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“Price Parallelism in the Greek Steel Market: Evidence of a False Cartel Accusation”

Yannis Katsoulacos and Marc Ivaldi

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1. Introduction: Background to the case, the HCC investigation and its findings

1.1 Background

Following dawn-raids in 2008⁴, the Hellenic Competition Commission (HCC) commenced an extensive investigation of the three Greek steel producers (SIDENOR, HALIVOURGIKI and HELLENIC HALIVOURGIA) and of their Industry Association (ENXE). This investigation was following (a) complaints from wholesalers⁵ alleging that the producers were illegally colluding with respect to their pricing and (b) its own *ex officio* study of the Greek steel sector after widespread media reports of substantial common increases in prices. The objective was to investigate “the likelihood that there was a concerted practice between the three companies with respect to their pricing.”⁶ There was no hard evidence found of explicit collusive agreements between the three firms,

¹ The two authors acted as consultants to one of the three Greek steel manufacturers (SIDENOR). We are grateful for excellent research assistance, to Dr. Vasiliki Bageri, for the comments and suggestions and for the data provided, to the SIDENOR managers especially the Commercial Director Nikos Mariou, for providing in a very clear and succinct way detailed description of technical characteristics of production and of their mechanism of competitive price formation. Also to Prof. D Tzouganatos and Dr N. Kosmidis that provided the legal defence for their excellent collaboration and comments. Last but not least we are grateful for the many constructive comments and suggestions by the two editors of this book. We note that Marc Ivaldi was responsible for the econometric analysis presented in Section 5 below and Yannis Katsoulacos for the analyses in the other sections. Of course, all errors and ambiguities remain our own.

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⁴ The investigation continued until 2011, though much of our empirical analysis was based on data from 2002 to 2008. The Decision (no. 617) was taken in 2015 and concerned the *ex officio* investigation of the HCC to determine whether there was violation of articles 1 and 2 of law 703/11 or/and of law 3959/2011, and of articles 101 και 102 TFEU, in the production and sale of steel product. Also it concerned the allegation with protocol number 3636/30.05.2008 for violation of these laws by IRON TENCO A.E. against the 3 steel companies mentioned in the text and some steel wholesalers.

⁵ Specifically, the company IRON TECNO. See Decision of HCC no.617/2015, p. 1 – 5. The complaint referred to “the common pricing policies of the three steel producers as manifested in the common, sudden and simultaneous change in their prices as a result of a cartel-type agreement between them” (p. 5). Also they concerned allegation of the three companies cooperating with a public sectoral R&D company (EVETAM), setting standards in the industry, that made, it was claimed, more difficult the importation of steel into Greece. Here we examine only the first allegation.

⁶ Decision 617/2015, ab.cot. p. 3.

however. Yet there was quite striking documented evidence of price parallelism during some specific periods (details are provided below) and, specifically, evidence of the three firms changing their prices more or less simultaneously, which kept relative (list) prices more or less unchanged during the time that new list prices were announced by each firm. Accordingly, the HCC was concerned that the three steel producers were involved in tacit collusion or a concerted practice, possibly supported by their association ENXE⁷, that resulted in excessively high prices.

The three producers and ENXE categorically denied any involvement in price coordination, claiming that their behavior had always been independent and completely legal, that they were engaged in strong competition, and that the Greek steel market could not support collusive agreements. We were asked by SIDENOR to examine their claim that their behavior was not collusive and indeed could not be other than competitive. For this we used extensive economic analysis, detailed data about the evolution of prices in relation to costs, production and capacity levels, imports, and exports, and modelling of the structural conditions of the market, as well as econometric analysis.

In this case study, we draw on our findings to present a case of a mistaken allegation of collusion. We will explain, in the context of this case, that competition and collusion can be difficult to distinguish on the basis of observed patterns of price evolution which contain incidences of parallelism. Subsequently, we will discuss a number of ways through which a proper distinction can be achieved. In other words, our analysis of the Greek steel market serves to demonstrate how it can be shown that competitive behaviour can provide a reasonable alternative explanation of the patterns of price and other market changes to that of tacit collusion.

The difficulty of correctly associating price parallelism with tacit collusion⁸ is of course appreciated since the early landmark European case of Wood Pulp⁹. The HCC Decision recognizes this as the case that “has prescribed the relation between (legal) price parallelism and (illegal) concerted practice” (p. 105). As observed by the Wood Pulp Decision, “when parallel behaviour can be explained with reasonable reasons other than those associated with the existence of collusion, in the conditions of the case under investigation, **the parallel behaviour cannot be considered illegal**, because it constitutes the legal consequence of (oligopolistic interaction)” (p. 106). The allegations against the Greek steel producers were based on the assumption that the behavior of the Greek steel producers could not be explained other than as collusion, which we show to be false.

⁷ Through information exchange. See p. 98 of Decision 617/2015. The HCC investigation focused on the potential existence of a concerted practice (p. 102).

⁸ See also the Decision 617/2015,

⁹ Judgment of the Court of 27 September 1988. - A. Ahlström Osakeyhtiö and others v Commission of the European Communities. - Concerted practices between undertakings established in non-member countries affecting selling prices to purchasers established in the Community. - Joined cases 89, 104, 114, 116, 117 and 125 to 129/85.

After a thorough examination of the steel market in Greece and of the behaviour of the three producers, and taking into account the arguments put forward by the defendants and their consultants, the HCC considered in its Decision 617/2015 that there were not grounds to support the allegations of collusive behavior and decided to acquit the companies of this charge. To reach this conclusion the HCC relied on three considerations:

- (i) Market structure characteristics and demand fluctuations were not such as to create the conditions that, according to economic theory, are associated with a strong likelihood of collusion. Furthermore, a very high degree of transparency can be considered responsible for the quick adjustment in the prices of the rival producers to a change in the (list) price of one of them (p. 112 – 115). We examine this consideration in the next sub-section and in section 2 below.
- (ii) The evolution of prices and other market changes can be explained reasonably and plausibly as an outcome of competitive behaviour, which implies, according to EU case law mentioned above, that parallelism cannot be considered illegal. We examine this in sections 3 and 4 below.
- (iii) Finally, the HCC established from the information it collected from the three companies that price parallelism did not, in by far most cases, involve *final prices* paid by their customers, which implied that there was competition between the producers through the use of discounts on their list prices (p. 111 of the Decision).¹⁰

1.2 The HCC investigation

In the context of procedures that it used to obtain detailed information about the three companies' pricing practices, the HCC undertook dawn raids in July 2008 at the offices of the three steel producers as well as of ENXE and 9 wholesalers. It also collected information from extensive questionnaires sent to the producers, ENXE, the Greek Standardisation Organisation, and the Greek Statistical Office.¹¹ Preliminary findings of patterns of price parallelism that were identified motivated the HCC's subsequent investigation.¹²

Concerning pricing practices, as observed by the HCC in its Decision, two of the steel producers issue, as a matter of policy, list prices for all the steel products for all areas in Greece. Their clients are aware of these wholesale prices, and each customer

¹⁰ See also below. It should be mentioned here that our information did not extend to information on the level of final prices of the three producers.

¹¹ Decision 617/2015, pages 33 – 34.

¹² These preliminary findings were subsequently shown not to constitute an appropriate basis for supporting the allegation of a concerted practice, as mentioned above.

can negotiate discounts that could be applied to its contract. The HCC found that the majority of *price adjustments to their clients by these two producers involved adjustments in the list prices*. Thus, for the period 2004 – 2011, one of the two producers adjusted its list prices 75 times and adjusted its prices through discounts 12 times. The other company had adjusted its list prices 78 times and its prices through discounts 5 times. With regard to price parallelism, “both companies adjusted their prices either directly or through discounts, by the same amount, either on the same day or with a day difference 76 times”¹³. The third company did not issue list prices. In order to compare its price adjustments to those of the other two companies, the HCC used the “price offers” made by the company during 2004 – 2008 (obtained during the dawn raid from the company’s electronic files). In three days during 2008, it was found that “all three producers adjust their prices in a common way (simultaneously and by the same amount).”¹⁴

Concerning the adjustments in the list (or offer¹⁵) prices, the HCC notes that all firms described exactly the same process that justifies the high speed of adjustment (depicted in a Diagram in p. 64 of the Decision): “a change in the cost in the international or domestic market creates the need to adjust prices and this is announced immediately by one company or plant (within 1 hour), and the information is diffused quickly between competitors, so an announcement follows immediately by the other companies.”¹⁶

1.3 Additional remarks regarding the process of price formation

Some more remarks concerning the process of price formation and adjustments are useful here.¹⁷ To start with, all three firms can get, from the same sources, the same detailed information each morning, at the same time, international and regional price levels and price changes for each product type. This allows them to determine the maximum price that a Greek producer would be able to sell in the domestic market given the prices that Greek importers can purchase steel in other countries *and deliver*¹⁸ it to Greek customers. Note that there are wholesalers that are pure importers of steel. This maximum price will be different for different countries. There will be such a maximum price related to imports from Italy, the country that can provide equivalent quality steel with the minimum differences in other conditions (e.g., credit) to that of Greek producers at minimum transport cost, and higher

¹³ Decision 617/2015, p. 61.

¹⁴ Decision 617/2015, p.63.

¹⁵ As noted for two firms it is the lost prices and for the third the offer prices.

¹⁶ Decision 617/2015, p. 63 – 64.

¹⁷ The information in the remainder of this section was obtained from our own interviews of company representatives.

¹⁸ These prices are the ex-works prices (see below) in the country of origin, plus transport cost, plus various duties that have to be paid in the ports, plus the margin of the wholesalers.

maximum prices related to other countries. The domestic producers operate in one of the most competitive regional markets in the world which includes Italy, Turkey, and Ukraine, all of whom are some of the largest producers and exporters of steel worldwide.

Focusing on a maximum import price, this *reference price* is common knowledge to all Greek producers and importers at any given time; it is determined outside the Greek market, and so they consider it as exogenous as far as they are concerned. Demand in Greece is too small to influence the import prices from Italy or Turkey, two very large international players in the steel market.¹⁹ The demand faced by the domestic producers has a kink at the price level corresponding to the reference price of imports. Given total domestic demand at prices lower than this level, imports are given by total demand minus domestic production which depends on the capacity levels of the three producers. Along with the ex-works export price²⁰, the marginal production cost (the maximum of which determines “effective marginal cost”) and the production capacities of the producers, we can determine the monopoly (or full collusion) price, the oligopolistic competitive price, and the efficient (perfectly competitive) price and corresponding output levels. The producers claimed that their prices were the oligopolistic competitive prices or, for short, “competitive prices”.

The reference (import) price is changing when cost conditions change (especially the price of the main input, scrap, which takes up 60% of the final price, as well as other materials and energy) or there are changes in the factors that affect demand for steel regionally and internationally (primarily related to the construction industries). A change in the reference price induces a change in the competitive domestic list prices²¹ announced by the producers to the wholesalers or other customers, who are seeking new contracts and trying to get the best deal. A change in domestic prices can also be induced by a change in domestic demand.

As noted above, the HCC Decision mentions that all companies explained in the same way why the competitive changes in list prices - independently set (as they claimed) - in response to changed market conditions, would be announced at about the same time²². We add here the importance in explaining the actions of wholesalers and other (direct) customers when a change in price is announced by one of the producers. They will immediately inform the other producers of this change in order to confirm this is an industry wide change, something which leads to the immediate

¹⁹ In 2011 Greek production was about 1.8 million metric tons (which covered domestic demand), compared to 30m in Italy, 35m in Turkey and 36m in Ukraine.

²⁰ This is the price that a Greek producer receives from exports net of any transport, port, shipping, and insurance costs that the buyer has to incur to get the steel to its location.

²¹ Or, as mentioned above, offer prices for one producer that does not issue list prices. As also noted, Greek producers may offer quantity discounts to their customers or, for example, provide credit or delivery facilitation.

²² The decision to change prices may not be immediate as producers may wait a few days to confirm that the change in market conditions affecting the regional and international price levels are not temporary. This does not affect the argument that follows.

announcement of price changes by the other producers. This actions by wholesalers and other customers is necessary in order for them to ensure that:

- (i) They cannot get a better deal from another producer or, in the case of a wholesaler facing a price fall, that it does not lose customers who get better deals from other producers;
- (ii) They know the current value of their stock;
- (iii) They do not sell to their own customers (in case of wholesalers) at too low a price relative to the price that will prevail in the market.

However, given the asymmetries between the producers, these actions of wholesalers do not necessarily imply that the changes in prices will be the same, as the HCC notes that they are in a number of cases (see above the information provided in the Decision). As noted also below, this suggests that specific pieces of evidence are not sufficient for proving the presence or absence of collusion and that it is only the combination of the assessment of various considerations together that can allow a judgement.

2. Market analysis: do market conditions support the hypothesis of a strong likelihood of tacit collusion?

2.1 Introduction

In this and the next section we present two approaches that were used to examine the hypothesis that there was tacit collusion between the three steel producers in the period under examination:

- (i) Section 2 offers an investigation of the structural characteristics of the Greek market;
- (ii) Section 3 involves an investigation that relies on a number of screen tests applied to the available data²³, on prices, costs, shares, capacities, domestic demand, volume of domestic sales, imports, and exports, in order to identify patterns in the evolution of the data that would be unlikely to hold in the presence of tacit collusion between the producers during 2002 – 2011. A model of Bertrand-Edgeworth (B-E) competition between three capacity-constrained sellers was used to describe the competitive market equilibrium and compare with the collusive outcome.
- (iii) Section 4 provides further empirical evidence to support the main conclusions derived from the analyses presented in Sections 2-3. To do so, we estimate a differentiated-products oligopoly model while taking account of the competitive constraint imposed by the international steel

²³ See for example, Harrington (2005, 2006) and Abrantez-Metz and Bajari (2009).

market and then test which behavioral hypothesis - collusion or competition - best represents the functioning of the Greek steel market.

2.2 The nature of products

The investigation concerned three steel products: reinforcing steel in bars (known as rebar), common steel mesh, and steel jackets. These are complementary products of steel used in certain proportions in the construction industry. Rebar, being the main product and making up about 85% of total domestic production, is the focus of the econometric analysis. These products are to a large extent homogeneous, though there are attributes related to the products themselves and to the services provided by each of the firms that could make wholesalers and their customers treat firms as offering differentiated products; this is particularly true of imports with which it is easy to supply the Greek market mainly from Italy, Turkey, and to a lesser extent Ukraine and Egypt.²⁴ This is due to the fact that imports may not satisfy all the technical standards which are established by the Greek Standardization Organization (though this does not hold for Italy and other EU countries). Quality differentiation may be the result of differences in the purity of the main input used in steel production (scrap). The main other differentiating factors are:

- (i) The credit conditions provided, which are usually better from Greek producers and may differ even between the latter;
- (ii) The amount of time needed for delivery, especially at times when there is a trend of price reductions;
- (iii) Exchange rate risks for imports from outside the EU;
- (iv) Greek producers differ also in the range of varieties offered in order to satisfy customised orders as well as in various peripheral services offered depending on the size of their distribution network and sales force that can lower transaction costs and strengthen the perceived quality of purchasing by a specific producer.

According to available data, about 80% of the buyers purchase steel from all the different Greek producers which implies a significant degree of homogeneity but also the presence of some differentiating factors. Also, SIDENOR is able to charge a price per ton that is slightly above (by about 1 – 1,5% or 3 – 5 euro) that of the other Greek producers and the Greek producers can charge slightly higher prices than those of steel producers in other (especially non-EU) countries, without losing customers for the reasons mentioned above.

2.3 Structural conditions

²⁴ Imports from other EU countries, e.g. Spain, are certainly feasible too, at somewhat higher transport cost and, indeed, Greek producers have also been exporting in some periods to Spain.

According to economic theory²⁵, sustainable tacit collusion can occur if two necessary (though not sufficient) conditions hold:

- A. Firms must all have the incentive to reach a common understanding concerning the prices to be charged;
- B. The conditions in the market must be suitable for making coordination feasible. Specifically, there must be:
 - (a) an ability to monitor the behavior of rivals;
 - (b) a credible mechanism for deterring cheating;
 - (c) conditions that allow the coordinated behavior to be sustainable.

We discuss the main conditions known to result in an incentive and an ability to collude and assess whether they apply to the Greek steel producers case to an extent that would give support to the hypothesis of illegal cooperation.

A. Incentives for cooperation

The strength of the incentives for cooperation depends on the strength of the producers' common interests in the cooperative scenario, something that depends on the extent to which strategic objectives are sufficiently aligned. Strong incentives will result under various conditions, but the following factors are particularly important:

- (a) Cross-ownership: each firm has financial interests in the other firms even if these do not imply control of the other firms;
- (b) There is significant symmetry between firms – in terms of market share, capacity, cost and demand conditions;
- (c) Absence of “maverick” firms, that is, of firms that constrain effective coordination because they do not have the same incentives in cooperating.

None of the above factors was present in the Greek steel industry. The three companies did not (and do not) have financial interests in each other and so this significant factor that strengthens incentives to collude is absent.

When there are asymmetries, firms are *less likely* to “agree” on a common collusive price that is significantly higher than the competitive price; even when this is achieved, some firms are more likely to end up with strong incentives to deviate from the “agreement” and not to be equally disciplined by the prospect of punishment. While the demand conditions are broadly symmetric between the three companies, there have been quite strong asymmetries in market shares, mainly as result of asymmetries in production capacities, and also asymmetries in cost between at least two of the companies.²⁶ These asymmetries weaken the incentives to collude

²⁵ See Ivaldi, Jullien, Rey, Seabright, Tirole (2003) for a succinct summary.

²⁶ This was confirmed by the HCC Decision, p. 113 – 114.

especially when the total production capacity in the market is inadequate²⁷, as it was in 6 out of the 8 years in the market under examination.

In relation to asymmetries, it is also worth mentioning here the factor of “multi-market presence” (which is also relevant in the discussion on feasibility of tacit collusion below).²⁸ While multi-market presence can facilitate collusion when it is limiting asymmetries, this is not the case here: while there is presence in other markets of the Greek producers, this presence actually *increases* the asymmetries between them because the producers with the higher domestic market share have also the largest presence in other markets.

Maverick firms can be smaller firms that are in a phase of expansion of their production capacity, something that can lower significantly the collusive price and the share of profits of the other firms and hence lead to a breakdown of the tacit agreement. In the Greek steel market, one firm faced a significant capacity disadvantage in 2002 but managed to reverse this by internal growth - significant investments in increasing capacity (that often seemed not to make good economic sense to its rivals and other observers) - and thus increasing market share from 7% to 27% by 2009. Thus, the behaviour of this firm during the period under consideration is consistent with that of a maverick firm.

Hence, we can conclude that the relevant structural conditions present in the Greek steel market in the years 2002 – 2011 *do not provide strong incentives* for collusive behaviour, though we recognize that asymmetries between the producers are not generally incompatible with collusive behavior. This suggests that individual screen tests in isolation for proving collusion or no collusion can be of limited value. It is really the combination of various indicators, including a convincing set of alternative, competition explanations for observed behavior that should be decisive for a judgement.

B. Is collusion feasible?

(a) Ability to monitor the behavior of rivals.

This depends on:

- The degree of market concentration, on market transparency, market stability, and predictability of demand evolution.

The high concentration implied by the presence of just three firms that are active in the Greek steel market and the high degree of transparency (on which we will return in more detail below) facilitate the monitoring of rivals. However, market conditions were volatile during the period under investigation with domestic demand falling from 2050 tons in 2002 to 1800 tons in 2004, then rising to 2300 tons in 2006 and falling again to 1817 tons in 2008. The two declines in

²⁷ See Compte, Jenny, and Rey (2000) for an analysis of the effects on collusion of capacity levels.

²⁸ Bernheim and Whinston (1991) and Evans and Kessides (2001).

demand were anticipated as they followed the big increase induced by the Olympic Games (that took place in mid-2004) and the big increase induced by the change in the regulatory framework²⁹ that affected favorably the Greek construction industry in 2005 and 2006. Under such conditions,³⁰ it was relatively difficult for the steel producers to achieve tacit collusion at least prior to the anticipated demand decreases.

- Product differentiation and discount-based pricing³¹

This could in principle affect the monitoring of rivals' behavior but we did not expect an adverse effect on monitoring in the Greek steel market where as mentioned above there are certainly no strong elements of product differentiation. On the other hand, as mentioned, the producers' competed rigorously on the basis of discounts off of their announced list prices, which are very difficult for rivals to monitor.

- Asymmetries

Given the high degree of market transparency, we did not expect that the asymmetries between the three steel producers would significantly affect monitoring of rivals.

(b) A credible mechanism for deterring cheating.

While transparency and ability to monitor rivals' behavior, as well as the fact that prices are often adjusted (see also below) facilitate retaliation following deviation of a rival from the tacit agreement, the threat of retaliation was not credible because, for most of the period 2002 to 2008, the firms were facing capacity constraints in expanding production and costs increase very rapidly after production exceeds 75% of this capacity (see also below).

From the above it follows that, while the factors that affect the monitoring of rivals' behavior are not overall unfavorable to establishing a tacit agreement, there was not an effective mechanism of deterring deviations from this agreement and hence the likelihood of tacit collusion having been sustained was small.

(c) Conditions for the coordinated behavior to be sustainable.

The conditions for sustainability were not satisfied:

- As already noted, one of the three firms could be characterized as maverick;
- Potential competition is strong. There are no legal or regulatory barriers to the entry of new firms or the expansion of smaller rivals in the domestic market though there is quite a significant sunk entry cost for the establishment of a new plant. But it is worth mentioning that one of the three firms

²⁹ That reduced taxation on new building construction.

³⁰ See Haltiwanger and Harrington (1991).

³¹ See Motta (2004) and Ross (1992).

(HALIVOURGIKI) exited the market in 1990 and re-entered without difficulty in 2000, while expanding its capacity and market share to 27% by 2008. However, potential competition is very strong because of the ease in importing steel to Greece; on average over the years 2002 – 2008 when the capacity of Greek firms was constrained in most years, imports made up about 15% of market supply. The availability of imports, with Greek wholesalers sometimes having been active only as importers, limits considerably the ability of Greek producers to jointly increase prices to supracompetitive levels since these are constrained by competition from other countries' producers.

- Significant buyers' power can reduce the sustainability of collusion³². In the Greek steel industry, while most buyers and wholesalers do not have significant power, their power is not always negligible. For example, a very large construction company accounted for 15% of SIDENOR's sales and one wholesaler accounted for 10%.

Considering all the above factors we conclude that the likelihood of tacit collusion to be sustainable was low.

Overall, the conclusion from the above qualitative analysis is that there were weak or no incentives for collusion in the Greek steel market and, while there were some factors that could have been conducive to collusion, other factors constrained significantly the extent to which collusion could be feasible and sustainable in the period under examination. Of course, in and of itself, this does not prove that there was no collusion. Yet it indicates that structural market conditions in the Greek steel industry were more conducive to competitive than to collusive behaviour.

3. The likelihood of tacit collusion: screen tests

As noted above, a number of screen tests were also applied to the available data on prices, costs, shares, capacities, domestic demand, volume of domestic sales, imports, and exports in order to identify patterns in the evolution of the data during 2002 – 2011. A model of Bertrand-Edgeworth (B-E) competition between the three capacity-constrained sellers was used to describe the competitive market equilibrium and compare it with the collusive outcome. The results are summarized below.

Conclusion 1:

The Greek steel market faced excessive domestic demand (relative to total capacity of the three producers) in 2002 – 2003, excessive capacity in 2004, excessive demand in 2005 – 2006, and excessive capacity from 2007 – 2011. Despite these episodes of insufficient demand, two of the three producers invested heavily in new

³² See, for example, Ivaldi et.al (2003), p. 53.

capacity during this period and SIDENOR's investment was intended to reduce its costs. The increase in capacity is related to the elimination of imports, that fell from 18% in 2003 to 0,7% of domestic steel consumption in 2010. Domestic consumption is about the same in 2003 and 2007 but domestic consumption was significantly reduced after 2007 while capacity had at the same time significantly increased³³. The behaviour that led to the increase in capacity (especially by one of the firms that could be characterized as a maverick) is not compatible with sustainable tacit collusion but it is compatible with strong competition between the three producers.

Conclusion 2:

As already mentioned and is clear from Table 1 below, the market shares of the three producers fluctuated over the period examined without a negative correlation, and these fluctuations in shares were not the same so relative market shares changed. This is another sign of strong competition between them for market share³⁴.

Conclusion 3:

SIDENOR's delivered price in periods of excess capacity fell below the prices of imports from Italy and even Turkey, though when there is no excess capacity prices track or are a bit higher than those of these countries, indicating competitive behavior.

Conclusion 4:

When we move from excessive demand to excessive capacity as happened between 2004 and 2007, the domestic ex-works prices converge to the export prices (the effective marginal cost), something consistent with competitive but not collusive behaviour. Further, exactly as predicted by the model of competitive behaviour, in period of excessive capacity there is a strong squeeze of the ex-work prices to marginal cost. This conclusion is strengthened when we calculate prices net of the cost of credit facilitation and of the unit avoidable cost, for then the margins are *negative* from 2008 onwards.

Conclusion 5:

³³ This increase in domestic capacity and significant reduction in demand meant that imports were squeezed out. Indeed, domestic demand fell significantly following the 2004 Olympic Games but, in anticipation, the government introduced a new law after the Games that lowered taxes on new building construction which led to a temporary increase in the demand for steel up to 2007.

³⁴ We remind the reader that domestic prices were kept just below the delivered prices of imports (otherwise imported steel could easily satisfy all domestic demand) and imports were equal to domestic consumption minus the production of the three Greek producers. When domestic capacity was still low relative to domestic demand, imports were quite significant but their share converged to zero as domestic capacity was increased and domestic demand was reduced.

Some other price-related screen tests for collusion are also relevant. These are the following³⁵ (the third test has been performed by, for example, Abrantez-Metz R., L. Froeb, J Gewke, and C Taylor, 2005)³⁶:

Under collusive behavior, price increases do not appear to be explainable by increased costs. We observe that this is not true for domestic prices when taking into account that export prices constitute the effective marginal cost of domestic producers.

Under collusive behavior, discounts are eliminated which is something that has certainly never occurred in the market under investigation.

Prices tend to be stable under collusion and do not follow cost movements very closely. We calculated the mean, the standard deviation, and the coefficient of variation ($CV = \text{mean} / \text{standard deviation}$) of SIDENOR's domestic final prices, domestic marginal production cost, and export EXW prices. Under competitive behavior, one expects the standard deviation and CV for domestic and EXW export prices and domestic marginal cost are quite close and this is indeed what we find. Actually, the standard deviation of final and EXW export prices are almost identical and the CVs of prices and marginal production cost are extremely close³⁷.

The results in this and the two previous sections support the overall conclusion that the evolution of the market in the period 2002 – 2011 can be more satisfactorily interpreted in terms of a hypothesis of competition than a hypothesis of (tacit) collusion.

4. Econometric analysis of the Greek steel market

In this section we offer further empirical evidence that the observed pricing in the Greek steel market at the time was not collusive. We consider a differentiated-products oligopoly model and show that the pricing patterns are consistent with competition and not with monopoly. To that end we estimate both demand and supply sides of the industry before testing for collusion against competition. Although the main product is reasonably homogenous, the commercial practices of the different firms (as noted in Section 2) could introduce a significant level of differentiation, which we need to consider. This explains the choice of the model that we detail later.

In the sequel, for brevity, we name the three firms of the industry as A, B, and C, and we name the main product type (rebar) product X.

³⁵ They are included in the survey of Abrantez-Metz and Bajari (2009) "Screens for Conspiracies and their Multiple Applications", *Antitrust*, Vol. 24.

³⁶ In "A Variance test for collusion", FTC Working Paper.

³⁷ The relevant Table cannot be reproduced here as it contains confidential information.

Before presenting the econometric analysis, let us first provide a description of the data made available to us.

4.1. Descriptive analysis

The data, which covers the period 2002-2008, are complete for firm A and for the whole industry. They bear on the domestic prices of firm A, its domestic production levels and exports, its production capacities, the prices of raw material Y, the prices of international product X, the production capacities of competitors, and the level of Greek exports of product X. Some approximations of the market size are also available. However, we do not observe the prices of product X sold by competitors, nor do we have measures of any quality differences between the firms' products.

4.1.1 Market figures

The three main competitors' domestic market shares during the period under investigation are reported in Table 1. Firm A's market share is the highest during the period under consideration, fluctuating between 35% in 2005 and 42% in 2008. The yearly difference in terms of market share between Firm A and the second largest producer, namely firm B, is about 10%, except for 2005. The third producer, firm C, experiences a jump in its production level in 2004-2005 following the increase in its production capacities. Up to 2004, firm C's market share is lower than the market share of importers. Since 2005, this trend is reversed. Finally, observe a sharp drop in imports at the end of period.

The differences in market shares across competitors might be indicative of differentiation among their products, though they also reflect differences in capacity levels. In the absence of any differentiation,, and keeping capacity unchanged, the industry should tend to a symmetric equilibrium. (See however Besanko and Doraszelski, 2004, on this point.)

Table 1: Product X market shares

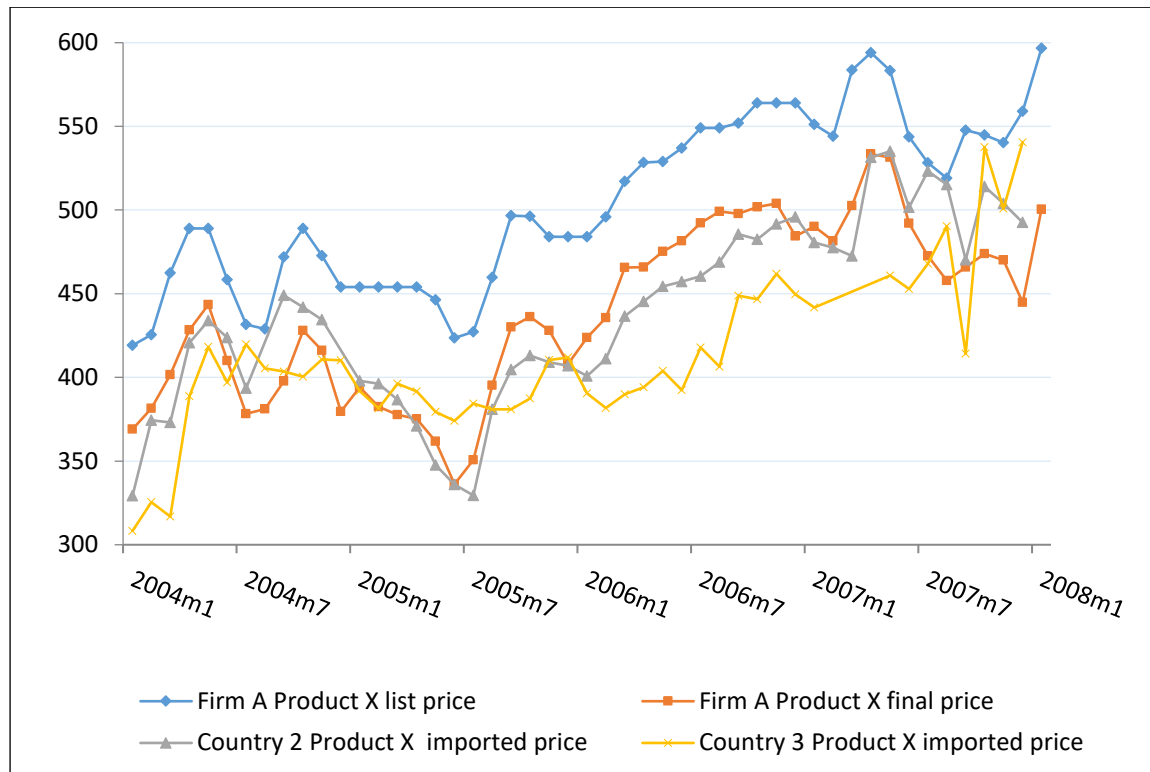
Undertaking	2002	2003	2004	2005	2006	2007	2008
Firm A	40%	36%	37%	35%	37%	40%	42%
Firm B	31%	34%	33%	33%	27%	30%	25%
Firm C	8%	8%	13%	21%	18%	23%	28%
Imports	20%	22%	17%	11%	18%	7%	4%

Source: Confidential industry data

Two types of prices are available for firm A: the list price and the final price³⁸. Their evolution over the period are similar, as shown in Figure 1, but the list prices are significantly higher than the final prices. As the final prices are the prices actually paid by customers, they are more relevant than list prices in the analysis of the demand side of the market.

The main importers of product X (Italy and Turkey) are referred to as country 2 and country 3; they compete with domestic firms' products. Although the final prices of firm A are often higher than the prices of importers, there remains a positive demand for the domestic products. The domestic firms might take advantage of their domestic position, differentiating their production of product X through commercial networks and marketing activities. In the sequel, we aggregate the importers (which, from hereon, we refer to as the Representative Importer) and we use a weighted average of importers' prices for the price of imports.³⁹

Figure 1: Final prices versus list and imported prices



Source: Data on the industry provided by SIDENOR. The unit is euro per ton.

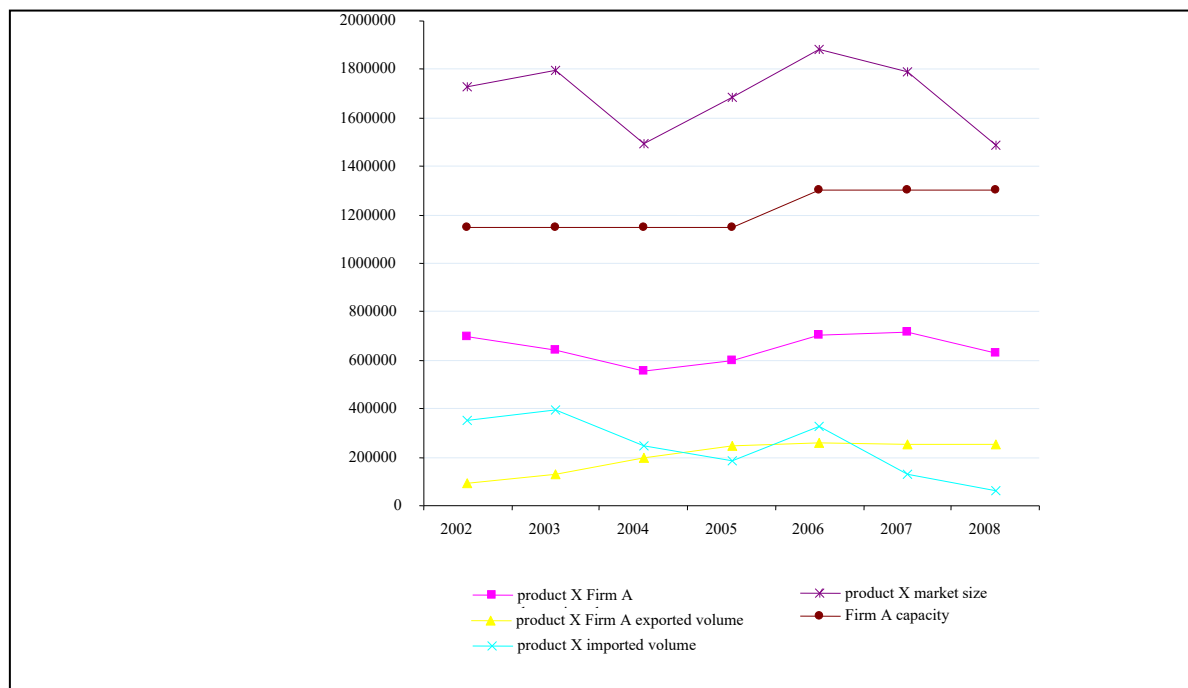
Consider now the quantities. The relevant quantities are firm A's production, both for domestic and international markets. We observe that firm A's domestic production decreases until 2004, then increases until 2007 (see Figure 2). There is a downturn starting in 2008. The level of imports and the total market size show roughly

³⁸ See the end of section 1.1 for a discussion relating the pricing policies of the companies to list prices and final prices, where the latter are the list prices after discounts are applied.

³⁹ We could have used the lowest price of importers prices and it would not affect the conclusions.

the same evolution, while the exports increase until 2005 and remain stable thereafter. Firm A's production capacities increase in 2006.

Figure 2: Domestic market size, level of productions and capacities



Source: Confidential data on the industry. The volumes are expressed in tons.

4.1.2 Discussion on capacity constraints⁴⁰

A crucial issue related to identifying the market equilibrium is to characterize the level of capacity utilization (Figures 3 and 4). If one looks at the situation of firm A as presented in Figure 3, the level of capacity utilization is higher than 75 percent, which is considered the efficient level of production⁴¹, in all years except in 2003 and 2004; these latter years experience excess capacity.

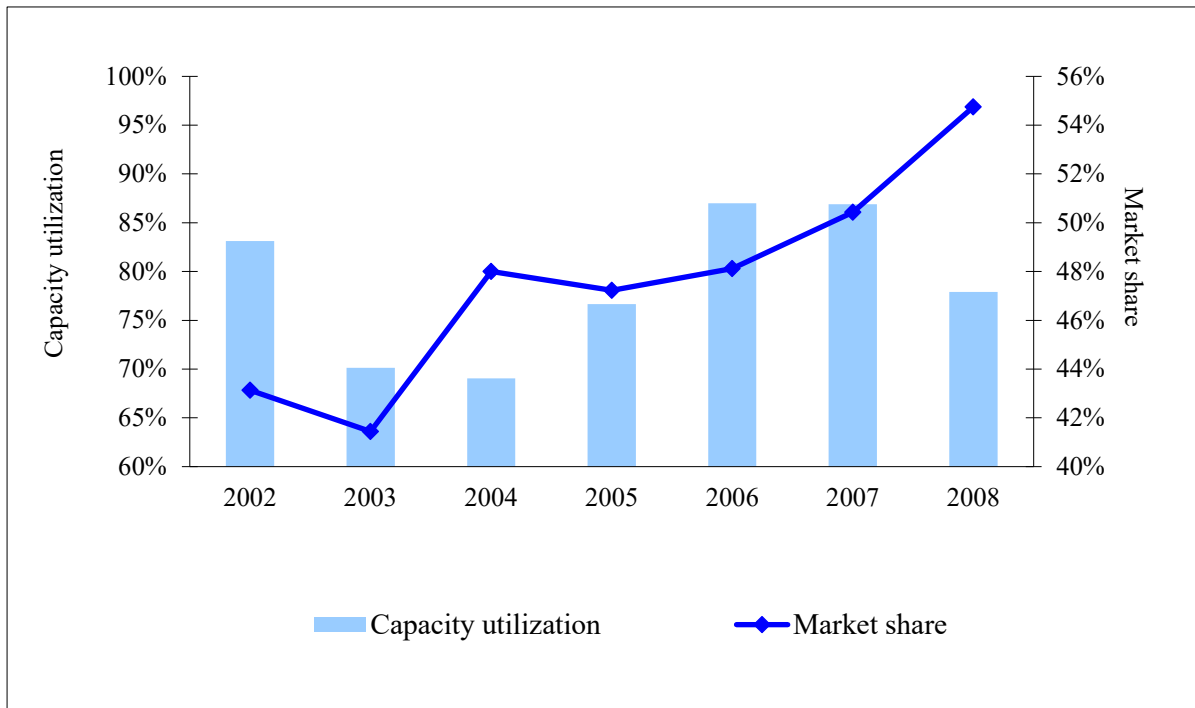
Figure 4 displays how the capacity utilization has evolved during the period under investigation at the industry level. We observe only one year where there is excess capacity, specifically 2004. With 76.09 percent capacity utilized, the year 2008 is just at the threshold for full capacity utilization. These are two specific years: 2004 follows a period of economic boom and 2008 is the beginning of the international downturn.

Given that we restricted attention to static equilibria (mainly because of limited time to develop the econometric analysis), we propose to apply a model for each period depending on a state of excess or full capacities.

⁴⁰ Here we consider total capacity referring to physical capacities that can be directed to domestic sales or to exports.

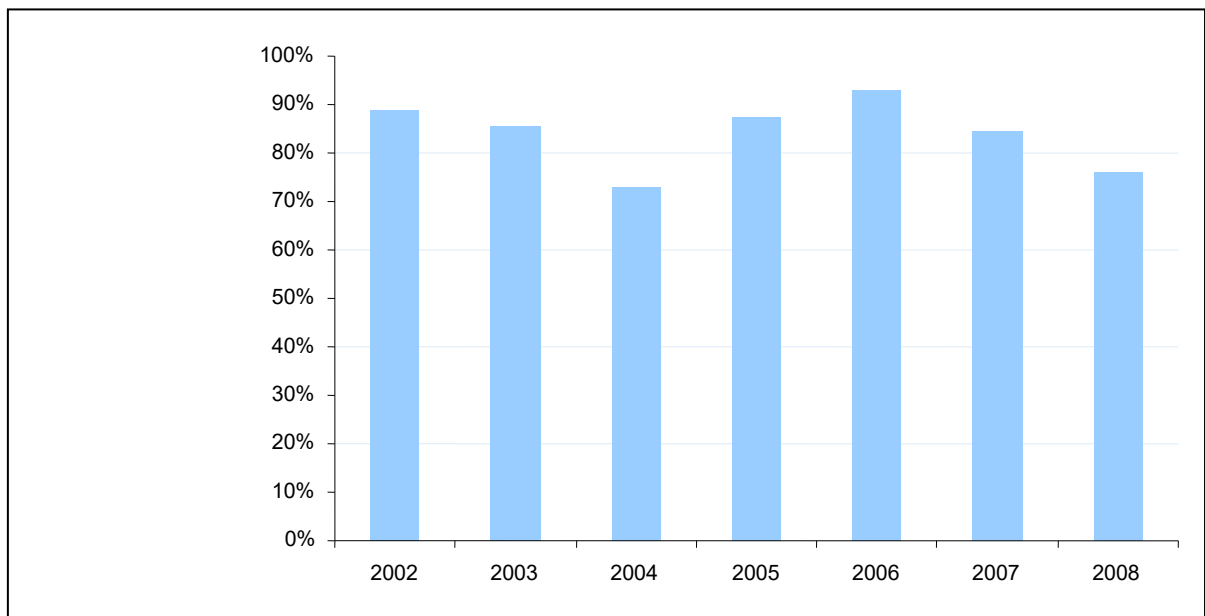
⁴¹ That is, the level of production at which unit cost minimisation is achieved. The figure of 75% is based on information provided by the company directors.

Figure 3: Capacity utilization and market share for firm A



Source: Confidential data on the industry.

Figure 4: Capacity utilization at the industry level



Source: Confidential data on the industry

4.2 The empirical analysis

The empirical analysis is performed in four steps. In the first step, we build a mathematical representation of the working of the industry. The second step is

devoted to the estimation of the model under the assumption that the market is competitive. The third step provides an estimation of the model when it is assumed that the main firms on the market formed a cartel and, more specifically, are behaving like a monopoly. Finally, the fourth step consists in comparing the two estimations in their capacity to represent reality, i.e., detecting which form of conduct – competition or collusion – is the most statistically adequate to represent the working of the market. The main result is that, in the industry under consideration and regarding the period of interest, the competition model statistically performs better than the collusion model.

The innovative part of our analysis lies in the use of a limited amount of information. Indeed, by assuming that the imports play the role of the outside alternative for the domestic customers and are provided by an importer with no strategic capacity in terms of price competition – which, we consider, are mild assumptions - we easily reach identification of a static Nash equilibrium based on a logit-type demand model. This adds to the originality and the specific interest of the proposed model.

Appendix 1 provides the model notation. The mathematical specification of the demand for product X is precisely described in Appendix 2. Appendix 3 describes the supply equations as well as the equations resulting from the firms' maximisation program. The econometric specification is discussed in Appendix 4.

4.2.1 Empirical results

The estimation results are reported in Tables A5.1 and A5.2 in Appendix 5. We focus here on the main economic indicators that allow us to select between the different models and assumptions, i.e., whether the capacity constraint is or is not binding and whether firms' behaviour is competitive or collusive. The economic indicators are the estimated own-price elasticities of demand, the level of estimated margins, and the estimated marginal cost in the case of non-binding capacity constraints. Moreover, the sign of some of the parameters has to be checked for economic consistency. First, we discuss the estimated model under the assumption of binding capacity constraints. We compare the level of economic indicators obtained under the competitive assumption and under the assumption of coordinated practices. Second, we discuss the results of the models estimated under the assumption of non-binding capacity constraints. We compare the level of economic indicators obtained under the two behavioural assumptions. Finally, we present the results of a statistical standard test, the Vuong test, which is a specification test that is used to evaluate which of the conduct assumptions best represents the observed data.

4.2.1.1 Binding capacity constraints

Under the assumption of binding capacity constraints, the equilibrium is described by three equations: the demand addressed to firm A or to the monopoly, the demand addressed to the Importer, and the mark-up. The estimated parameters of the competitive and coordinated models are reported in Table A5.1 of Appendix 5. All the parameters are statistically significant at the 1% or 5% level, whether competitive or coordinated behaviour is considered. The parameters δ_i , $i=0,1$, which reflect any own firms' characteristics, are positive, as well as the marginal utility of income, α . Table 2 below reports the values of the latter for the two models under competition and monopoly. Moreover, the parameters α_{GDP} , related to the GDP, are negative as expected since one it is natural for the marginal utility of income to decrease when income increases.

The own-price elasticities of demand belong to the interval [-9.6, -6.17] in the case of competition (see Table 3 below). They are higher in absolute value in the case of coordination across the firms, as they belong to the interval [-38.7, -8.5].

The estimated margins are reported in Table 4. Under the competitive assumption, the estimated margins belong to the interval [47.46, 66.11]. The margins increase during the period of consideration. Under the assumption of coordinated practices, the estimated margins belong to the interval [9.37, 150.15]. They do not exhibit a regular trend during the overall period. One expects that margins under coordinated practices would be higher than margins under competitive behaviour. Our estimation shows contrary results except for the two last years of the period under consideration.

With respect to the main indicators, one can conclude the two models estimated under competition and monopoly are consistent with the main properties implied by economic theory. However, at this stage of our analysis, the relative values of own-price elasticity of demand and the relative values of the estimated margins favour the assumption of competition as a better approximation of the data.

4.2.1.2 Non-binding capacity constraints

Under the assumption of non-binding capacity constraints the equilibrium is described by four main equations: the demand addressed to firm A or to the monopoly, the demand addressed to the Importer, the mark-up and the marginal cost equation; plus the additional total cost equation. The estimated parameters of the competitive and coordinated models are reported in A5.2 of Appendix 5. All the parameters are statistically significant at 1% level whether the competitive or coordinated behaviour is considered, except the constant, β_{cst} in the total cost function and the parameter related to the interaction between raw material Y's price and product X's production in the total cost function, $\beta_{RM,Y}$. The parameters δ_i , $i=0,1$, are positive, as well as the marginal utility of income, α . Notice that, contrary to the previous model, the marginal utility of income is constant over time.

The own-price elasticities of demand belong to the interval $[-2.14, -1.09]$ in the case of competition. They are lower than one in absolute value in the case of coordination across firms, as they belong to the interval $[-0.46, -0.14]$ (see Table 5). This result is fairly inconsistent with the results implied by economic theory related to monopoly (i.e., joint profit maximization). In the case of a monopoly, the own-price elasticity of demand has to be higher than one in absolute value, otherwise the mark-up equation leads to negative marginal costs. Even if Table 7 shows positive marginal costs both for competition and coordinated practices across firms, it means that the pricing equation under the monopoly assumption is poorly estimated, which explains why the estimated margins are unstable under this assumption (see Table 6).

Table 2 – Estimated values of the marginal utility of income under the assumption of binding capacity constraints

Year	2002	2003	2004	2005	2006	2007	2008
Competition	0.034	0.033	0.032	0.031	0.030	0.028	0.027
Monopoly	0.562	0.524	0.483	0.445	0.397	0.350	0.310

Table 3 – Own-price elasticities of demand under the assumption of binding capacity constraints

YEAR	2002	2003	2004	2005	2006	2007	2008
# Obs	12	12	12	12	12	12	12
Competition							
Mean	-6.170	-7.112	-8.045	-7.799	-8.855	-8.241	-9.536
Std	0.542	0.735	1.198	1.214	0.928	1.051	3.311
Min	-7.006	-8.215	-9.663	-9.101	-10.970	-10.482	-18.331
Max	-5.359	-5.590	-5.661	-5.196	-7.552	-6.483	-5.841
Monopoly							
Mean	-35.029	-38.641	-32.250	-19.208	-33.334	-12.570	-8.511
Std	11.384	9.815	11.773	7.699	10.350	7.437	9.102
Min	-50.055	-51.462	-52.205	-36.118	-47.111	-28.418	-31.266
Max	-12.474	-19.871	-11.203	-7.972	-16.121	-1.246	0.000

Table 4 – Estimated mark-ups under the assumption of binding capacity constraints

YEAR	2002	2003	2004	2005	2006	2007	2008
# Obs	12	12	12	12	12	12	12/11
Competition							
Mean	49.541	47.465	50.916	50.828	54.280	59.515	66.105
Std	4.663	4.923	8.434	6.827	4.751	7.067	12.393
Min	40.675	40.923	42.299	42.019	45.497	50.884	44.981
Max	54.367	56.204	70.934	67.486	61.323	77.519	86.256
Monopoly							
Mean	10.045	9.372	14.608	23.563	15.877	69.825	150.156
Std	5.209	3.163	7.214	10.363	5.655	96.779	143.033
Min	6.126	6.620	7.692	11.905	9.888	17.247	26.751
Max	24.839	16.023	34.013	49.432	26.281	373.784	430.914

Table 5 – Own-price elasticities of demand under the assumption of non binding capacity constraint

YEAR	2002	2003	2004	2005	2006	2007	2008
# Obs	12	12	12	12	12	12	12
Competition							
Mean	-1.098	-1.306	-1.529	-1.534	-1.819	-1.770	-2.132
Std	0.097	0.135	0.228	0.239	0.191	0.226	0.740
Min	-1.247	-1.508	-1.837	-1.790	-2.253	-2.252	-4.099
Max	-0.954	-1.026	-1.076	-1.022	-1.551	-1.393	-1.306
Monopoly							
Mean	-0.338	-0.400	-0.362	-0.234	-0.455	-0.195	-0.149
Std	0.110	0.102	0.132	0.094	0.141	0.115	0.159
Min	-0.483	-0.533	-0.586	-0.441	-0.643	-0.440	-0.547
Max	-0.120	-0.206	-0.126	-0.097	-0.220	-0.019	0.000

Source: Confidential data on the industry

Table 6 – Mark-ups under the assumption of non binding capacity constraint

YEAR	2002	2003	2004	2005	2006	2007	2008
# Obs	12	12	12	12	12	12	12
Competition							
Mean	35.908	45.016	58.202	51.084	55.763	58.186	71.591
Std	11.191	11.914	12.992	16.700	8.157	8.067	14.062
Min	24.798	20.991	34.372	19.199	45.360	41.613	49.331
Max	59.457	60.669	68.142	76.248	71.765	70.824	100.638
Monopoly							
Mean	-12.761	-5.370	21.168	0.084	15.541	13.077	40.287
Std	12.257	10.902	6.994	12.151	9.465	7.291	22.281
Min	-37.364	-27.310	7.524	-25.265	-7.451	2.709	-1.205
Max	3.603	7.356	34.019	20.603	24.182	25.600	68.994

Source: Confidential data on the industry

Table 7 – Estimated marginal costs under the assumption of non binding capacity constraint

YEAR	2002	2003	2004	2005	2006	2007	2008
# Obs	12	12	12	12	12	12	12
Competition							
Mean	194.835	184.027	167.261	187.986	211.149	202.078	155.890
Std	35.850	41.656	50.433	54.945	40.627	38.566	58.688
Min	117.384	132.229	117.590	90.831	140.926	154.558	-5.258
Max	233.311	275.499	261.023	283.314	262.049	293.437	225.411
Monopoly							
Mean	341.539	351.560	315.618	386.084	401.275	419.642	334.338
Std	32.182	28.620	25.606	22.187	27.858	17.290	45.584
Min	306.098	315.612	264.952	341.396	365.031	385.501	259.327
Max	401.577	405.349	352.367	421.147	455.258	447.456	391.267

Source: Confidential data on the industry

4.2.2 Vuong test as a test of model selection

A standard statistical test to determine which of two models better fit the data is the Vuong test (see Gasmi, Laffont and Vuong, 1992) This test is based on the comparison of likelihood values of the estimated models, taking into account the variance-covariance matrix of the parameters and the estimated errors of the models. In our specific case, the Vuong test allows us to compare the assumptions of competition and coordinated practices.

If the Vuong test statistic is higher than 2, then the competitive assumption is a better approximation of the data. If the Vuong test statistics is lower than -2, then the assumption of coordinated practices across firms is a better approximation of the data. Finally, if the Vuong test statistics belongs to $[-2, 2]$, neither of the assumptions is statistically preferred to the other.

The Vuong test can only be applied when capacity constraints are binding since, only in this case, do the estimated models under competition and monopoly satisfy the economic conditions as explained above. In this case, the Vuong test statistics equals 2.19. From a statistical point of view, it means that the assumption of competition is preferred to the assumption of full coordinated practices. This result confirms the previous findings obtained through the analysis of the estimated economic indicators. Under the assumption of binding capacity constraints, the hypothesis of competition prevails over coordination.

5. Concluding remarks

We have provided a comprehensive examination of the Greek steel market, with the objective to investigate whether it would be reasonable to consider the behaviour of the three Greek producers of steel as tacitly collusive, as suspected by the HCC, or not, during the period 2002 to 2011.⁴² This study has included undertaking qualitative analysis of the structural conditions of the market, explaining price formation and evolution on the basis of a Bertrand-Edgeworth model of the industry to assess whether the market data are or are not compatible with collusion, as well as with studying the phenomenon of price parallelism, investigating a number of collusion markers and, finally, undertaking econometric analysis. As noted above, the latter is innovative in the use of a limited amount of information. Specifically, the estimation of the model is performed based on data on the price and price from only one firm of the oligopoly, on the price and quantity of imports, and on some aggregated data related to the market, thanks to the model specification and the role of the international side of the market.

The analysis of this case study suggests that competition and collusion can be difficult to distinguish on the basis of observed patterns of price evolution which contain incidences of parallelism. A number of lessons emerge. Seemingly coordinated behavior such as simultaneous increases or decreases in prices can be the competitive response of producers to changes in import prices in conjunction with the information dissemination activities of wholesalers who have strong incentives to establish the new price levels of all producers. It is then important to establish whether, as was usually the case in the present case, the changes concern list prices and whether producers' changes in final prices, after the application of discounts, diverge.

In general, a competition authority, having in a preliminary investigation ascertained the facts in relation to the above considerations and depending on its findings, could examine whether structural conditions and econometric analysis can provide more support to the hypothesis of collusion than to that of competitive behavior. A message that emerges is that pieces of circumstantial evidence and

⁴² 2002 – 2008 for the econometric analysis.

individual screen tests in isolation for proving collusion or no collusion can be of limited value. Particular individual red flags may be false alarms and mean something else. In such a case, it is really the combination of various indicators, pieces of evidence and analyses, including a convincing set of alternative, plausible competitive explanations for observed behavior that can be decisive for a judgement.

In this specific case study, it was found that, taking into account a multitude of complementary analyses and evidence, that the evolution of the Greek steel market in the period 2002 – 2011 can be more satisfactorily interpreted in terms of a hypothesis of competition. The HCC therefore was correct to ultimately drop its accusations against the Greek steel producers. That it took over 8 years of investigation before the decision was finally reached only goes to show the importance of the lessons we draw from this case for future priority setting.

Appendices

Appendix 1: Notations

The product X is produced by three firms noted by $i = 1, 2, I = 3$ and by an importer indexed by the number 0.

The main notations are as follows:

- Domestic production capacity = \bar{Q}_i
- Domestic production = q_i
- Domestic price = p_i
- Export of firm $i = x_i$
- Total domestic production = $\sum_{i=1}^I q_i = q_d$
- Imports = q_0
- Import price = p_i
- International price = W
- Domestic market size = sum of domestic production + imports = Q
- Market share = $s_i = \frac{q_i}{q_0 + \sum_{i=1}^I q_i} = \frac{q_i}{q_0 + q_d} = \frac{q_i}{Q}$

Appendix 2: The demand model

A typical buyer of product X has to choose among the three domestic firms or the Importer to satisfy its demand. The logit specification of the demand is then adequate for this situation (see for instance Motta, 2004) It is written as

$$\ln s_i - \ln s_0 = \delta_i - \alpha p_i, \quad (8)$$

where δ_i is the “quality” of the product sold by firm i and p_i is its price. For technical reason, one must assume that

$$\delta_0 - \alpha p_0 = 0. \quad (9)$$

With this hypothesis, the model basically says that the market share of product i (or firm i) is a percentage of the market share of imports that represents an outside alternative to buying from a domestic producer, this percentage depending on the trade-off between quality and price determined by the parameter α , which is a rate of change between quality and money.

In the econometric model, the parameters δ s have to be estimated as well as the parameter α .

Note that with this specification, the own-price elasticity ε_i is given by:

$$\varepsilon_i = -\frac{p_i}{q_i} \frac{\partial q_i}{\partial p_i} = \alpha p_i (1 - s_i). \quad (10)$$

Appendix 3: The supply side

In the first place, assume that the industry is competitive. In this case, each firm sets her price and the quantity exported so as to maximize her profit, knowing that the other competitors are doing the same. Then the profit maximization is as follows:

$$\text{Max}_{p_i, x_i} p_i q_i + W x_i - C(q_i + x_i) \quad \text{st} \quad q_i + x_i \leq \bar{Q}_i. \quad (11)$$

That is to say, each firm maximizes its profit defined as the difference between revenues and cost, where the revenues come from domestic sales and exports and where the cost is a function of the total production.

The first order conditions are:

$$\begin{aligned} q_i + \left(p_i - \frac{\partial C}{\partial q_i} - \lambda \right) \frac{\partial q_i}{\partial p_i} &= 0, \\ W - \frac{\partial C}{\partial q_i} - \lambda &= 0, \\ (\bar{Q}_i - q_i - x_i) \lambda &= 0, \end{aligned} \quad (12)$$

where λ is the multiplier associated with the capacity condition.

There are different cases:

The capacity constraint is binding, in which case p_i is chosen so that:

$$\frac{(p_i - W)}{p_i} = \frac{1}{-\frac{p_i}{q_i} \frac{\partial q_i}{\partial p_i}}, \quad (13)$$

and x_i is chosen as: $x_i = \bar{Q}_i - q_i$.

The capacity constraint is not binding, then $\lambda = 0$ and p_i and x_i are chosen so that:

$$\frac{(p_i - W)}{p_i} = \frac{1}{-\frac{p_i}{q_i} \frac{\partial q_i}{\partial p_i}}, \quad (14)$$

and

$$\frac{\partial C}{\partial q_i} = W. \quad (15)$$

In the second place, assume that, together, the different firms in the industry behave as a monopoly. In this case, the monopoly sets its price and the quantity exported so as to maximize its profit, just knowing that there is an importer which creates some competitive pressure. Then the profit maximization is as follows:

$$\text{Max}_{p,x} pq_d + Wx_0 - C(q_d + x_0) \quad \text{st} \quad q_d + x_0 \leq \bar{Q}. \quad (16)$$

The same type of equations holds in this case except that they apply at the industry level and not at the firm level.

Appendix 4: Specification A partial equilibrium on a product market is characterized by a system of equations related to both demand and supply of all firms. However, here the model is fully identified, thanks only to the description of demand and supply of firm A and the demand of the Importers on the domestic market.

Let index i be equal to A or to 0 when it refers to firm A or to the Representative Importer. Based on a logit-type specification, the demand function addressed to firm i is expressed as follows:

$$\ln(s_i) - \ln(s_0) = \delta_i - \alpha p_i + \zeta_i, \quad (1)$$

where s_i is the market share of firm i on the product X domestic market, s_0 is the market share of the product X Importer on this market, p_i is the price charged by firm i for one unit of the product, δ_i measures the observed “quality” of product X sold by firm i , ζ_i measures the unobserved “quality” of product X sold by firm i , and α is the marginal utility of income. The market share of firm i is measured as:

$$s_i = \frac{q_i}{q_0 + q_d}, \quad (2)$$

where q_i is the production level of firm i , q_d is the total domestic production (i.e., the sum of production levels of all domestic firms) on the market, and q_0 is the total amount of imports of product X.

Hence the demand for product X results from a trade-off between “quality” and price. The term denoted by δ allows for a differentiation across undertakings, which might be interpreted as reflecting any own firm’s characteristics, in particular its capacity to react to new economic conditions. In the case of an exogenous shock, the demand would shift due to change in this term. As a matter of fact, this term is expressed as a function of a dummy variable which accounts for the specific aspects of year 2008 compared to the other years, as previously pointed out. Specifically, we write:

$$\delta_i = (\delta_{i,cst} + \delta_{i,2008} * dummy_{2008}), \quad (3)$$

where $\delta_{i,cst}$ and $dummy_{2008}$ are parameter to be estimated.

The parameter α related to the price, defined as the marginal utility of income, might be interpreted as an exchange rate between one unit of quality and one monetary unit. Note that, by specifying this parameter as a function of country 1’s GDP, that is to say,

$$\alpha = (\alpha_{cst} + \alpha_{GDP} * GDP), \quad (4)$$

where α_{cst} and α_{GDP} are parameter to be estimated, we expect it to be positive and decreasing with GDP, reflecting a wealth effect, namely that a richer country is less sensitive to any change in money value.

Whatever the assumption, competition or collusion, two demand functions are estimated jointly in the model, the first one for firm i , firm A or the monopoly respectively, the second one for the Importer.

The supply side of the economy is characterized by the mark-up of the firm, either firm A or the monopoly depending on the assumption related to the level of competition. One can show that the mark-up is a function of the own price elasticity of demand; thus the mark-up is in particular a function of the parameter α described in the demand equation.

Each firm maximizes its profit defined as the difference between revenues and cost, where the revenues come from domestic sales and exports and where the cost is a function of the total production. On the domestic market, we assume that the

firms compete in price. This choice is driven by the observation of firms' behaviours and is meaningful given the product X heterogeneity given firms' characteristics. On the international market, the firms take prices as given and compete in quantities.

Deriving the maximization program of the firm, one can show that the mark-up is expressed in terms of the product X export price rather than in terms of marginal costs of production. The expression of the mark-up is the following:

$$p_i - W = \frac{1}{\alpha(1 - s_i)}, \quad (4)$$

where:

- p_i , s_i are respectively the price charged by firm i and its market share on product X domestic market;
- α is the marginal utility of income and its expression is identical to the one in the demand function;
- W is the price for exports, which is given for firm i .

Whatever the assumption, competition or collusion, the mark-up related to firm i is the only mark-up included in the model to be estimated. Under the assumption of binding capacity constraint, the mark-up equation perfectly describes the behaviour of the firm and allows us to determine the optimal level of domestic production, while the level of exportation is deduced from the full capacity condition.

However, under the assumption of non-binding capacity constraint, an additional equation is necessary to describe the strategic behaviour of the firm, as both the level of domestic production and the level of exports have to be determined. This additional equation expresses that the marginal cost of production equals the export price (see also Sections 3-4 above). The marginal cost of production is expressed as a linear function of the Raw Material Y price and the total level of production (domestic production and exports). From an econometric perspective, both the equation related to the marginal cost of production and the equation related to the total cost of production will be included in the system to be estimated.

The specification for the total cost function is the following:

$$TC(y_i) = \beta_{cst} + \beta_{RM} \cdot p_{RM} + \beta_{RM,Y} \cdot p_{RM} \cdot y_i + \frac{1}{2} \beta_Y (y_i)^2 \quad (5)$$

where

- y_i is the total production of product X, that is the sum over domestic production, q_i , and exports x_i . In the case of competition, q_i , and x_i are firm A's domestic production and exports respectively; in the case of monopoly, q_i , and x_i are respectively the total domestic production and the exports of all domestic firms;
- $TC(y_i)$ is the total cost to produce the quantity y_i ;

- p_{RM} is the Raw Material (RM) Y price.

Given the specification of the total cost function, the marginal cost function is expressed:

$$MC(y_i) = \beta_{RM,Y} \cdot p_{RM} + \beta_Y y_i \quad (6)$$

The equilibrium is characterized by equality between marginal cost and export price. Thus, under the assumption of non-binding capacity constraints the following relationship holds for firm i:

$$W = \beta_{RM,Y} \cdot p_{RM} + \beta_Y y_i \quad (7)$$

As explained previously, both this latter equation and the total cost function related to firm i are included in the model to be estimated.

Appendix 5 – Estimated parameters of the models and main relevant test statistics

Table A5.1 – Estimated parameters under the assumption of binding capacity constraint

Parameter	<i>Competition</i>					<i>Monopoly</i>				
	Estimate	Approx. Std. Err	t Value	Approx. Pr > t	1st Stage R-Square	Estimate	Approx. Std. Err	t Value	Approx. Pr > t	1st Stage R-Square
δ_0	12.143	0.711	17.08	<.0001	1.000	171.969	14.659	11.73	<.0001	1.000
$\delta_{0,2008}$	5.274	1.566	3.37	0.0012	1.000	37.942	12.729	2.98	0.0038	1.000
δ_1	13.357	0.702	19.04	<.0001	1.000	177.63	14.952	11.88	<.0001	1.000
$\delta_{1,2008}$	6.750	1.561	4.32	<.0001	1.000	29.792	12.740	2.34	0.0219	1.000
α_{cst}	0.049	0.009	5.70	<.0001	0.893	1.098	0.140	7.85	<.0001	0.827
α_{GDP}	-7.1E-7	3.1E-7	-2.29	0.0244	0.935	-3.0E-5	4.3E-6	-6.00	<.0001	0.867
Number of Observations										
Used	83					83				
Missing	1					1				
Statistics for System										
Objective	1.508					1.819				
Objective *N	125.151					151.004				

Notes: If $\text{Approx. Pr} > |t| < 0.01$ the corresponding parameter is statistically significant at level 1%;
if $0.001 < \text{Approx. Pr} > |t| < 0.05$ the corresponding parameter is statistically significant at level 5%;
If $\text{Approx. Pr} > |t| > 0.1$ the corresponding parameter is not statistically significant.

Table A5.2 – Estimated parameters under the assumption of non binding capacity constraint

Parameter	Competition					Monopoly				
	Estimate	Approx. Std Err	t Value	Approx. Pr > t	1st Stage R-Square	Estimate	Approx. Std Err	t Value	Approx. Pr > t	1st Stage R-Square
δ_0	2.498	0.138	18.10	<.0001	1.000	2.263	0.130	17.41	<.0001	1.000
$\delta_{0,2008}$	0.921	0.161	5.74	<.0001	1.000	1.010	0.155	6.52	<.0001	1.000
δ_1	3.474	0.171	20.3	<.0001	1.000	3.858	0.166	23.31	<.0001	1.000
$\delta_{1,2008}$	2.348	0.294	7.99	<.0001	1.000	2.064	0.295	7.00	<.0001	1.000
α_{cst}	0.006	0.000	17.98	<.0001	0.971	0.005	0.000	18.06	<.0001	0.777
β_{cst}	1458633	1990910	0.73	0.4659	1.000	8086291	8122373	-1.00	0.3225	1.000
β_{scrap}	124569	27293	4.56	<.0001	1.000	254065	90975	2.79	0.0066	1.000
$\beta_{scrap,Y}$	-0.318	0.350	-0.91	0.3658	0.891	-0.482	0.619	-0.78	0.4380	0.997
β_Y	0.003	0.001	6.30	<.0001	0.772	0.003	0.001	4.11	<.0001	0.988
Number of Observations										
Used	82					82				
Missing	2					2				
Statistics for System										
Objective	3.772					3.275				
Objective*N	309.265					268.511				

Notes: If $Approx.Pr > |t| < 0.01$ the corresponding parameter is statistically significant at level 1%;
 if $0.001 < Approx.Pr > |t| < 0.05$ the corresponding parameter is statistically significant at level 5%;
 If $Approx.Pr > |t| > 0.1$ the corresponding parameter is not statistically significant.

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