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SUSTAINABILITY OF COLLUSION: EVIDENCE FROM THE LATE 19TH CENTURY BASQUE IRON AND STEEL INDUSTRY

PEDRO MENDI
Universidad de Navarra
RÓBERT F. VESZTEG
Universidad Carlos III de Madrid

We examine the minutes of the executive committees of two Basque firms in the iron and steel industry, Altos Hornos de Bilbao and Vizcaya, to discuss the relevance of different factors on the survival and failure of the collusive agreements reached in the industry from 1886 to 1901. We observe intense communication among colluding parties during and after collusive arrangements. Collusion seems to be more likely to break down in periods of falling demand, while strong demand provides these agreements with stability. Additionally, the presence of centralized sales agencies, and similar degrees of vertical integration among colluding firms facilitate collusion.

Keywords: Market power, collusion, iron and steel industry.

(*JEL* L13, L41, N84)

1. Introduction

Alternating episodes of competition and collusion characterized the late 19th Century Spanish iron and steel industry. The 1880s and 1890s witnessed the formation and dissolution of several cartels exhibiting disparate degrees of stability. The purpose of this paper is to highlight the most important factors that led towards cartel stability or, contrary, towards failure. Evidence is drawn from the minutes of the executive committees of two large Biscayan firms: Altos Hornos de Bilbao (hereafter AHB), and Vizcaya. Our goal is to provide and discuss a type of evidence that has seldom been considered due to its

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qualitative nature, and to suggest features that should enrich theoretical models of collusion. The most salient features are intense communication between the parties, haggling over market shares, tailored punishments preceded by a number of warnings, and even cooperation in some particular markets after collusion breaks down in markets for other products. Theoretical models of collusive behavior typically fail to take into account these outcomes. We conclude that it is crucial for colluding parties to design an agreement that adapts well to changing circumstances. We also find that coincidence in different product markets and the existence of monitoring institutions are important factors that facilitate collusion.

This case study considers the set of collusive agreements in which AHB and Vizcaya took part between 1882 and 1901, i.e. from the foundation of AHB and Vizcaya to the merger that led to the foundation of Altos Hornos de Vizcaya (hereafter AHV). An interesting feature of the period considered is the lack of antitrust law to prevent and prosecute collusion, which did not require colluding parties to conceal communication among them. This way, minutes of the meetings of the executive committees of the main firms involved in the collusive arrangements may be regarded as evidence on the strategic considerations and arguments related to the establishing, operation and also the ceasing of such arrangements.

From this perspective, our paper is also closely related in its philosophy to Genesove and Mullin (2001), where narrative evidence is also discussed. They regard collusive agreements as incomplete contracts that have to be adapted to a changing environment, calling for the creation of an institution that completes the contract, namely the Sugar Institute, formed in 1927. They also show the importance of communication in the operation of a cartel. In particular, individual deviations or cheating were discussed in the regular meetings of the institute. Finally, punishment did not mean reversion to competitive conditions as suggested by many theoretical models, but it rather included a specific solution to the problem at hand.

The literature on economic history has considered collusion in the particular case of the iron and steel industry. Barbezat (1989) and Peters (1989) report historical evidence on the International Steel Cartel of 1926 and the Rheinish-Westphalian Coal Syndicate before World War I respectively. They point out that due to the numerous difficulties achieving collusive behavior –namely individual interests, cheat-

ing, heterogeneous products or dynamic market conditions– the intents to completely eliminate competition among members did not succeed. However, partial success was achieved. The International Cartel did limit trade among its members and allowed for the formation of domestic cartels, and also the German Coal Syndicate did operate for over two decades. Webb (1980) analyzes the role of tariffs on the sustainability of cartel agreements, studying the specific case of early 20th-Century German steel industry (see Mendi and Veszteg, 2007 and Mendi *et al.,* 2007 for theoretical models on the relationship between tariffs, collusion, and mergers).

The evidence discussed in this paper stresses the fact that there was intense communication among the parties to achieve collusive outcomes. Although this was a period when explicit collusion was not prosecuted, modern antitrust practice also finds that colluding parties maintain communication channels. On the one hand, communication allows firms to better implement market shares, or avoid unnecessary instantaneous retaliation. On the other, it leaves the door open for returning to cooperation after collusion breaks down. While the former features have a positive impact on the sustainability of collusion, the latter hinders it by increasing discounted profits after deviation. In some sense, cutting communication channels may be interpreted as a commitment to punish deviations. However, our view is that the net effect of communication on collusion is positive, and the antitrust authority should beware of the existence and activities of any institution that could become an active communication channel for industry members, such as a trade association.

We also observe that industry members increase their contact efforts and more eagerly seek understanding in booming years and also following several years of low demand. By contrast, collusion is most likely to break down in the initial phase of a downturn. This may be precisely because a downturn alters the environment the initial agreement is based upon, introducing tensions among cartel members. However, after several periods of low demand, firms acknowledge that it is jointly beneficial to avoid competition and thus increase their communication efforts and try to seek for understanding.

Finally, the existence of monitoring institutions increases cartel stability. The role of monitoring could be performed by a retailer or a supplier. In the case that we are analyzing, a shipping company, which had the exclusive right to ship the firms' production obviously

had the incentive to make every effort possible to preserve the agreement. Hence, the antitrust authority should be aware of the potential monitoring incentives that exclusive dealing contracts with suppliers or retailers have. In addition to monitoring, these suppliers or distributors might become an effective communication channel for colluding members, as pointed out above.

The paper is organized as follows: Section 2 discusses some factors that facilitate the sustainability of collusion based on the existing literature. Section 3 presents the historical background, section 4 discusses the collusive agreements reached throughout the final decades of the 19th Century, and section 5 concludes.

2. Cartel stability

A crucial question addressed in this paper is on cartel stability, making it closely related to Levenstein and Suslow (2006). These authors review existing empirical evidence on factors that increase the likelihood of cartel survival, starting from the seminal work by Stigler (1964). They point at the ability of the collusive agreement to adapt to changes in the environment, as well as entry in the industry as the most important determinants of cartel stability. A poorly-designed agreement is prone to ex-post bargaining among the parties that jeopardizes the stability of cartels. They also point out that colluding firms go through a learning process in the sense that they are able to come up with more sophisticated agreements as time goes by. Our findings are mostly consistent with the evidence reviewed in Levenstein and Suslow (2006). In particular, we verify that most of the times collusion broke down because of a change in the environment that induced disparate incentives among cartel members.

Although modern antitrust practice makes a clear difference between explicit and tacit collusion, economic theory generally does not (refer to Harrington, 2006 and 2008). Authors tend to categorize collusive agreements based on direct communication as explicit, and those that are based on indirect communication as tacit collusion. However in our view, the importance of communication in both cases makes the distinction between them rather difficult.[1] In our example, the colluding

[1] Among others, Harrington (2006, 2008), Muren and Pydokke (2006) emphasize the importance of communication based on field and experimental data, respectively. While the former marks the difference between the two types of collusion, the latter does not, yet they reach similar conclusions.

parties never actually turned to a court to enforce these agreements. The written, i.e. direct form of communication doubtlessly makes a detailed agreement more feasible, nevertheless we believe that it does not substantially change the incentive constraints to be considered. The importance of the written documents is that the minutes of the executive committees of AHB and Vizcaya reflect decisions made by managers of both firms, providing information on the reasons for such decisions.

Formal models of collusion use game theoretic arguments to describe the forces behind collusive agreements, emphasizing that their success requires repeated interaction that allows firms to punish individual deviations.[2] This way, cooperation may be sustained even if the one-shot equilibrium involves no cooperation, as in the simple prisoners' dilemma game. In equilibrium, cheating is not observed. The literature has considered several factors that may facilitate or hinder collusion. One such factor is variations in demand. Rotemberg and Saloner (1986), assuming uncorrelated demand shocks, predict countercyclical prices because firms' incentives to deviate are highest in booms. Bagwell and Staiger (1997) qualify this somewhat counter-intuitive result, obtaining procyclical prices with positively correlated demand shocks. Green and Porter (1984) assume unobservability of demand shocks and of rivals' output choices, and consider price wars to be part of the collusive equilibrium. In this model, the distribution of the demand shock affects the value of the trigger price and the length of the reversionary period. Other articles consider factors that are regarded as collusion-enhancing. For instance, the presence of colluding firms in several markets whose demands are not perfectly correlated expands the scope for collusion, see Bernheim and Whinston (1990). The existence of a common marketing agency may also be used to sustain collusive behavior, as in Bernheim and Whinston (1985). Similarities among firms in capacity levels have also found to be a factor facilitating collusion, as in Compte *et al.* (2002) or Vasconcelos (2005).[3]

Although Nash reversion makes theoretical models tractable, it turns out to be inconsistent with observed behavior. Indeed, we document

[2] Check, for example, Mas-Colell *et al.* (1995) for an introduction.

[3] Escrihuela-Villar (2003, 2004) shows that the number of firms and also the applied discount factor have significant effect on collusion among firms. Given the characteristics of our data we cannot consider the effect of these factors.

several episodes of collusion after competition stages. Evidence suggests that firms were well aware of the activities of other firms, ruling out demand unobservability as a driving force of collusive activities. For this reason, it seems implausible that firms use price wars as an equilibrium strategy. We should think of a collusive outcome as one that survives as long as all firms have the incentive to stick to the agreement. Changes in the environment, which might asymmetrically affect firms in the collusive agreement, introduce strains that jeopardize its very existence.

Models of tacit collusion assume the absence of any communication among the colluding parties. This way, profits after deviation are the sum of instantaneous deviation profits plus the discounted sum of Nash-equilibrium profits (due to reversion to the Nash-equilibrium outcome) forever. Communication alters this incentive constraint by introducing a positive probability of these profits being greater than Nash-equilibrium profits, since communication could induce firms to return to the collusive outcome. Indeed, we observe firms reconsidering their punishment behavior and seeking understanding. In some sense, communication makes firms have a shorter memory than what standard models assume. Specifically, it introduces a strictly positive probability of returning to the collusive outcome after deviation. With communication, cooperation is harder to sustain, but it is more likely to arise. Hence, we expect to observe alternating periods of cooperation and competition. Cutting communication channels should decrease the number of collusive agreements, although surviving agreements are expected to be more stable.

From another perspective, empirical results from the experimental laboratory also help us to better understand the forces behind collusive agreements.[4] Repetition of quantity competition has been observed to decrease cooperation in single-period market games in the laboratory. In multiperiod games, repetition with the same cohort and with previous cohorts has been observed to increase cooperation. These results are in line with the intuition according to which repetition with the same cohort helps to establish trust and a reputation for punishing individual deviations. Punishment strategies play an important role of keeping up collusion both theoretically and empirically. While with two firms a defector can be punished without harming a cooperative

[4]This part on experimental research in industrial organization is based on Holt (1995).

third party, with more players direct punishment may be necessary to enhance cooperation. The effectiveness of nonbinding communication in maintaining collusive behavior, though intuitively very important, seems to depend on the market institution implemented in the lab.[5] Finally, Abbink and Brandts (2006) reports experimental data on duopolies in the lab showing that collusion is almost three times as frequent in shrinking markets as in growing ones, moreover prices are more than twice as high.

3. Historical background

Overall, the Spanish economy in the late 19th Century was characterized by recession and a turn towards protectionism. The 1880s and 1890s witnessed a depression in agriculture that, given its weight in the Spanish economy at that time (50% of total output), implied a feeble demand for industrial products.[6] The 1869 Tariff (effective during the 1880s) provided relatively low protection for Spanish firms. After its several modifications, a new protectionist tariff was introduced in 1891. This turn towards protectionism was also observed in other European countries.[7] The relevance of lobby groups in the design of the new Spanish tariff policy, in particular, the influence of the domestic iron and steel industry in the choice of tariff protection is unquestionable. The depreciation of the Spanish peseta throughout the 1890s, with a peak in 1898 due to the Spanish-American War, provided additional protection for the domestic industry. Given the combined protection of high tariffs and a depreciated peseta, Spanish iron and steel producers were able to charge prices close to the monopoly level without prompting any imports.

[5] Competition among price setting firms has been the objective of several experimental studies. For example, Dufwenber and Gneezy (2000) study collusion in a static framework and find that prices exceed marginal cost for the case of two firms, but are equal in the case of three and four. Experimental studies on quantity competition provide similar conclusion. In a recent survey of the literature Huck, Normann and Oechssler (2004) argue that while duopolies sometimes manage to collude, collusion is very difficult with more than three firms on the market. Muren and Pyddoke (2006) find that this number effect is robust and cannot be explained by the increased difficulty of establishing a coordinated pricing scheme among more than two firms.

[6] The time series of the Spanish real GDP is flat through most of the period considered, with some years of negative growth until 1896, when output began its recovery. Refer to Carreras and Tafunell (2003) for more details.

[7] Protectionist tariffs were adopted in Germany, France, Austria, Italy and Russia in the late 19th Century, see Bairoch (1989).

The Spanish iron and steel production in the late 19th Century was concentrated in the Northern regions of Asturias and the Basque Country.[8] The extraction of iron ore to be exported to Britain boomed after the discovery of important phosphoric iron deposits in the Basque province of Biscay. Following suit, the production of iron and steel in this region quickly increased in the 1870s and 1880s, making Biscay one of the most industrially intensive regions in Spain, see Houpt (2002). The production of Spanish iron jumped from 69,149 tonnes per year in 1876-80 to 184,600 tonnes per year in 1886-90. During the final five years of the 19th Century three firms, AHB, Vizcaya and San Francisco de Mudela, produced 78% of the iron ingot in Spain. Finally, in 1897 the total production of iron and steel in Spain was regulated by syndicates and/or bilateral agreements across producers. Altos Hornos de Vizcaya emerged as the dominant firm of the industry in 1901 as a result of the merger of three Biscayan iron and steel producers: AHB, Vizcaya, and Iberia. AHV remained the leader in the Spanish market throughout most of the 20th Century.

Regarding the firms that are the object of our analysis, AHB was established (with its full name as Altos Hornos y Fábricas de Hierro y Acero de Bilbao) in 1882 as the result of the acquisition and reform of two obsolete works, namely *Nuestra Señora del Carmen de Baracaldo* and *Nuestra Señora de la Merced de Guriezo,* both of them belonging to the Ibarra and Cía. Company.[9] The purpose of the works was, as stated in the first meeting of the Executive Committee, to develop in Spain a competitive Bessemer and Martin-Siemens steel making industry. Vizcaya (Sociedad Anónima de Metalurgia y Construcciones Vizcaya) was also founded in Bilbao in 1882. Its initial stockholders were Basque entrepreneurs related to mining and mercantile activities, and represented a more homogeneous group of interests than those of AHB. Vizcaya installed in 1887 three Martin-Siemens converters (a fourth was built in 1889), so as to begin the production of steel, as well as facilities for the transformation of steel into more elaborate products, starting the production of steel in April 1889.

[8] For details, refer to Sánchez (1945) who lists the main producers of iron and steel products that were active in Spain at that period.
[9] This subsection follows González-Portilla (1985).

4. Competition and collusion, 1886-1901

This section describes the evolution of collusive arrangements in which AHB and Vizcaya were active players, before they eventually merged to create AHV in 1901. It also discusses how different factors that might facilitate or hinder collusion affected the cartel agreements in which these two firms were present.

AHB and Vizcaya were initially producing pig iron to begin the transformation of ingot into steel shortly afterwards. Very early on, these firms started making efforts to reach agreements so as to restrict competition in these different markets. Indeed, the first collusive agreement for the sale of pig iron ingot was effective in 1886, merely four years after AHB and Vizcaya were founded. Following the usual definitions in the literature, all these agreements could be classified as explicit rather than tacit collusion. Contracts were signed that clearly regulated the workings of the cartel agreements, and the parties discussed the contents of these agreements in the meetings of their executive committees, reflecting these agreements in the minutes of these meetings. It is interesting to see that a clause was typically included so that the parties would waive their right of going to court in case of contract breaching by some other party. This implied that conflicts among the parties had to be solved within the cartel. Also interesting are the warnings issued in case one of the parties suspected cheating from another party, rather than instantaneous reversion to equilibrium. Table 1 provides a brief summary of all the arrangements that took place between 1886 and 1901 and that included AHB and/or Vizcaya. It displays a summary of cartel participants, scope, and duration of these different cartel agreements.

TABLE 1
Collusive arrangements in the Spanish iron and steel industry, 1886-1901

Duration	Scope	Participants
Feb 1886 - Jan 1888	pig iron	Vizcaya, AHB, San Francisco
Mar 1889 - Jun 1891	iron and steel products	AHB, Felguera, Mieres, Moreda, Vizcaya (1890)
Jan 1893 - May 1896	iron and steel products	Duro, Mieres, Moreda, Vizcaya, AHB + others (1896)
Jul 1894 - Dec 1903	pig iron (for copper)	Vizcaya, AHB, San Francisco (1895)
Feb 1896 - 1900	rails and other products	Vizcaya, AHB
Feb 1897 - 1904	iron and steel	Duro, Mieres, Moreda, Vizcaya, AHB + others

The table shows that the scope of the arrangements was initially limited to the market for pig iron, since Vizcaya would not start production of steel until 1890. During the 1891-93 period, which witnessed a

severe recession in the domestic market, no collusive agreement was in place. Collusion gradually extended throughout the 1890s to include most iron and steel products, and included not only the Biscayan producers, but also Asturian producers such as Duro, Felguera, Moreda and Mieres. Indeed, the 1897 agreement meant the almost complete cartelization of the Spanish iron and steel industry, which were to persist throughout most of the period to 1936.

Before the detailed analysis of the collusive agreements a comment on our approach is in order. Given that the principal source of this study is the minutes of the executive committees, we rely on primary information about the formation, working and dissolutions of cartels. Using secondary indicators –such as prices, quantities and profits– to address our questions would be especially complicated due to the complex, ever-changing economic environment and the lack of data on the costs of the production processes of the firms. All the agreements listed in Table 1 aimed at increasing profits for the participants by joint actions against foreign competition, splitting the market and/or fixing unique, non-competitive prices. The objective of this case study is to identify the factors that made the existence of the agreements harder or easier.[10]

4.1 Communication, cheating and punishment

Theoretical models of collusion predict that cheating will not occur in equilibrium: the parties are able to design a collusive agreement that satisfies the colluding parties' incentive-compatibility constraints. Indeed, the focus of theoretical models is on the identification of conditions for which a given collusive outcome may be sustained. If price wars are observed, they are considered to be part of the equilibrium, as in Green and Porter (1984). Thus, a natural question that arises is whether cheating actually occurs, and what is the parties' reaction.

We observe that cheating indeed occurred several times throughout this period. However, rather than instantaneous reversion to the Nash-

[10] For the above reasons and because we do not offer historical comparisons, the nominal price levels do not play a crucial role in our analysis. However, Carreras (1989) and González-Portilla (1985) may offer interesting historical numbers for the curious reader. For example, the collusive agreement of 1886 on pig iron was born to make prices (initially fixed at 70 pesetas per tonnes) follow the production costs and the movements of the international markets. After the dissolution of the cartel in 1888, Vizcaya offered the same product at 58, San Francisco at 50, while AHB at 70 pesetas per tonnes.

equilibrium outcome, or the use of other punishment mechanisms, the remaining cartel members issued warnings to suspected deviators, tried to avoid punishment, and broke up the collusive agreement only as a last resort. Only if the defecting firm did not modify its behavior, reversion to competition was adopted. This stresses the crucial relevance of communication among cartel participants.

For example, in February 1887 Vizcaya had evidence that San Francisco was selling ingot below the specified price. Rather than immediately retaliating and generating a price war, Vizcaya tried to solve the issue as soon a possible, without even communicating the other firm in the cartel, AHB. This particular problem was solved and the cartel survived until January 1888, being dissolved for totally different reasons.

Another example is the letter sent from Vizcaya to the Ibarra e Hijos Company –which had the exclusive right of shipping ingot to be used in the production of copper, as reflected in the 1894 agreement- on December 31, 1894. Vizcaya complained that AHB had sold iron to the Tharsis Company in the Glasgow market, thus violating its agreement with Vizcaya. The letter suggests that Vizcaya could cease cooperation, but it clearly calls for preservation of the agreement, and demands action by the Ibarra Company. The dispute was eventually settled thanks to the mediation of the Ibarra Company.

Also, the penalties stipulated for cheating are different from those predicted by theoretical models. The worst threat is the dissolution of the cartel itself, which is not instantaneous, but must follow a 30-day notice, as in the 1886 and 1893 agreements. We also observe tailored, rather than industry-wide, punishments. For instance, the 1893 agreement stipulates a 25000 pesetas fine for defection. This fine is to be paid by the deviating firm and, interestingly, this amount of money is not to be received by other cartel members, but is to be devoted to charities.

4.2 Demand stability and non-members' pressure

While the effect of demand fluctuations on the sustainability of collusion has received much attention from the theoretical literature, there is one aspect that has been overlooked by the literature and yet seems to be important in practice. This is that any modification in the level of demand calls for an adaptation to the new situation, which might

create tensions between the parties, and possibly, attempts to renegotiate the terms of the agreement. All this endangers the stability of the cartel. This danger is specially intense in periods of low demand: the parties must adapt quantities produced and/or prices to meet the new demand conditions. These reductions in revenues may asymmetrically affect firms, for instance because of different financial needs, thus creating conflicts, disputes, and costly renegotiation of the agreement. On the other hand, pressure from non-participants may also be a factor affecting cartel stability. As pointed out in Escrihuela-Villar (2008), cartel stability increases the larger the cartel is relative to the total number of industry members.[11]

Falling demand and competitive pressure from firms outside of the cartel was clearly a crucial factor behind the breaking down of the iron and steel products cartel in 1891. This agreement was initially signed by AHB together with three works located in Asturias: Felguera, Mieres, and Moreda. Vizcaya joined the agreement in 1890, once its steel converters became operative. Before entering the cartel Vizcaya pursued an aggressive pricing strategy so as to gain market share, given its high installed capacity and its novelty in the market for steel. However, Vizcaya started production of steel in the midst of a recession, and its presence outside of the cartel endangered its very stability. Indeed, the cartel was about to be dissolved in June 1890 because of competition from Vizcaya, and its entry allowed the cartel to temporarily survive.

The entering of Vizcaya into the agreement called for a redesign of market shares, which generated discrepancies among cartel members, which were aggravated by the falling domestic demand. The agreement was not to last long, and it was precisely Vizcaya the one that chose to stop cooperation. The reason given was the need to react against competition from firms not adhered to the cartel, which were selling at prices below those set by the cartel. Whereas this would have been less of a problem in an environment of growing demand, in a low-demand setting, this clearly endangers survival of the agreement: cartel members realize sales well below the expected level, which may lead towards inefficient proportion and even financial distress. Hence,

[11] In a related work, concerning the negative effect that the competitive pressure that firms outside the cartel impose on the stability of cartels, d'Aspremont *et al.* (1983) show that profits of cartel members increase with the size of the cartel. In their setup the cartel behaves as a price-leader.

the combination of low demand and competition from of non-members caused dissolution of the iron and steel products cartel in 1891.

While collusion is likely to break down during a period of falling demand, an extended period of low demand increases the likelihood of firms seeking understanding and initiating a cartel agreement. Firms realize that their survival is endangered, and contact other industry competitors to raise prices. For instance, in January 1893, after more than one year of competition between Basque and Asturian producers, and in a recession, representatives from the Asturian producers contacted AHB and Vizcaya to try and reorganize the cartel that broke down in 1891. After a short negotiation, which reflected the parties' willingness to reach an agreement in a period of low prices, the new cartel was formed on January 25, 1893.

4.3 Alignment of interests and multimarket contact

The probability of sustainable collusion increases with colluding firms' similarity in cost structure, degree of vertical integration, and the number of markets where they are simultaneously active. Industrial Organization models typically assume that colluding firms are homogenous, although this was far from true in the case that we are analyzing. If they are not, conflicts of interests might arise as soon as the conditions depart from those the agreement is based upon. Regarding multimarket contact, the simultaneous presence of colluding firms in different markets increases the probability of collusion, since deviation in one market prompts retaliation in every market, see Bernheim and Whinston (1990).

Different degrees of vertical integration created a serious conflict of interests among colluding firms in the 1886-88 pig iron cartel. The collusive arrangement specified fixed market shares for cartel members, and there was a system of penalties and compensations for production exceeding or falling short of assigned shares. Prices were set by the Syndicate, which managed orders received by member firms, and had the exclusive right to alter prices. The agreement was extended to international sales in March 1886.

The problem with this agreement, and the reason why it ultimately broke down, was that AHB had the incentive to devote most of its production of pig iron to the production of steel. Hence, the Syndicate had to reject some orders, and AHB consistently produced below

its share, which meant that AHB was a net receiver of compensation payments from the other two firms. With Vizcaya considerably increasing its production capacity, and given the fixed shares for the domestic market, Vizcaya could only use its excess capacity on the much less profitable foreign market. This market was subject to increased protection: for instance, Italy, which absorbed a sizeable amount of production from Vizcaya, raised tariffs in 1887. Thus, the initial design of the cartel agreement greatly benefited AHB, since it ensured a constant flow of revenues through the sale of ingot or compensation by other firms in addition to sales of steel, which remained excluded from the agreement. Vizcaya realized about this perverse effect, and repeatedly tried to renegotiate its share in total sales. Indeed, Vizcaya demanded at least a 50% share in total sales in January 1888, right before the Syndicate was dissolved. Hence, in this case the main reason for the breaking down of collusion was differences in degree of vertical integration among cartel members. These differences generated a perverse incentive on AHB's side to take advantage of the terms of the agreement, which ultimately led towards the dissolution of the cartel.

AHB's refusal to lower prices of pig iron was cited as one of the reasons given by Vizcaya to quit the cartel. Since AHB produced steel, it was in its interest to keep the price of iron ingot high, raising competitors' costs. This caused Vizcaya to produce at an inefficient scale, well below capacity, an effect that is aggravated by greater protection in foreign markets. Evidence suggests that AHB was actually taking advantage of the Syndicate, obtaining extra revenues from sales of pig iron. In fact, AHB's reaction to Vizcaya announcing that it would no longer support the syndicate was to close one of its blast furnaces.

In the 1890s, Vizcaya and AHB produced a similar array of products, and were mainly targeting the domestic market, especially after the passing of the 1891 Tariff Act. The gradual increase in tariff protection in Spain as well as in foreign countries that were markets for Vizcaya's production induced this firm to focus on the domestic market. Most of AHB and Vizcaya's business in the 1890s consisted on supplying independent producers of steel products, and they had an interest in sustaining high steel prices. Hence, the interests of the two firms became more aligned in the final decade of the 19th Century. Indeed, no collusive agreement was signed after 1890 where one of the two firms, but not the other, was present.

Similar degrees of vertical integration also meant that both firms were simultaneously present in a large number of markets. Multimarket contact is expected to be a factor that facilitates collusion, since deviation in one market should to prompt retaliation in every market. This should explain the ever-growing number of collusive agreements where AHB and Vizcaya were present, and the greater stability of these agreements throughout the 1890s. However, there are some facts that are surprising if one expects firms to behave exactly as predicted by theory. For instance, even as Vizcaya announced its exit from the 1889-91 cartel, which also included AHB and Asturian producers of iron and steel, Vizcaya communicated AHB its willingness to continue cooperation in fixing the price of billets. One would have expected AHB to retaliate in every market where Vizcaya was also present, following Vizcaya's exit from the cartel. However, AHB accepted Vizcaya's proposal and both firms jointly set prices in the billets market. A similar situation occurred in May 1896: although collusion among AHB, Vizcaya and Asturian producers broke up, AHB and Vizcaya continued cooperation in the markets for pig iron and rails. Again, communication was crucial for this outcome to arise.

4.4 Existence of monitoring institutions

Collusion models assume that the mechanism that sustains above-equilibrium prices is the threat of retaliation if deviations from the collusive agreement are observed. In these models, it is up to the firms to detect deviations from specified market shares or prices, and hence to monitor the behavior of the rest of the firms included in the cartel. Monitoring effort may fall short of the optimal level if such effort is costly, which reduces the scope for collusion. Therefore, the presence of a party that is not a producer in the market where firms are colluding, but at the same time benefits from the very existence of the collusive agreement increases the likelihood of cartel survival. This is because of this player's incentive to monitor colluding firms' behavior to ensure the correct working of the cartel.

In this line, the distinctive feature of the cartel for the sale of iron to copper producers that began in 1894 was the role of the Ibarra e Hijos shipping company as a monitoring institution. The agreement initially included sales of iron to be used in the production of copper, although the agreement was extended to sales of iron, steel and rolled steel products in 1895. In contrast to the 1886 cartel, the foreign

market was not included in the agreement, mostly because of the low interest of AHB in exporting.

In 1895 AHB, Vizcaya, and San Francisco, together with Ibarra e Hijos signed a five-year agreement with an automatic renewal clause. The deal established members' market shares, stipulated prices, and granted Ibarra e Hijos the exclusive right to ship the goods produced by cartel members. Hence, Ibarra e Hijos had the ability to verify actual sales by cartel members, and at the same time had the incentive to monitor firms' behavior. In fact, Ibarra e Hijos had a strong incentive to verify that no iron was shipped by any other shipping company.

Additionally, Ibarra e Hijos acted as an intermediary in case of disagreement between firms. The fact that Ibarra e Hijos was not a producer of iron confers this firm with the independence required for efficient conflict solving, always seeking the continuation of the agreement. This is undoubtedly a factor that increases the likelihood of collusion being sustained. The continuing expansive cycle of the economy and the monopoly power of the syndicate formed by the three Spanish producers resulted in the highest price level for ingot in Europe. This success implied the extension of the collusive agreement until 1903, even after AHV was founded.

In contrast, the 1886 agreement for sales of pig iron did not originally include a centralized sales agency, it was introduced only in April 1887, following a proposal by Vizcaya. However, in this case, the existence of a common agent was not enough to keep the agreement alive. Indeed, as it was pointed out in the previous subsection, cartel members' interests were so divergent that the sales agent of the Syndicate resigned in October 1887, shortly before the dissolution of the cartel in January 1888.

5. Conclusions

Theoretical models of collusion typically focus on firms' incentives to deviate and the design of punishment mechanisms to sustain above-equilibrium prices. Our examination of the behavior of Spanish iron and steel producers in the late 19th Century suggests that models for collusion may fail to consider interesting features of actual cartel agreements, and calls for a reconsideration of what these agreements really are. In particular, the study of collusive agreements signed by AHB and Vizcaya between 1886 and 1901 allows us to highlight a

number of factors that make collusion more or less sustainable and other features that could be of interest when rethinking theoretical models of collusion.

The evidence presented here stresses the importance of the initial design of the collusive agreement, and how it adapts to a changing environment. If a cartel is to be sustainable, it has to satisfy the parties' incentive compatibility constraints, otherwise the parties will abandon cooperation. Changing circumstances, or perverse incentives embedded in the contract itself, may prevent these incentive compatibility constraints from being satisfied. In this sense, cartels may be seen as incomplete contracts that have a self-enforcing range, see Klein (1996). Within this self-enforcing range, it is in the parties' interest to continue cooperation. As soon as at least one of the parties finds itself outside of this self-enforcing range, cooperation is likely to break down. These situations occur, for instance, after changes in legislation, demand, or degree of vertical integration. In this context, the role of monitoring institutions, for instance a centralized sales agency, is crucial to prevent the parties from cheating, and to solve any dispute that might arise.

This paper precisely provides evidence on factors that shape this self-enforcing range, and also what is the parties' reaction to finding themselves outside of these boundaries. It may therefore suggest future avenues of research for theoretical models of collusion. Since these models focus on a narrow set of features, they may be enriched from considering other dimensions of cartel agreements, such as the ones presented in this paper. Hence, an attempt to fully explain the sustainability of collusion in a particular industry, based on theoretical models where the determinant of sustainability of collusion is, say fluctuations in demand only, may leave out crucial factors which might render such exercises as incomplete. In particular, while falling demand increases the likelihood of collusion breakdown, we also find evidence that suggests that a protracted period of low demand induces industry participants to seek understanding. In contrast, increasing demand, or a raise in tariff protection increases the likelihood of collusion being sustained. In addition to demand factors, we have to take into account whether the cartel includes all the firms in the industry or leaves out a significant number of players. In the latter case, chances are that the cartel eventually breaks up, especially amid a scenario of falling demand.

In our view, the evidence presented and discussed in this paper could be useful to reconcile the notions of tacit and explicit collusion. It is unrealistic to assume, in the case of tacit collusion, that there is absolutely no communication among cartel members, and therefore at some point these cartel members have to specify a set of market shares and procedures to avoid deviations. Obviously, if collusion is illegal, these rules will not be enforceable, but it turns out that they were not in the period that we analyze, since the parties waived their right to enforce collusive contracts in court. Indeed, we observe intense communication between the colluding parties, and we found that this intense communication was crucial to avoid collusion breakdown. In most countries explicit collusion is considered to be illegal, although this does not necessarily imply that communication is inexistent. Indeed, many modern antitrust cases report evidence of intense communication among cartel members. The evidence that we discuss also suggests that exclusive-dealing contracts with suppliers or retailers could provide them with incentives to constitute a channel of communication for cartel members, as well as an effective monitoring institution.

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Resumen

Examinamos las actas del Consejo de Administración de dos empresas vascas de la industria siderúrgica, Altos Hornos de Bilbao y Vizcaya, con el objetivo de discutir la relevancia de diferentes factores en la supervivencia y el fracaso de los acuerdos colusivos de la industria entre 1886 y 1901. Observamos comunicación intensa entre las partes colusivas durante y después de los pactos. La colusión parece fracasar con mayor probabilidad en periodos de demanda decreciente, mientras una demanda fuerte le proporciona estabilidad. Adicionalmente, la existencia de agencias de venta centralizadas y grados de integración vertical similares entre las empresas facilitan la colusión.

Palabras clave: Poder de mercado, colusión, industria ciderúrgica.

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