gunpowder and other uses related to production will not be counted as part of said 15% margin.

Article 16: Any producer who exports in excess of his annual export quota will pay a fine of eighteen pennies sterling for each Spanish quintal of excess, and the excess exports will be deducted from the quota of the following nitrate year.

However, if the excess is not greater than 2 1/2% of the export quota, this situation may be settled without incurring a fine if a second plant that has not yet completed its export quota yields a fraction of it, of equal amount as the excess exports, to the first plant. This transaction shall be communicated to the management of the association.

The fines described in the current and the previous articles will be imposed by the board and will enter the common funds of the cartel.

Article 17: The board will appoint commissions that will verify nitrate stocks in the plants, roads, and ports at the end of each nitrate year.

The NPA board of directors is authorized to hire inspectors when it deems necessary and to assign them the salaries it deems appropriate.

The signatories of this agreement will be bound to give both commissions and inspectors free access to their plants and to provide any additional information they require for the proper fulfillment of their mission.

The inspectors will perform their duties according to the regulations issues by the board of directors.

Article 18: All the decisions made during a general meeting and the suggestions the NPA board submits for the producers' approval will be mandatory for all cartel members, as long as they are accepted by a number of members equivalent to, at least, 80% of total market shares according to the table mentioned in articles 6 and 7.

Article 19: For the expenses caused by this agreement, the associates commit to pay a special fee, which will not exceed a quarter of a cent per Spanish quintal exported and will be charged month by month by the Nitrate Propaganda Association.

Article 20: In the event of transferring for any reason or in any form their rights in the land they own or operate, or plants in which they produce, or to give them in lease, use, loan, or to celebrate any other similar contract, the signatories of this agreement are expressly obligated to clearly stipulate with the new owner that he will inherit all the obligations originated on this agreement; and in order for this clause to have all the legal effects and bind third parties, even if such conditions are not stated in said contracts, the signatories authorize that this clause be transmitted to the corresponding Real Estate Conservators and Mines Conservators as a limitation to their domain.

Article 21: Any disagreement over any potential infringements of the clauses of this agreement and any other conflicts over issues not explicitly contained within this agreements will be resolved in friendly arbitration by mediators appointed from the members of the cartel, one by the NPA board and another by the disaffected producer. These two mediators will designate of common agreement a third arbitrator so that, in case of disagreement among each other, this third arbitrator will make a last instance decision without ulterior appeal of any class.

Transitory Article:

A. The board of the Nitrate Propaganda Association will measure the nitrate stocks of every plant on December 31, 1900. These stocks can be freely exported during the months between January to March of 1901.

   The nitrate stocks that have not been exported before March 31, 1901, will be deducted from the respective plant quota during the first nitrate year of this agreement. (It is estimated that if the exports between June and December of 1900 reach 21,000,000 of Spanish quintals, there will be total stocks in the Nitrate Coast of about 7,000,000 to 8,000,000 to be freely exported from January to March 1901, according to the previous clause.)

B. The same board will decide the maximum amount to be exported in addition to the stocks enumerated in the previous subsection during the months of January to March, 1901. This quantity will be determined based on current market conditions.

   The decision regarding the additional amount to be exported will be communicated by the board in the second half of January of 1901, once the stocks measured on December 31, 1900

are known, and will be allocated among all the plants in proportion to their export quotas as expressed on the table mentioned in article 6 of this agreement.

C. The nitrate produced by the plants in the months of January to March of 1901 will not be exported until after April 1 of that same year and will be deducted from the cartel quotas, except as prescribed in subsection B above.

D. Nitrate stocks stored in any form at the plants of the Nitrate Coast on March 31, 1901, with the exception of those on board of ships that have cleared customs but not yet sailed, will be deducted from the export quota corresponding to each plant from on April 1 of that same year.

Appendix 2.G   Fifth Cartel Contract

Escrituras Públicas de la Combinación Salitrera de 1906 a 1909[56]

Artículo 1: Los que suscriben convienen en no exportar ni elaborar salitre de los terrenos que actualmente poseen ó explotan i [sic] de los que poseyeren i esplotaren [sic] de esta fecha i durante la vijencia [sic] de este Convenio, sino en la cantidad i cuota anual que con sujecion a las reglas que se espresarán [sic] a continuación, fijará el Directorio de la Asociación Salitrera de Propaganda. El Directorio de la Asociación Salitrera de Propaganda lo será á la vez de la Combinación Salitrera establecida por el presente Convenio en virtud de lo autorizado en el inciso cuarto del artículo segundo de los Estatutos de esa Asociacion [sic]. Dicho Directorio deberá ser nombrado anualmente, procediéndose á su elección conforme al artículo noveno de los Estatutos mencionados.

Artículo 2: El presente convenio rejirá [sic] por tres años forzosos desde el 1° de Abril de 1906 hasta el 31 de Marzo de 1909, salvo lo dispuesto en el inciso 2° del artículo 7°.

Artículo 3: La esportacion [sic] total en cada uno de los años salitreros será fijada provision-almente por el Directorio i avisada a los productores a mas [sic] tardar el 15 de Mayo. Esta cifra podrá ser aumentada a mas tardar en la primera semana de Julio de cada año, si así lo acuerda un

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[56]Semper et al. (1908, p. 321).

número de asociados que represente a lo menos el 65% del total de las cuotas de las Oficinas, segun [sic] el cuadro mencionado en los artículos 6°, debiendo el Directorio convocar a Junta Jeneral [sic] estraordinaria [sic] con ese fin. Si no hai [sic] la mayoría requerida, quedará como definitiva la cifra provisional.

Artículo 4: La esportacion de cada año salitrero no podrá fijarla el Directorio en cantidad menor que la del consumo total en los doce últimos meses comprendidos entre el 1° de Mayo y 30 de Abril.

Artículo 5: El Directorio tendrá la facultad para fijar, a mas tardar el 15 de Mayo, la proporción de lo que convenga exportar en los nueve meses de abril a diciembre, pero no podrá reducirla a ménos [sic] del 75% de la esportacion total del año salitrero respectivo.
Los saldos a que se refiere el artículo 14 no estarán sujetos a esta restriccion [sic]. Para la liquidacion [sic] de lo esportado por dicha proporcion se seguirán las reglas establecidas en el artículo 15 para determinar las existencias a bordo.

Artículo 6: Se formará un cuadro jeneral de las cuotas convenidas para sus oficinas con cada productor, que se suscribirá en escritura pública adicional, la cual será considerada como parte integrante de este convenio.
Dichas cuotas iniciales servirán de factor para la liquidación de la cuota efectiva de cada Oficina en cada uno de los años de la Combinación en esta forma:
Deducidas de la cifra jeneral de esportacion que se acuerde para el año respectivo, las cantidades necesarias, como provision para las cuotas que se calcule, se darán en el año por la construcción de nuevas Oficinas o por el ingreso de nuevos productores i tomados en consideracion los saldos por esportar del año anterior, i agregado lo que se estime dejarán de elaborar o esportar algunas Oficinas, se tendrá el saldo realmente prorrateable.
La relacion [sic] entre esta cantidad i el total de las cuotas iniciales dará el porcentaje de rebaja o aumento que corresponderá en ese año a todas i cada una de las Oficinas i aplicado ese porcentaje a la cuota inicial se llegará a la cuota anual efectiva de cada una de ellas.
Ejemplo: supongamos que el total de las cuotas iniciales sea de 60.000.000 de quintales i que la cuota jeneral de esportacion sea de 40.000.000 de quintales i se estime que hai que hacer provision para

nuevas oficinas i para saldos sobrantes del año anterior [de] 5.000.000 de quintales, quedarian [sic] 35.000.000 de quintales. Si se agrega a este saldo lo que se calcula que no alcanzarán o no podrán elaborar o esportar algunas oficinas [de] un millon de quintales, quedarían para ser prorrateados 36.000.000 de quintales.

Hecha la relacion entre esta cifra i los 60.000.000 de quintales, se ve que representa el 60%; luego la rebaja jeneral es de 40%, que aplicada a una Oficina cuya cuota fuera, digamos de 1.200.000 quintales, su cuota efectiva resultaria [sic] ser de 720.000 quintales.

Queda el Directorio facultado para liquidar i distribuir las cuotas en conformidad a las disposiciones de los incisos anteriores.

Artículo 7: El Directorio queda ampliamente facultado para hacer arreglos con nuevos salitreros para su adhesion [sic] a este Convenio.

Si el productor nuevo se niega a entrar en arreglo con el Directorio o [sic] adherirse por escritura pública a la Asociación Salitrera de Propaganda i a la Combinación Salitrera, el Directorio podrá declarar desahuciado el presente Convenio por la mayoría absoluta de todos sus miembros, previa consulta de los asociados en Junta Jeneral convocada al efecto.

Artículo 8: Toda nueva Oficina sufrirá desde el primer año de su elaboración la misma rebaja del tanto por ciento que corresponda en ese año a las cuotas iniciales de las demás oficinas i la cuota así rebajada solo rejirá por la parte proporcional de los meses que faltan del año.

Las cuotas se asignan por años salitreros, o sea desde el 1° de Abril al 31 de Marzo.

La cuota de toda oficina nueva comenzará a rejir desde el mes siguiente al en que se compruebe por una comisión designada por el Directorio, que la máquina está concluida definitivamente. El salitre que [se] haya elaborado hasta entonces forma parte de la cuota.

Ejemplo: Una Oficina que recibe como cuota inicial 1.200.000 quintales españoles i en ese año la reduccion [sic] jeneral es de 40%, su cuota [e]fectiva [sic] será de 720.000 quintales, i en caso de estar definitivamente instalada su máquina en el curso mayo [sic], rejirá desde el 1° de junio [sic], o sea por diez meses, lo que le daria [sic] derecho a esportar 600.000 quintales.

Artículo 9: Si un productor asociado construye máquina en terreno no considerado en la cuota de su oficina o de cualquier otra, la de la nueva oficina se fijará i rejirá en la forma determinada en

los artículos 7° i 8°.

Artículo 10: No se concederá durante la vijencia de este Convenio aumento de cuotas por mejoras o aumento de máquina, ni por mejora en la lei de los caliches, ni por la elaboración de nuevos terrenos en la máquina ó máquinas existentes, ni por construcción de nuevas máquinas en terrenos que sean propiedad de un productor al tiempo de firmar este Convenio i que hayan sido considerados parte integrante de la Oficina al asignarse la cuota.

Durante la vijencia de este Convenio será prohibido en absoluto disminuir el número y cubicaje de los cachuchos, bateas i calderos de la máquina que existia al asignarse la cuota de la Oficina.

Artículo 11: La Oficina que no elabora su cuota ó parte de ella en el primer año salitrero pierde todo derecho de elaborar la cuota de ese año ó esa parte en el año siguiente i así sucesivamente.

Sin embargo, el productor propietario de varias Oficinas tendrá la facultad de trabajar las cuotas que correspondan a cada una de sus oficinas indistintamente en cualquiera de ellas.

Se esceptúan de esta concesion las oficinas que adquiera por compra, traspaso o cualquiera otro concepto, o tome en arriendo, uso o comodato, a partir del 1° de Julio de 1905 i durante la vijencia de este Convenio, las que deberán ser trabajadas i sus cuotas liquidadas separadamente.

Igualmente toda nueva Oficina que ingrese a la Combinacion deberá trabajar i se le liquidará separadamente su cuota.

Las oficinas con cuotas iniciales de 300.000 quintales, o ménos [sic], podrán acumular sus cuotas de esportacion de dos o mas años.

Para hacer uso de esta concesion el productor deberá declarar por escrito al Jerente de la Asociacion, a mas tardar el 15° de Abril de cada año, si opta por trabajar en el año o acumular para el siguiente.

En los años que tenga dos o mas cuotas acumuladas i que opte por trabajar, deberá espresar ademas el total de cuotas que elaborará en el año salitrero respectivo.

No habrá derecho a elaborar en el año siguiente la parte de [la] cuota dejada de producir en el año que haya espresado esta declaracion.

La Oficina que acumule su cuota en la forma dispuesta en el inciso anterior deberá trabajarla en la misma Oficina, no siendo permitido traspasarla o hacerla en otra, aunque sea del mismo productor.

Artículo 12: Ningún productor podrá elaborar en caso alguno en el año salitrero más del quince por ciento en exceso de su cuota anual de esportacion, sin incurrir en multa de seis peniques esterlinos por cada quintal de exceso.

Tanto dicho quince por ciento, como lo producido demas [sic] no podra esportarse en dicho año i se computarán como parte de la cuota del año salitrero siguiente.

El salitre usado para pólvora i consumo propio de la Oficina no forma parte de dicho quince por ciento.

Artículo 13: Cualquier productor que esporte en exceso de la cuota anual que le corresponde pagará una multa de diez i ocho peniques esterlinos por cada quintal español de exceso, i la cantidad exportada de mas se le descontará de la cuota del año salitrero siguiente.

Igual multa pagará el que esporte el exceso de la cantidad fijada a su Oficina como máximum [sic] de esportacion en los meses de abril a diciembre de cada año.

Sin embargo, si el exceso no es mayor del dos i medio por ciento de la cuota de esportacion, podrá saldarse sin incurrir en multa por traspaso de otra Oficina que haya producido el salitre dentro de su propia cuota i no lo haya esportado, debiendo dicho transpaso ser indicado a la Jerencia de la Asociacion de comun acuerdo entre los interesados.

Las multas expresadas en este artículo i el anterior serán impuestas por el Directorio i sus valores ingresarán a los fondos comunes de la Combinación.

Artículo 14: La Oficina que no esporte íntegramente su cuota en el año salitrero podrá embarcar el saldo en el año siguiente, pero sólo en el caso de que lo haya elaborado en el año anterior.

Artículo 15: El Directorio nombrará comisiones que verificarán las existencia de salitre tanto en las Oficinas como en camino i en los puertos al fin de cada año salitrero.

Para esta operacion se considerará como existencias las cantidades que estén a bordo de vapores o buques que no hayan salido definitivamente de los puertos de la Zona Salitrera por no haber completado su cargamento, pero si dichas naves han contemplado su cargamento i tienen el despacho de aduana, se considerará este salitre como esportado, aunque el buque no haya zarpado.

En el caso de no ponerse de acuerdo la comision con el productor con respecto al monto de las

existencias, el Directorio tendrá la facultad de nombrar una nueva comision cuyo fallo será definitivo.

Artículo 16: Queda autorizado el Directorio para nombrar inspectores cuando lo creyera necesario i asignarles los sueldos que estime conveniente. Los inspectores ejercerán sus funciones de acuerdo con el reglamento que dictará el Directorio.

Artículo 17: Los firmantes de este Convenio tendrán la obligacion de dar a las comisiones e inspectores de que hablan los dos artículos anteriores libre acceso á sus Oficinas i bodegas, donde tengan depositado su salitre, con todas las facilidades posibles para el debido cumplimiento de su misión.

Artículo 18: Tanto los acuerdos de las Juntas Jenerales como las proposiciones que el Directorio someta a la aprobación de los productores, o la modificacion de cualquiera parte de este Convenio, serán obligatorios para todos los miembros de la Combinacion, siempre que sean aceptados por un número de Asociados que represente, a lo ménos, el 85% del total de las cuotas de las Oficinas, según el cuadro mencionado en el artículos 6°.

Artículo 19: Para los gastos que orijine este Convenio los Asociados se comprometen a pagar una contribucion especial que no excederá de un cuarto de centavo por quintal español exportado i será cobrada mes á mes por la Asociación Salitrera de Propaganda.

Artículo 20: Los firmantes de este Convenio se obligan espresamente en el evento de transferir por cualquier motivo o en cualquier forma sus derechos en los terrenos que poseen o explotan, u oficinas en que elaboran, o en caso de darlos en arrendamiento, uso, comodato, o de celebrar otro contrato semejante, a estipular claramente con el nuevo adquirente que éste tomará á su cargo todas las obligaciones del presente Convenio, i para que esta claúsula surta todos los efectos legales i obligue a terceros, aun [sic] cuando no se estampe tal condición en dichos contratos, los firmantes facultan para que de esta claúsula se tome razon en los Conservadores de Bienes Raices i de Minas correspondientes, como una limitacion de su dominio.

Artículo 21: Toda diverjencia sobre infraccion de las estipulaciones de este Convenio i toda otra dificultad cuya resolucion no estuviese prevista en él, será resuelta en arbitraje de amigable

composición de árbitros arbitradores nombrados de entre los miembros de la Combinación, uno por el Directorio i otro por el Productor divergente, i estos dos árbitros designarán de común acuerdo un tercero de igual categoría para que, en caso de discordia, éste falle en última instancia sin ulterior recurso de ninguna clase.

En caso de negarse alguno de los árbitros a concurrir a las decisiones del Tribunal o a firmar la sentencia, las decisiones i sentencia que pronuncien los otros dos serán válidas.

Public Deed Nitrate cartel from 1906 to 1909[57]

Article 1: The subscribers agree not to export or produce nitrate from the grounds they currently own or exploit, and from those they will own and exploit after this date and during the term of this agreement, but in the amount and annual quota that, subject to the rules detailed below, will be set by the board of the Nitrate Propaganda Association.

The board of directors of the the Nitrate Propaganda Association [**note:** NPA] will serve simultaneously as the board of the nitrate cartel established by this agreement in virtue the authorization in paragraph IV of article 2 of the statutes of that Association. Said board shall be appointed annually, its election proceeding according to article 9 of said statutes.

Article 2: The present agreement will last for five years from April 1, 1906 to March 31, 1909, except as provided in subsection 2 Article 7.

Article 3: Total exports on each nitrate year during the duration of this agreement will be determined by the NPA board and notified to the producers no later than May 15 of each year. The total exports quantity may be increased at the latest in the first week of July of each year, if so agreed by a number of producers equivalent to at least sixty-five percent of total market shares according to the table mentioned in article 6. The board will have to convene an extraordinary general meeting for that end. If the required majority is not reached, the figure proposed by the NPA board will remain as definitive.

Article 4: The total export on each nitrate year of the agreement will not be set by the board in a smaller quantity than that of the total consumption in the last twelve months between May 1

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[57]Translated by author from Semper et al. (1908).

and April 30.

Article 5: The board of directors will have the power to set, at the latest on May 15 of each year, the fraction of the output that will be exported in the nine months from April to December of each year, but this fraction will not be smaller than 75% of the total exports of the respective nitrate year. If a plant has not fully exported its quota during a nitrate year and decides to export it in the following year (as described in article 14), the restriction on this article will not affect the transferred amount from the previous nitrate year. The amount exported under this clause will be determined following the rules in article 15.

Article 6: A table, summarizing all plant-level initial exports quotas will be published. This table will be considered as an integral part of this agreement.

The table with the initial export quotas will be the basis to determine the export quotas in the following years of the agreement in the following manner: By deducting from the total quantity to be exported in each nitrate year, the quantities deemed likely to be allocated to new plants and firms, and considering the amount that will be exported from unfulfilled quotas from previous years and the quantities that probably will not be produced or exported by some plants, the total exports quantity that can be in practice be allocated among the producers will be obtained.

The ratio between the sum of the initial export quotas and the quantity available to be allocated among the producers each year will correspond to the discount that will be used to compute the effective export quota of every plant.

Example: assuming that the total sum of initial quotas is 60,000,000 quintals, the industry quantity to be exported corresponds to 40,000,0000 quintals, and it is estimated that 5,000,000 must be reserved for quotas of new plants and unfulfilled quotas from the previous year, 35,000,000 quintals would remain. If to this number we add one million quintals, which is the estimated quantity that existing plants will not be able to produce during the current year, there are in total 36,000,000 quintals to be allocated among the producers in the current period.

Taking the ratio between this figure and the total sum of initial quotas, the quantity to allocate corresponds to 60% of the initial quotas. Thus, a plant with an initial quota, for instance, of 1,200,000 quintals will have an effective quota of 720,000 quintals.

The NPA board will have the power to compute and allocate the quotas according to the previous

clauses.

Article 7: The NPA board will have broad powers to make agreements with new producers in order to incorporate them to the cartel.

If the new producer refuses to negotiate with the NPA board, or to join by public deed to the Nitrate Propaganda Association and to the nitrate cartel, the board may declare the present agreement terminated by the absolute majority of its members, after consulting all signatories in a special general meeting convened for that purpose.

Article 8: Every new plant will experience from its first year of operation the same discount between initial and effective quotas that applies to all already existing plants, and during its first year of operation will enjoy an effective export quota proportional to the remaining fraction of the year at the moment it becomes fully operational.

Export quotas are allocated according to nitrate years, which go from April 1 to March 31.

The quota of every new plant will become active one month after the plant's construction has been verified as completed. The nitrate produced until that moment will be deducted from the plant's quota.

Example: A plant that obtains an export quota of 1,200,000 Spanish quintals and starts operation in a year when the general discount is 40% will have an effective export quota will be 720,000. If its construction is completed in the month of May its quota would become active in the month of June, meaning that the plant will receive ten months of its effective quota, ending with a right to export 600,000 quintals during its first year of operation.

Article 9: If an associated producer builds a plant on nitrate lands that have not been included among the feeding grounds of any other of its plants, the export quota of the new plant will be determined as explained in articles 7 and 8.

Article 10: During the term of this agreement, quota increases will not be granted for improvements or investments in a refining facility, nor for an increase in the nitrate content of the nitrate ores, nor for the use of new lands in the existing plant or plants, nor for the construction of new plants in lands that were already owned by the producer at the time of signing this agreement and were accounted as a part of an existing plant when the quotas were determined.

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During the validity of this agreement it will be completely forbidden to reduce the number and cubic capacity of the leaching tanks, crystallizing tanks and boilers of the refining facility that existed when the plant's quota was assigned.

Article 11: The plant that does not produce its quota, or part of it, in the first nitrate year of the agreement will not have the right to produce the missing quantity in the following year. The same will apply in the successive years of the agreement.

However, a producer who owns several plants will be able to produce their quotas in any of them. This option will not be available for plants that were bought, loaned, or leased after July 1, 1905 and during the validity of this agreement. These plants will have to produce their effective quotas individually.

Likewise, every new plant that enters the cartel will have to produce their effective quotas individually.

In addition, plants with initial quotas of 300,000 quintals or less may accumulate their quotas for two or more years.

To make use of this clause the producer must communicate in writing to the manager of the association, no later than April 15 of each year, if he chooses to work during the current year or to accumulate for the next.

In the years a producer will produce two or more accumulated quotas, he must also express the total number of quotas that will be used in current nitrate year.

If the producer declared that he would produce a given quota and he is unable to complete its production, the remainder of the export quota cannot be produced in a different year.

The plant that saves its quota in the manner described above for a future nitrate year will not be able to transfer in any way the production of the postponed quota to a different plant of the same producer.

Article 12: Plants will not produce more than 15% in excess of their effective export quota in any nitrate year. Each Spanish quintal of excess production over this threshold will be fined with six pennies sterling.

Any production above the effective export quota of the plant will be exported in the following nitrate year and deducted from that nitrate year's export quota. The nitrate used to manufacture

gunpowder and other uses related to production will not be counted as part of said 15% margin.

Article 13: Any producer who exports in excess of his annual export quota will pay a fine of eighteen pennies sterling for each Spanish quintal of excess, and the excess exports will be deducted from the quota of the following nitrate year.

The same fine will be imposed on the producers that export in excess of the maximum fraction allowed between the months of April and December.

However, if the excess is not greater than 2 1/2% of the export quota, this situation may be settled without incurring a fine if a second plant that has not yet completed its export quota yields a fraction of it, of equal amount as the excess exports, to the first plant. This transaction shall be communicated to the management of the association.

The fines described in the current and the previous articles will be imposed by the board and will enter the common funds of the cartel.

Article 14: The plant that does not fully export its quota in a nitrate year will be able to export the balance in the following year, on the condition that the nitrate was produced in the preceding year.

Article 15: The board will appoint commissions that will verify nitrate stocks in the plants, roads, and ports at the end of each nitrate year.

For this purpose it will be considered as stocks the quantities of nitrate that are on board of ships that have not yet sailed out of the Nitrate Region's ports for still not being completely loaded. However, if the ship has bee loaded and has cleared customs, its nitrate will be considered as exported.

In case of disagreement between the commission and the producer regarding the precise quantity of stocks, the NPA board will be able to name a new commission whose opinion will be definitive.

Article 16: The NPA board of directors is authorized to hire inspectors when it deems necessary and to assign them the salaries it deems appropriate.The inspectors will perform their duties according to the regulations issues by the board of directors.

Article 17: The signatories of this agreement will be bound to give both commissions and inspectors free access to their plants and warehouses and to provide any additional information

they may require for the proper fulfillment of their mission.

Article 18: All the decisions made during a general meeting and the suggestions the NPA board submits for the producers' approval will be mandatory for all cartel members, as long as they are accepted by a number of members equivalent to, at least, 85% of total market shares according to the table mentioned in article 6.

Article 19: For the expenses caused by this agreement, the associates commit to pay a special fee, which will not exceed a quarter of a cent per Spanish quintal exported and will be charged month by month by the Nitrate Propaganda Association.

Article 20: In the event of transferring for any reason or in any form their rights in the land they own or operate, or plants in which they produce, or to give them in lease, use, loan, or to celebrate any other similar contract, the signatories of this agreement are expressly obligated to clearly stipulate with the new owner that he will inherit all the obligations originated on this agreement; and in order for this clause to have all the legal effects and bind third parties, even if such conditions are not stated in said contracts, the signatories authorize that this clause be transmitted to the corresponding Real Estate Conservators and Mines Conservators as a limitation to their domain.

Article 21: Any disagreement over any potential infringements of the clauses of this agreement and any other conflicts over issues not explicitly contained within this agreements will be resolved in friendly arbitration by mediators appointed from the members of the cartel, one by the NPA board and another by the disaffected producer. These two mediators will designate of common agreement a third arbitrator so that, in case of disagreement among each other, this third arbitrator will make a last instance decision without ulterior appeal of any class.

In case that any of the mediators refuses to concur in the decisions of the panel or to sign the judgement, the decisions and judgements made by the other two will be valid.

Chapter 3

Sent Away: Long-Term Effects of Forced Displacements

There is great interest in understanding the extent to which low-income neighborhoods have a negative causal effect on the outcomes of families and, especially, on the future outcomes of children. This paper describes a novel large data set that combines archival records and administrative data regarding a natural experiment that occurred during the Chilean dictatorship between 1979 and 1985, when the government mandated the relocation of a large number of slums in the city of Santiago, Chile. Three facts about the program's implementation make it of unique interest to study the broad effects of neighborhoods on social mobility and inequality: the unit of treatment was the slum (not specific households); participation was mandatory and compliance was very high, since the policy was implemented during a highly repressive dictatorial government; and only some of the slums were removed from their original location, creating two groups of families: movers and non-movers, which allows us to identify a causal displacement effect. Our data set comprises data for more than 26,000 households that were part of this program (out of a total of 40,000 households) and more than 58,000 of their children, which allows us to perform a causal estimation of the long-term and inter-generational effects of moving to a high-poverty neighborhood on education, mortality, income and crime.

3.1 Introduction

3.1.1 Motivation

A key question in the modern policy debate centers around the extent to which the environment affects the outcomes of families and, particularly, children. For adults, living in a low-income neighborhood could impact their access to labor market, expose them to higher levels of crime, and increase their mortality. Meanwhile, growing up in a low-income neighborhood has the potential to affect children's future educational attainment, labor income, and incarceration rates. Chetty, Hendren, Kline, et al. (2014) shows that neighborhood quality is associated to education, income inequality, and social mobility in the United States.

The fundamental challenge to identify a causal effect of neighborhoods is a selection problem: In most cases families decide where they live creating endogeneity between unobserved household characteristics and their selected neighborhood.

In this project we contribute to this literature by exploiting a policy implemented during the Chilean dictatorship between 1979 and 1985 that forced the displacement of entire slums from high- and median-income districts to low-income districts on the periphery of the city, creating ghettos of poverty in public housing. Moreover, the places where people moved where characterized by high poverty rates, low provision of public goods, and in some cases political violence, exposing children to worse neighborhoods on average.

A key aspect of our approach is that in our context families did not decide when and where to move. Chile at the time was a dictatorship and planners at the central government determined what and when each slum would be treated. An addition, most districts in low-income areas of the city both received and expelled groups of families. This exogenous variation permit us to estimate a causal displacement effect separate from the fixed effect of each destination. Moreover, the characteristics of the dataset will allow for future work to match our sample to a large number of administrative databases, allowing to pin down the specific mechanisms affecting the treated families.

Our setting has other distinctive features with respect to the previous literature on neighborhoods effects. First, the dataset we construct encompasses both parents and children. Hence, we are able to estimate effects of the displacement policy on all family members and to understand the

mediation mechanisms between the effects of parents and children (e.g., does the higher mortality of the parents have a direct effect on the lower high-school graduation rates of their children?). Second, since the program ended approximately 35 years ago, we can evaluate the long-term outcomes of the policy. Third, as entire slums are displaced by the policy, the social networks within the slums remained intact. Thus, we can clearly identify the mechanisms behind the observed outcomes without worrying about the disruption to social networks (For instance, in our case children's social networks are not disrupted as they are forced to attend a worse school and exposed to more criminal activity).

3.1.2 Related literature

The literature on neighborhoods effects has grown considerably in the last decade. A first strand of the literature studies neighborhood effects using experimental data. Oreopoulos (2003) uses variation in the quality of public housing in Toronto to estimate long-term effects in labor market outcomes finding small effects. In the U.S. several works have used the Moving to Opportunity (MTO) experiment (Chetty, Hendren, and Katz (2016), Pinto (2018)). In particular, Chetty, Hendren, and Katz (2016) shows that when families move from high poverty to low poverty neighborhoods the outcomes of children, such as education and income, improve linearly as a function of the time spent in the new area, a result consistent with previous findings in the literature (Chetty and Hendren (2018a), Chetty and Hendren (2018b)).

Displaced families in our sample were moved to higher poverty neighborhoods, located mainly on the periphery of the city where access to public services such as schools, hospitals and public transportation was of lower quality than in the original location. This pattern is similar to the Indian experiment studied in Barnhardt, Field, and Pande (2017) which finds only positive effects on housing quality fourteen years after participation in a housing lottery.

A second strand of the literature uses quasi-experimental data, particularly from demolitions of housing projects (Jacob (2004), Chyn (2018)). In a very recent work, Chyn (2018) finds large positive effects on the outcomes of children that moved to better neighborhoods due to demolitions in Chicago. In this case, the large magnitude of the estimated effects corresponds to a smaller degree of selection in the population treated by the program with respect to programs in the experimental literature where families have to apply, inducing a positive sample selection.

Figure 3.2.1: Example of slum (Nueva Habana) and destination neighborhoods

Finally, our project also speaks to the literature on the effects of re-settlements (Damm and Dustmann (2014), Deryugina, Kawano, and Levitt (2018), Abel (2019)). The closest study to our case is Damm and Dustmann (2014) that studies the case of refugees in Denmark and finds that children of refugee families who were exposed to high-crime neighborhoods were more likely to commit a crime in their adulthood.

3.2   Historical Background

By the late 1970s, out of the more than million inhabitants of the city of Santiago, capital of Chile, more than 15% lived in slums (INE, 1970).[1]

Slums at the time were squatter settlements without access to drinking water, electricity, and sewage. The median slum had between between 100-150 families, with an average size of 5.2 persons per family, although there was a large dispersion in slum size. The vast majority had their origin in a land seizure by a organized group of families. Hence, slum inhabitants lacked property rights over the land they used. Figure 3.2.1 shows an example of a typical slum.

From 1979 to 1985, the central government of Chile implemented a set of policies with the goal of eradicating poverty. One of the main programs of this effort was a large re-allocation

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[1]Santiago at the time concentrated 34.8% of Chile's population.

Table 3.2.1: Urban Marginality Program (1979-1985)

Treatment	Movers	Non-movers	Total
Number of families	26,291	14,200	40,491
Share %	65%	35%	100 %
Number of slums	211	67	278
Number of neighborhoods	63	67	130

Sources: Molina (1985, p. 53).

program to transform slums into neighborhoods.[2] The central idea behind the program was to move slum dwellers into newly built neighborhoods where they would become home-owners receiving a government subsidized property title.

The costs of the program were low. The average housing unit cost was \$7,000 and the average total annual cost of the program was \$34m, which was about 0.2% of Chilean GDP at the time. The families had to pay 25% of the cost of their new property in installments.

At the program onset in 1979 the government chose 340 slums to be treated as part of the program. There were two versions of the treatment: Some slums were kept at their original location receiving property rights over their land. Families and slums from this treatment are called *non-movers.* On the contrary, some slums were displaced from their original location, their inhabitants receiving housing units in a new neighborhood located in the periphery of the city. The families and slums from this treatment are called *movers.* More than 40,000 families participated in the program and approximately a third were non-movers. Table 3.2.1 presents basic statistics about both versions of the program, while Table 3.2.2 describes the main features of both versions of the program.

The allocation of slums into these two groups was not random but a function of slums characteristics. According to geographers and historians, the density of the slum and the potential difficulties for the provision of sewage and electricity were good predictors of displacement. However, other considerations were also important Rodríguez and Icaza (1998) explain "...these other criteria included the reputation of the district, especially in the of upper- and middle-income sectors, their land values, and the speculation about future prices."
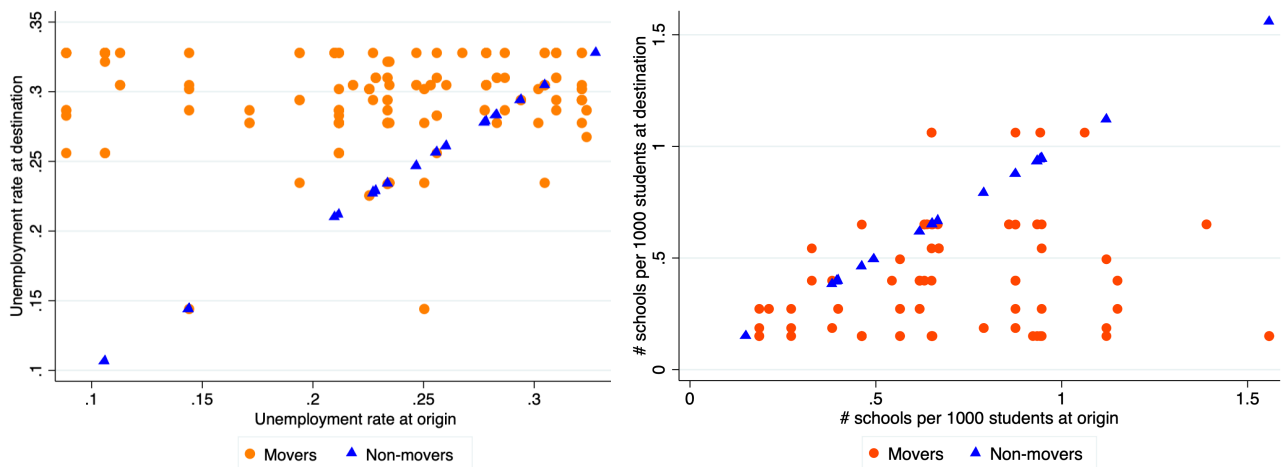
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[2]The program was known as Urban Marginality Program (*Programa de Marginalidad Urbana*), enacted under law 2552.

Figure 3.2.2: Population movements from (left) and to (right) the Renca district of Santiago
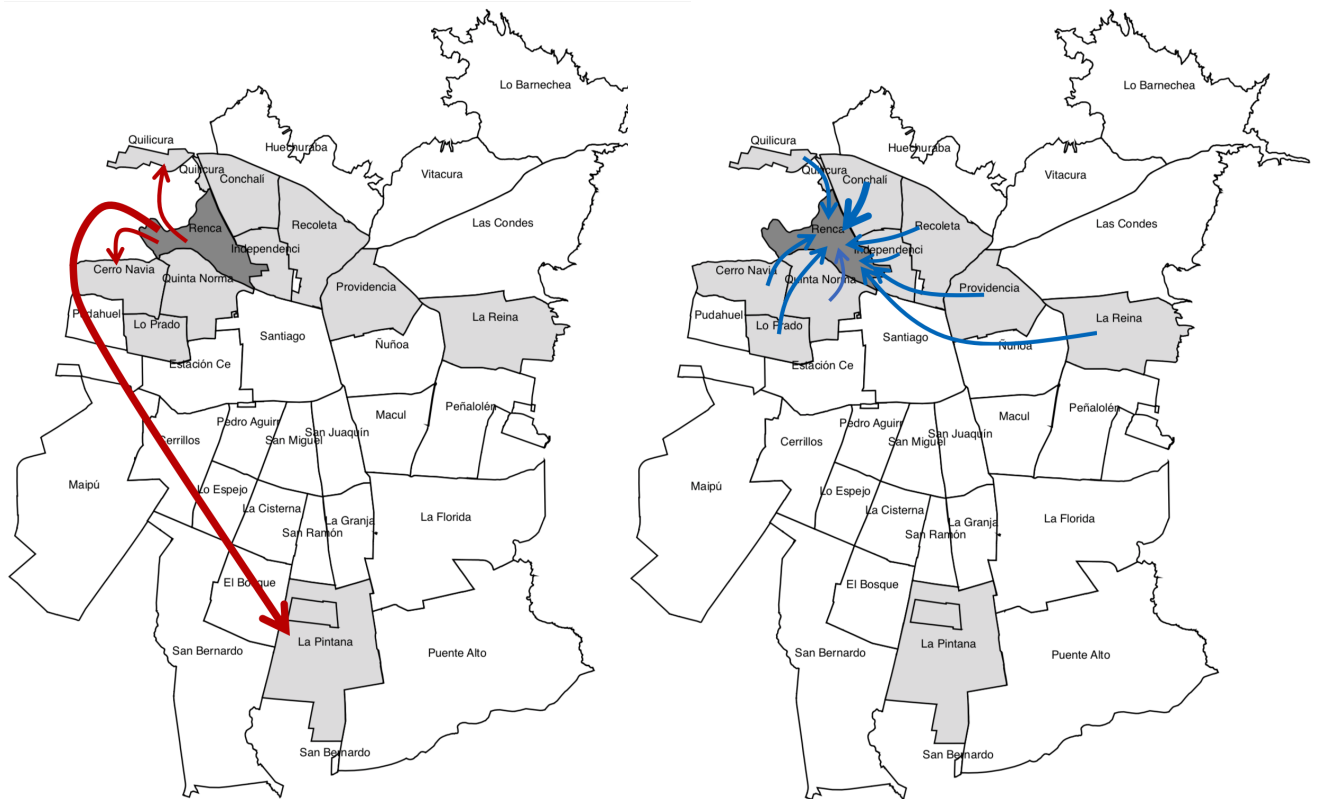
Figure 3.2.3: Characteristics of origin and destination districts

(a) Years of schooling (1982)

(b) Schools/1000 students (1982)

Figure 3.2.4: Location of treated population before and after the program

Years of schooling
(10,13.35]
(8,10]
(7,8]
[5.5,7]
No pop. in 1982

● Non-movers
○ Movers

(a) Before 1979

(b) After 1985
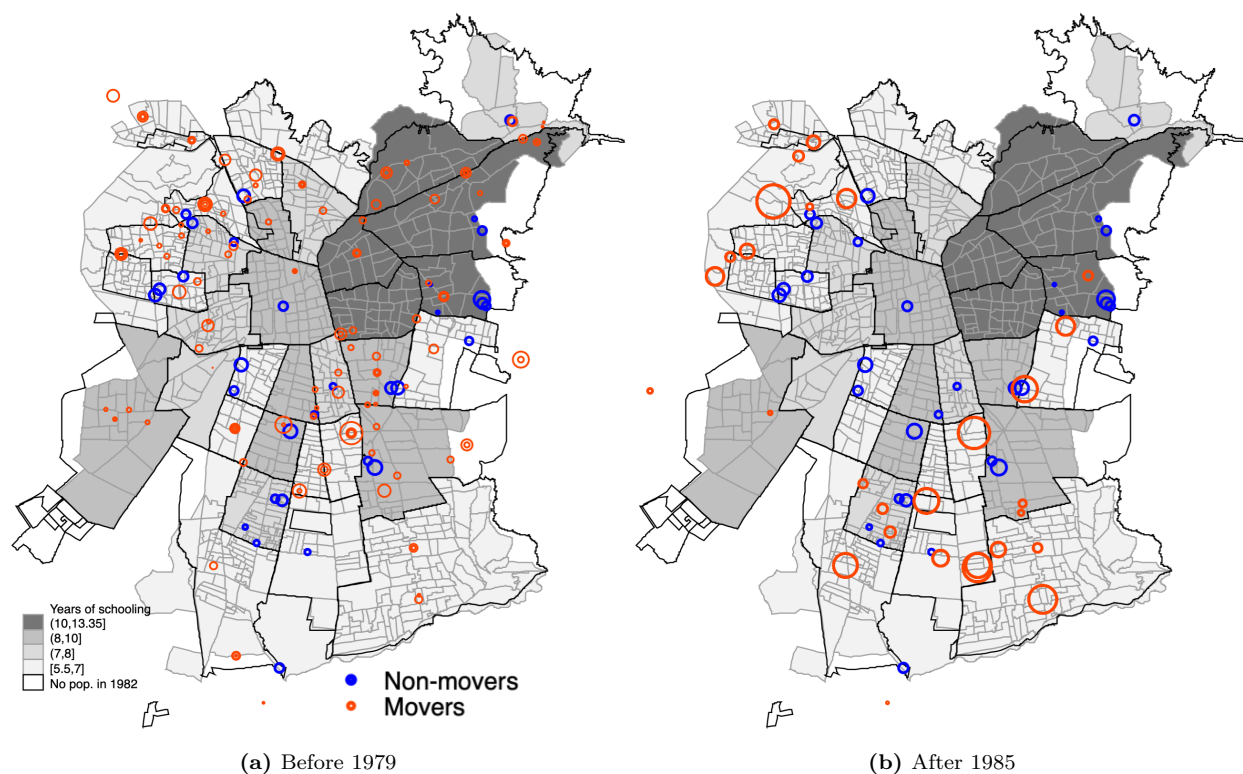
Sources: Benavides, Morales, and Rojas (1982), Molina (1985).

Table 3.2.2: Characteristics of both program versions

Treatment	**Location**	Property Right	Type of dwelling	Public Services	Cost for family
Non-movers	**Same**	Yes	Starting Kit (*)	Yes	25%
Movers	**New (periphery)**	Yes	Apartment or house	Yes	25%

Notes: (*) Starting kit includes a living room, a bathroom and a kitchen. *Sources:* Molina (1985), Morales and Rojas (1986).

3.3   Data Collection

In order to study the causal effects of the program on the treated population's outcomes it is necessary to have a dataset that contains both parents and their children, their slum of origin and

Figure 3.3.1: Example of archival record. Jose Miguel Infante neighborhood in Renca district

Family ID	Name	Relation to hh	ID	District	House	Address	Aport.	Aplic.	G.Not	Value
1	Gaete Dour Cardenio S.	1	137155	Valdivia	6	Toconce 1145	220	170	50	283.77
1	Rubilar Figueroa María Y.	2	125329	Valdivia	6	Toconce 1145	220	170	50	283.77

destination neighborhood. These records are then matched to administrative data from the Chilean Ministry of Education and Ministry of Social Development.

3.3.1 Archival Data: Parents sample

The initial source of data are the original lists of participants in the program, which are located in the Santiago Region Urban Development and Housing Service section of the Chilean National Administration Archives in Santiago, Chile.[3] From this source, we construct a database with the *parents* that were treated as part of the program.

The records are a detailed list of the people who were assigned property deeds by the Ministry of Housing as part of this program. Each destination neighborhood has one or more lists, depending on the number of stages on which its new residents arrived. Figure 3.3.1 shows an example of the records. The lists contain information on the head of the household and the spouse, their full names, national identification numbers (NID) and the address of their new house. Using the names of the neighborhood of destination, we can classify people as movers and non-movers. We digitized records that correspond to 26,283 families treated by the policy between 1979 and 1984, of which 18,690 families are movers and 7,593 are non-movers.

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[3]Each region of Chile has a Urban Development and Housing Service, dependant of the National Ministry of Housing and Urban Development to implement housing policies at the local level.

Treatment	Movers	Non-movers	Total
Number of families	18,690	7,593	26,283
Share %	71.1%	28.9%	100%
Number of slums	98	50	145
Number of neighborhoods	69	50	114

3.3.2 Matching process: Children sample

The second stage in the construction of the full database consists in finding the children of each family. Notice that the children that had already been born by the time of the displacement are not included in the lists that conform the archival data. Moreover, we want to have not only the children that had been already born but all the children these families eventually had. Figure 3.3.2 presents a simple diagram with the main steps of the process. The strategy to find the children is based on three features of the Chilean case. First, each potential child of these families would have as his/her last-names a combination of the last-names of their parents, which we know from the parents sample originated in the archival records.[4] Second, the ubiquitous use in Chile of a unique national identification numbers (NID) to identify citizens in all official documents including birth, marriage, and death certificates.[5] Third, the electoral records in Chile are public and the country has automatic voter registration.

The first step of the process is to construct a list of all the potential combinations of last-names the potential children of the treated families would have, by combining the first last-names of the spouses included in the archival records. The second step is to construct a second list with all the citizens in the electoral records that have the same combination of last-names as the potential children of the families in the parents sample. To do this step, we partner with Genealog Chile, a group of nonprofit genealogists that work reconstructing family trees in Chile. They are currently collecting administrative data for the Chilean population, including the electoral records, and marriage, birth, and death certificates of the entire population. Finally, the third step consists

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[4]In Spanish speaking countries people have two last-names. The first last-name of a child (in order from left to right) corresponds to the first last-name of the father, while the second last-name is the first last-name of the mother. Hence, both paternal last-names from the parents are transmitted to their children.

[5]Every citizen in the country is assigned, at the moment of birth, with an unique national identification number (NID). In Spanish the name of the identification number is *Rol Unico Nacional* and is usually called by its acronym, RUN. Importantly, this number is not considered as sensitive information and is used periodically by Chileans in their daily life while, at the same time, being used by all government agencies to identify citizens.

Figure 3.3.2: Diagram of process to match children to parents sample

Rodolfo Márquez Montenegro

Lucía Arjona Contreras

Family name is

"Márquez Arjona"
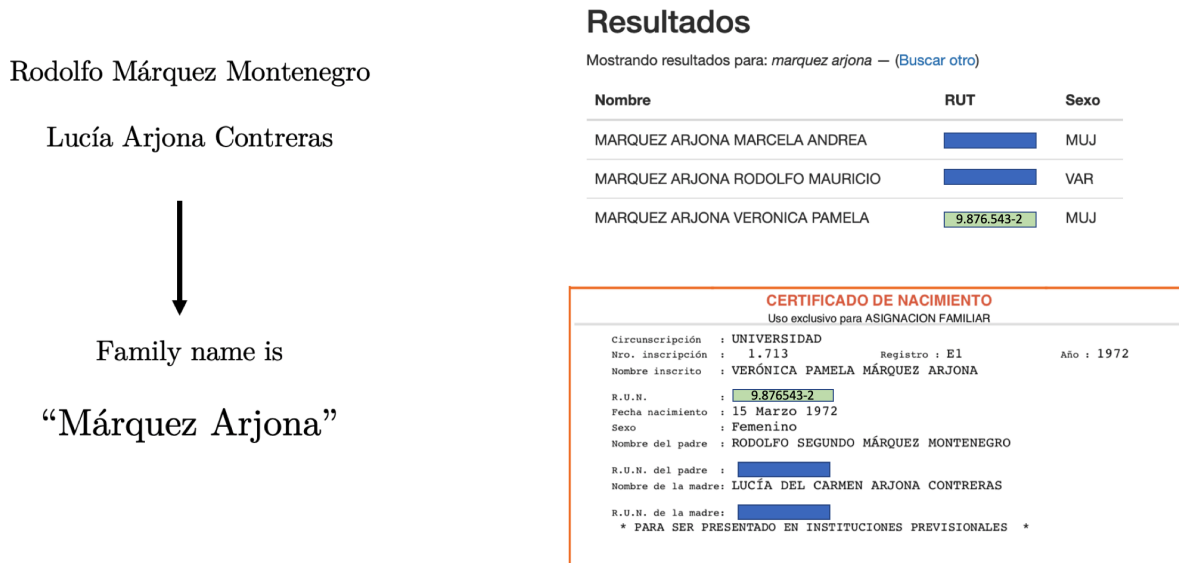
Figure 3.3.3: Summary of results data collection process
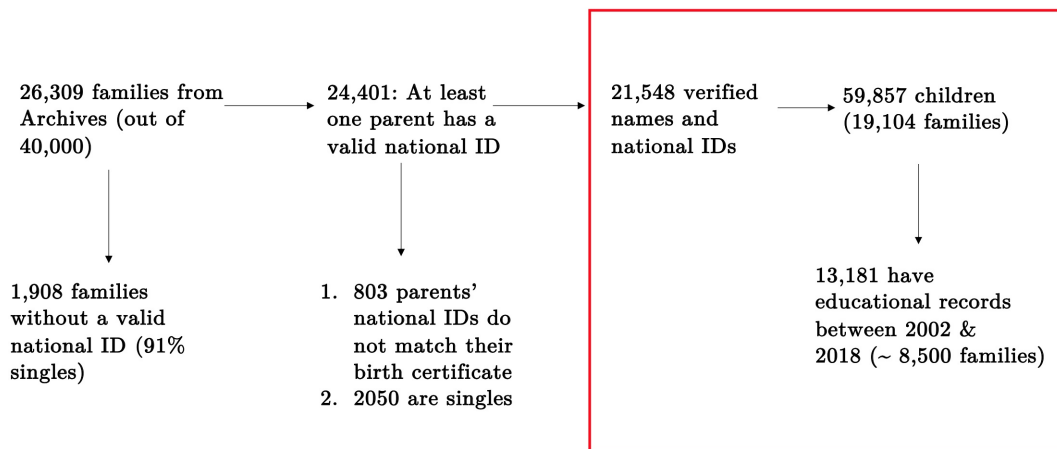
on linking children to parents using the information on their birth certificates. As shown in Figure 3.3.2, Chilean birth certificates include the NID number of both of the parents. Hence, we search among of potential children for a match with the NID numbers of the families in the parents sample.

Figure 3.3.3 shows the results of the matching process. From the initial sample of 26,309 families we are able to link 58,857 children, which correspond to 19,104 of the initial families.

176

Figure 3.3.4: Number of families by type and year of treatment in our sample
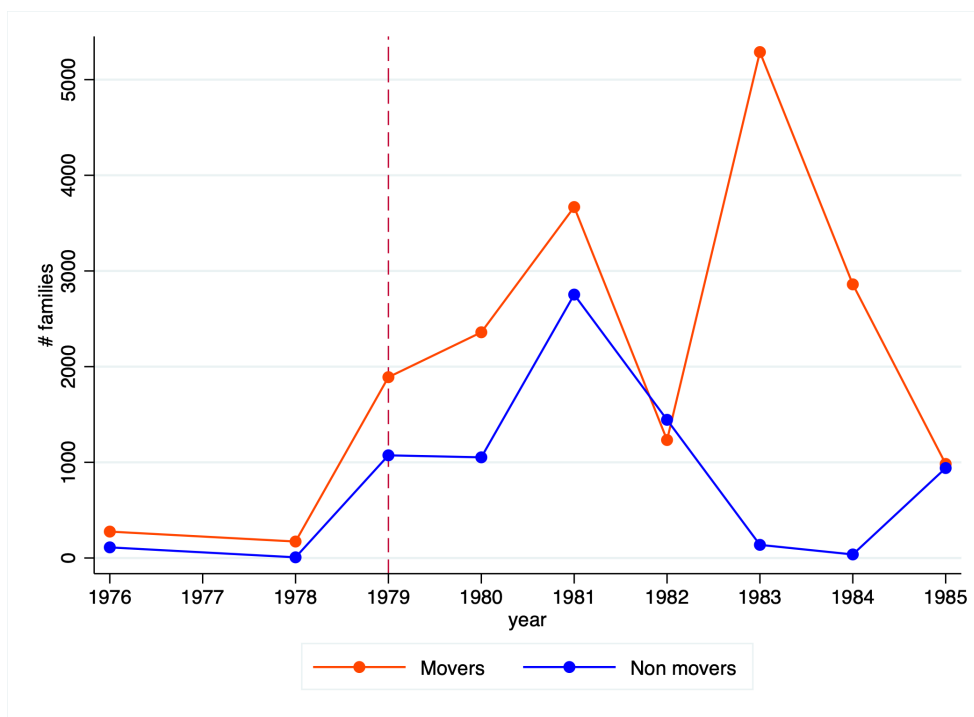
3.3.3 Locating slums and destination neighborhoods

Our archival records are based on the destination neighborhoods, so it is necessary to assign each family also to a slum of origin in order to complete the database. For doing this, we use information from three main sources sources. The housing programs of the Chilean dictatorship were contemporaneously studied by the Latin American Faculty of Social Sciences (FLACSO) in Santiago. We draw intensively from two of their studies. Benavides, Morales, and Rojas (1982) compiled a comprehensive list of existing slums in the year 1982, including characteristics such as surface, number of families and location. Morales and Rojas (1986), describe the treatment of slums, identifying neighborhoods of destination and providing a list of non-mover slums. We complement FLACSO sources with Molina (1985) that documents the treatment of slums that were moved before the year 1984 and contemporaneous internal documents from the Ministry of Housing and Urban Development.[6]

There are two main challenges in the allocation process of families to slums of origin. First,

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[6]The identification of slums is challenging given their dynamic nature. Slums names often changed for a myriad of reasons.For instance, after the military coup of 1973 several slums with left-wing related names were forced to change their names.

since the archival records are ordered by the date on which the families moved to the destination neighborhoods. Thus, in same cases they include groups of families with more than one slum of origin. Second, when a non-mover slum was treated, often the new neighborhood had a different name from the original slum. Moreover, adjacent non-mover slums were sometimes treated in a single new neighborhood of destination.

To solve the first challenge we use the number of mover families treated at every slum of origin, which we obtain from the sources above, together with the Place of Registration variable included in the archival records.[7] In order to identify non-mover slums of origin we match the address of the destination neighborhoods with the location of known non-mover slums and number of families treated.

3.3.4 Measuring outcomes: matching to administrative data

The last step in the construction of the database consists on matching our sample of families to administrative data of the Ministry of Education using the NID numbers of the children. Unfortunately, the Ministry of Education data only covers the years 2002 to 2018, reducing the total number of observations we are able to match. We obtain educational records for 13,181 children that belong to approximately 8,500 families.

3.4 Summary Statistics

This section presents descriptive information about our dataset with a focus on examining the balance of the sample between families that received different versions of the treatment.

Our basic empirical methodology is based on the estimation of the two following equations.

$$Y_i = \alpha + \beta Mover_{s\{i\}} + X_i'\theta + \psi_o + \varepsilon_i \tag{3.1}$$

$$Y_i = \alpha + \beta' Mover_{s\{i\}} + X_i'\theta + \psi_o + \psi_d + \varepsilon_i \tag{3.2}$$

where Y_i is current outcome for individual i; o is district of origin and d is district of destination;

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[7]Place of Registration is called as *Gabinete* on the records and corresponds to the Civil Registry and Identification Service (CRIS) office where the person was first registered. Most districts of Santiago had at the time a CRIS office.

Table 3.4.1: Summary Statistics: Families

	Mover mean	Non-mover mean	Difference (within district)
Demographics at displacement			
Head of Household age	35.29	36.51	-0.61
			(0.51)
Wife age	33.63	34.90	-0.64
			(0.50)
Husband age	35.23	36.54	-0.79
			(0.48)
Female HH	0.32	0.31	0.02
			(0.02)
Single	0.20	0.16	0.04***
			(0.01)
Widowed	0.02	0.02	0.00
			(0.00)
# Children	2.23	2.28	-0.05
			(0.05)
No children	0.11	0.11	0.01
			(0.01)
Demographics after displacement			
Total # children	2.80	2.72	0.03
			(0.04)
Wife died	0.22	0.20	0.04**
			(0.01)
Husband died	0.33	0.31	0.04**
			(0.02)
Observations	15,679	5,869	21,548

Notes: Within difference corresponds to the coefficient of *mover* in equation (1) stratified by origin FE and without controls.
Clustered standard errors at the slum level. 10%*, 5%**, 1%***.

$s(i)$ indexes the slum of origin for individual i; ψ_o and ψ_d are district of origin and district of destination fixed effects; and $Mover_{s\{i\}}$ takes the value of 1 if an individual's family lived in a displaced slum. Finally, X_i is a set of control variables: age, gender, family characteristics, and year of treatment.

Table 3.4.1 presents summary statistics at the family level, while Table 3.4.1 shows summary statistics for the children in our sample. Characteristics between the two sub-samples are very balanced. Importantly, age of the parents at the time of displacement presents a statistically non-significant difference of less than one year. The only characteristic on which there is a relevant difference is marriage status, since movers are more likely to be single at the moment of displacement.

Finally, Table 3.4.3 describes the correlation between characteristics of the families in the sub-sample of movers and attributes of their destination district. We find no evidence that mover-families were selected on observable characteristics when they were assigned a district of destination.

Table 3.4.2: Summary Statistics: Children

	All children		Children with educ. records	
	Non-mover mean	Difference (within district)	Non-mover mean	Difference (within district)
Demographics at displacement				
Female	0.5	0.01	0.49	0.01
		(0.01)		(0.01)
Age	7.63	-0.66	-2.24	0.23
		(0.41)		(0.37)
Older than 18 yo	0.10	0.00	0.01	0.00
		(0.01)		(0.00)
# Siblings	2.81	0.19***	2.85	0.13
		(0.06)		(0.09)
Mother age	33.96	-0.81*	29.45	-0.91**
		(0.43)		(0.41)
Father age	36.23	-0.83*	32.23	-1.11**
		(0.44)		(0.44)
Mother is HH	0.28	0.01	0.26	-0.03
		(0.02)		(0.02)
Single Parent	0.12	0.04***	0.15	0.03*
		(0.01)		(0.02)
School Outcomes after displacement				
Schooling (years)			11.21	-0.41***
				(0.08)
HS graduate			0.73	-0.09***
				(0.02)
Observations				
Individuals	15,987	59,857	2,749	13,181
Families	5,214	19,104	1,938	8,587

Notes: Within difference corresponds to the coefficient of *mover* in equation (1) stratified by origin FE and without controls.

Clustered standard errors at the slum level. 10%*, 5%**, 1%***.

Table 3.4.3: Destination attributes and family characteristics at time of displacement (sub-sample of movers)

Location Atributtes	Av. Years of Schooling (1)	Literacy rate (2)	Unempl. rate (3)	# Primary Care Cent./1000 pers. (4)	# Hospitals/ 1000 pers. (5)	# schools/ 1000 stud. (6)	# pub. schools/ 1000 stud. (7)
HH's age	0.000	0.000	0.000	0.000	-0.000	-0.001	-0.000
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Female HH	-0.019	-0.000	0.002**	0.001**	-0.000	0.001	0.004
	(0.018)	(0.001)	(0.001)	(0.000)	(0.000)	(0.009)	(0.007)
Single HH	0.008	-0.001	-0.001	-0.000	0.000**	0.012*	0.009*
	(0.013)	(0.001)	(0.001)	(0.000)	(0.000)	(0.007)	(0.006)
Widowed HH	-0.004	-0.002	-0.001	-0.000	0.001	0.010	0.008
	(0.043)	(0.002)	(0.002)	(0.000)	(0.000)	(0.015)	(0.010)
# children	0.002	0.000	0.000	0.000	-0.000	-0.000	-0.001
	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)	(0.002)
Test of joint significance of controls							
F	0.281	0.527	1.708	2.395	0.855	0.683	0.596
$p > F$	0.922	0.755	0.140	0.043	0.514	0.637	0.702
Dependent variable mean	6.53	0.63	0.28	0.018	0.004	0.67	0.56
District of origin FE	yes	yes	yes	yes	yes	yes	yes
Observations	15,679	15,679	15,679	15,679	15,679	15,679	15,679

Notes: Clustered standard errors at the slum level. 10%*, 5%**, 1%***. Attributes in columns 1-3 are measured at the district

level in 1982 when census data is available, while schools and hospitals are measured in 1985.

3.5   Final Remarks

This paper presents a novel large dataset that includes family members from two generations affected by a disruptive housing policy implemented by the Chilean dictatorial government between

1979 and 1985.

The program had two versions which differed regarding the location of the housing units the families received: Some remained in the same location where they already lived, while others were displaced to the periphery of the city where public services and labor market opportunities were scarcer. An analysis of the observable characteristics of families under the two versions indicate that both groups had similar characteristics at the moment of treatment.

Our dataset opens important opportunities to understand the mechanisms behind the neighborhood effects described by the previous literature. In particular, the existence of a NID number for every individual in our sample offers the potential to match it with existing administrative databases from the Chilean government (in addition to the Ministry of Education data) on social outcomes including incarceration rates, labor income, and causes of mortality.

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