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Is Cartelisation Profitable? A Case Study of the Rhenish Westphalian Coal Syndicate, 1893-1913[*]

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22 March 2009

Abstract

We examine the effect of one of the presumably most powerful cartels ever on the profitability of its members. More precisely, we consider the Rhenish-Westphalian Coal Syndicate, a coal cartel that operated in Imperial Germany in the late 19th and early 20th century, using a newly constructed dataset and two different methodological approaches. At first, we employ event study methodology to asses the reaction of the stock market to the foundation of the cartel and two major revisions of its original contract. Furthermore, we look at different performance measures calculated from accounting and financial data in a dynamic panel data framework. Overall, our results suggest that the investigated cartel had no significant effect on the profitability of its members. However, we also find that it was able to stabilise coal prices and powerful enough to ensure that on average, prices were set high enough to avert negative repercussions on company performance.

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1. Introduction

The effect of cartels and other collusive arrangements on the profitability of the participating companies is a widely disputed topic in empirical industrial organisation. One group of studies relies on cross-sectional investigations covering many industries and collusive arrangements. The results of these investigations are mixed. Asch/Seneca (1976, from whom we adapted the title of our paper) find that, in the U.S. manufacturing industry, collusion had a negative effect on company performance measured by the Return on Equity (RoE). In contrast, based on estimated price-average cost margins of 54 international cartels, Griffin (1989) concludes that at least some of the investigated organisations must have increased the profits of their members significantly. Another group of empirical studies focuses on one specific case of collusive conduct and uses game-theoretical models. Similar to the cross-sectional investigations, the results of these studies vary considerably. Levenstein (1997) finds that profits in the cartelised Bromine industry were at least temporarily close to the joint profit-maximising level. Röller/Steen (2006) show that cartelisation in the Norwegian cement industry resulted in profits far below the joint-profit maximising but above the non-cooperative Cournot level. In his seminal work on the Joint Executive Committee, Porter (1983) concludes that the profitability of the companies participating in the cartel did not exceed the non-cooperative Cournot level. In this study, we follow an approach that is distinct from both of the procedures mentioned above.[1] In line with investigations by Bittner (2005) and Marin/Sicotte (2003), we make use of the information content of stock market data and event study methodology to assess the effects of collusive conduct on company performance. In addition, we augment these results by a combined analysis of financial, accounting, and output data in a dynamic panel data framework.

The subject of our investigation is the Rhenish Westphalian Coal Syndicate (*Rheinisch-Westfälisches Kohlensyndikat*, RWKS), a coal cartel that operated in Imperial Germany's most important industrial region, the Ruhr district. Our investigation period ranges from the foundation of the cartel in 1893 up to the First World War. We believe that the RWKS is especially well-suited to asses the effects of cartelisation for at least two reasons. First, unlike today and in other countries at that time (e.g., the United States) collusion was legal in Imperial Germany. After a groundbreaking decision by the German Imperial High Court (*Reichsgericht*) in 1897, cartel contracts were even legally enforceable in the courts (see Böhm, 1948). As a result, the information problem that researchers of modern tacit collusion struggle with is absent in our study. In particular, we have detailed information on cartel duration, membership in the cartel, market shares, cartel contracts, and the negotiation processes that preceded these contracts. Second, the RWKS is one of the longest-lasting cartels ever (Levenstein/Suslow, 2006) and believed to be one of the most powerful of the numerous collusive arrangements that operated in Imperial Germany (see, e.g., Hentschel, 1978). Thus, it should be a prominent candidate for a cartel that

1 Another approach oftentimes used to determine the effects of collusion on prices and profits is the examination of antitrust prosecutions. See, e.g., Sproul's (1993) cross-sectional study on 25 antitrust cases in the 1970s and early 1980s, and Block/Nold/Sidaks' (1981) investigation of the effects of antitrust enforcement in the U.S. bread industry. Bosch/Eckard (1991) use event study methodology to assess whether antitrust indictments lowered investors' expectations of future profits.

affected its members' profitability. To put it differently: If the RWKS had no effect, which other cartel would? This question is related to a broader interpretation of Imperial Germany's economy history, namely that the rise of the country from a backwarded rural economy to one of the most dynamic industrialised nations in the world was linked to the existence of a peculiar German business model labelled 'organised capitalism' (Kocka, 1974; Parnell, 1994) or 'cooperative capitalism' (Chandler, 1990) and characterised by large joint-stock credit banks, tariffs, and – last but not least – a comparatively high level of cooperation among companies.[2]

The existing studies on the RWKS differ in their assessment of the cartel's effect on the profitability of its members. In line with the findings of contemporary scholars (Bock, 1914; Lüters, 1928), Blaich (1973) and Burke (1979) argue for a positive effect.[3] In contrast, Bittner (2005), Peters (1989), and Pounds/Parker (1957) regard the cartel as being rather ineffective and thus, not being able to affect performance in any way. Almost all of the studies mentioned above suffer from a common shortcoming: They do not offer compelling quantitative evidence to back their assertions. The only exception is Bittner's study. As we do in our investigation, Bittner uses stock market data and event study methodology. He finds that the formation of the cartel in 1893 resulted in very small positive performance effects for some cartel members, while others did not gain at all. As a result, Bittner comes to the conclusion that the RWKS had almost no effect on the performance of its members. However, his study has two major weaknesses. First, his sample is extremely small, as he investigates only six companies. Second, he does not account for the development of the RWKS in the years after 1893, because of his exclusive focus on the foundation of the organisation. In our study, we overcome these two shortcomings by looking at a sample of up to 19 companies and by investigating not only the foundation of the RWKS, but also two major revisions of the original cartel contract. Furthermore, we add another long-term perspective by examining the development of financial, accounting, and output figures over a time span of 33 years.

The results of our investigation are the following: In line with the results of Bittner, the findings from our event studies indicate that contemporary investors believed that the profitability of cartel members would be almost unaffected by the foundation of the RWKS. For the first revision of the original cartel contract this neutral assessment persisted. In contrast, in the event study of the second revision of the original contract, we detect a small but positive performance effect. The results from the combined analysis of accounting, financial, and output figures show neither a positive nor a negative effect of cartelisation on company performance, measured by the Return on Assets (RoA) or Tobin's q.

2 Apart from cartelisation, interlocking directorates and tight bank-company relations are identified as coordination mechanisms (for a review of the literature, see Fohlin, 2007).

3 A widely cited study on cartelisation in Imperial Germany by Webb (1980) is not relevant in this context. Webb focuses on the Steel Works Association and concludes that in combination with tariffs on iron and steel products this cartel reduced the sales risk of its members. As a result, they were more willing to engage in capital intensive vertical integration, which positively affected efficiency and thus also profitability. However, tariffs play a crucial role in the Webb model and there were none on coal.

Our study is organised in six parts. In the next section, we outline the theoretical foundations of our investigation. Afterwards, we introduce the institutional setting of the RWKS, discuss its aims, and present some stylised facts on market structure and the efficacy of the cartel with regard to price stabilisation. Furthermore, as a basis of the event study we give a detailed chronological account of cartel development in the years under consideration. In the next two sections, we present our research design and data. Then, we discuss our empirical findings. The last section concludes.

2. Theoretical Discussion

The theoretical predictions regarding the performance effect of cartelisation are ambiguous. In the most basic economic model cartels are equated with monopolies: They enable the participating companies to extract monopoly rents by reducing output and raising prices above marginal costs. However, in the same basic model it can be shown that cartel members have strong incentives to cheat by chiselling the cartel price once a cooperative arrangement has been agreed on, because as long as all other cartel members adhere to the agreement, such behaviour will increase their individual profits.[4] Then again, this non-cooperative strategy is strictly preferable only in one-period games. In settings with repeated interactions, a potential defector has to weight the short-term gains of cheating against the long-term losses of cartel breakdown: If the defection in the first period is detected, it will trigger a punishment phase in all following periods, where the other cartel members will also resort to the non-cooperative strategy (Friedman, 1971).[5]

Economic theory also provides a rich set of factors that might hamper the achievement and/or the maintenance of successful collusive conduct. Dynamic demand conditions, for example, make the detection of cheating more difficult, as, for the cartel members, it is harder to discriminate whether changes in their sales that are due to non-cooperative behaviour by another cartel member or due to changes in overall demand (Green/Porter, 1984; Rottemberg/Saloner, 1986). Furthermore, a large number of cartel members, heterogeneity of cost functions, and low barriers to entry can make collusion more difficult to achieve and sustain (Stigler, 1964, 1966): the first two factors, because they increases negotiation and monitoring costs; low barriers to entry, because they make the emergence of cartel outsiders more likely.

Finally, there are factors that can be both supportive or hindering to successful collusive conduct. Product heterogeneity, for example, reduces the profitability of cheating, as attracting customers from other cartel members by chiselling the cartel price becomes more difficult, but at the same time, the detection of cheating becomes more difficult as well and the punishment phases will be less severe (Deneckere, 1983). Excess capacities can also both support or hamper collusive con-

4 The basic cartel-monopoly model and the static cartel instability problem are described in every industrial economics textbook (see, e.g., Martin, 1994; Scherer/Ross, 1990).

5 In multi-period games, the profitability of cheating depends critically on the size of the discount factor a potential defector attaches to future profits.

duct (Davidson/Deneckere, 1990). On the one hand, holding excess capacities comes at a cost and thus, prevents colluding companies from jointly maximising their profits, but on the other hand, they increase their ability to punish defectors an thereby, can help to stabilise collusive arrangements.

In the following part, we will see that – according to official statements of the RWKS – price stabilisation was among the first and foremost aims of the organisation. The theoretical literature on price stabilisation cartels predicts that mean preserving price stabilisation (i.e., reducing the variability of prices over the business cycle without changing the mean of the price levels in boom and slump periods) will reduce the profitability of the participating companies (Oi, 1961).[6] Moreover, in order to implement such a price scheme, the cartel will have to enforce restrictions on the output of its members in boom periods, and in slump periods some form of non-price demand rationing will have to be applied. The negative performance effect can be offset if the cartel runs a buffer stock. In this case, enforced restrictions of production and non-price rationing will no longer be necessary, because total output over the business cycle is the same as with competition. However, for our study the idea of a buffer stock is unrealistic, as in the time period under investigation due to outgassing and the danger of spontaneous ignition larger amounts of coal could not be stored for extended periods of time (Orth, 1922).[7] The profitability of price stabilisation schemes will certainly change, if the cartel uses its market power to raise the mean price level above the mean level of competitive boom and slump periods (Scherer/Ross, 1990). If this increase is large enough to offset the negative repercussions of stabilised prices, cartel members will very likely be better off.[8]

Based on the theoretical considerations mentioned above, we construct four scenarios that will guide the following analysis of the RWKS: (1) If we observe a significant stabilisation of coal prices and a decrease in profitability after the formation of the RWKS, we can conclude that the

6 The model assumes that there are only two states of the economy – boom and slump – that occur with the same probability (0.5) and are characterised by equal-sized positive and negative shifts in demand. Empirical investigations on the business cycle in Imperial Germany show that there were more boom than slump years (Burhop/Wolff, 2005). Adjusting the model to these more realistic parameters would further aggravate the negative performance effect of mean preserving price stabilisation schemes.

7 Whenever we refer to coal, we will be talking about bituminous coal only. Thus, lignite coal is omitted from the investigation. This restriction is due to the fact that the markets for the two types of coal were even further separated in the 19th and early 20th century than they are today. Because of its chemical constitution lignite coal could not be used in most of the industrial applications that made up much of the demand for bituminous coal (e.g., coke for blast furnaces). In addition, the major deposits for bituminous and lignite coal were situated in different geographical areas. As a result, there was no direct contact between companies that mined bituminous and those that mined lignite coal. In our investigation period, not one company situated in the Ruhr district mined both types of coal and there was not one single takeover that involved a bituminous as well as a lignite coal mine.

8 Apart from its mixed implications for their profitability, price stabilisation schemes also affect the cartel members' price and profit risk. Simple mean preserving price stabilisation reduces the variability of both prices and profits. Given companies are risk-averse they should be willing to sacrifice some profitability for these reductions. However, so far it is far from clear that the positive effects of smaller risk are large enough to offset the negative repercussions of smaller profits, so that in the end, the cartel members would be better off. Theoretical considerations are only available for the buffer stock case. Moreover, these are also inconclusive. On the one hand, using a slightly modified version of the basic model, Newberry/Stiglitz (1981) show that even risk-averse producers will not gain. On the other hand, in a state-preference framework Chambers/Quiggin (2003) predict that such schemes always make risk-averse producers better off.

cartel stabilised prices, but was not able (or willing) to raise them above the mean preserving level. (2) If we observe a significant stabilisation of coal prices and stable or increasing profitability after the formation of the RWKS, we can infer that the cartel stabilised prices above the mean preserving level and, thus, produced monopoly rents for its members. (3) If we observe no significant stabilisation of coal prices and an increase in profitability after the formation of the RWKS, we can conclude that – in contrast to its official statements – the cartel actually raised prices above the competitive level and did not to stabilise them. (4) If we observe no significant stabilisation of coal prices and no increase or even decrease in profitability after the formation of the RWKS, we can conclude that the cartel was unsuccessful and inefficient. In order to test the plausibility of these four scenarios, we will explicitly and empirically approach two research questions: Did the investigated cartel stabilise price? and: Did it raise the profits of its members?

3. The Rhenish Westphalian Coal Syndicate

As mentioned before, the RWKS is widely regarded as one of the most powerful cartels that operated in Imperial Germany. From its foundation in 1893, it lasted for more than 50 years until it was finally broken up by the Allies after the Second World War. Between 1893 and 1913, the combined output of its members represented about 50 per cent of the national output in bituminous coal. In the Ruhr district the market share was even more impressive. Here, the RWKS controlled between 80 and 90 percent of the output (Peters, 1989).

The RWKS was both a price- and a quota-setting cartel.[9] In addition, it also managed the sales of its members. The participating companies were obliged to deliver their output to the organisation, which then sold it on the market and redistributed the revenues. The prices the cartel charged its costumers varied with the destination of sales. In non-competitive regions, where the members of the organisation enjoyed advantages in transportation costs that prevented outsiders from competing, prices were set annually.[10] Variations were only allowed to account for differences in quality. In areas with competition from cartel outsiders, the RWKS sold the coal at market prices and compensated its members for the difference between the market and the cartel price.

9 All statements on the institutional setting of the RWKS rely on the cartel contracts reproduced in Verein (1904b).

10 In Kontradiktorische Verhandlungen (1903: 70), Anton Unckell, the head of the executive board of the RWKS, defined the non-competitive area as follows: "The non-competitive area stretches to the north as far as Holland, East Frisia and the Hamburg district; to the east, as far as the province of Saxony in part or, more precisely, the Elbe river; to the south, as far as the point where we clash in competition with Bohemia; and to the west, as far as Belgium and France. [The] competition from Saar coal [...] is not [...] as palpable for us to have to draw the border of the non-competitive area before reaching the Saar area." Original: "Das unbestrittene Gebiet wird begrenzt im Norden durch Holland, Ostfriesland und den Hamburger Bezirk, im Osten teilweise durch die Provinz Sachsen, oder richtiger durch die Elbe, im Süden, da wo wir mit der Konkurrenz von Böhmen zusammentreffen, und im Westen durch Belgien und Frankreich. [Die] Konkurrenz der Saarkohlen [...] macht sich [...] nicht so fühlbar für uns, daß wir die Grenze des unbestrittenen Gebiets schon vor Erreichung des Saarbezirkes hätten ziehen müssen."

Output was controlled by a dynamic quota system that allowed changes in the relative output shares of cartel members. The original quotas were assigned on the basis of their production in either 1891 or 1892 and expressed in absolute numbers (metric tons). The sum of these individual quotas was equal to the maximum total output of the cartel. In order to match supply and demand, the cartel authorities were allowed to impose an equal percentage reduction to each member's quota. Non-compliance with the rules of the organisation – e.g., failures in meeting the delivery requirements or production in excess of one's cartel quota – was sanctioned by severe fines. The overhead costs of the organisation as well as the compensations for sales in competitive areas were financed by a variable percentage deduction from the revenues that the RWKS redistributed to its members.

According to the official statements of the RWKS, the first and foremost aim of the organisation was the stabilisation of coal prices at a "reasonable" (*angemessen*) but "moderate" (*gemäßigt*) level.[11] Furthermore, it was also intended to raise and stabilise profits and to reduce the variability of output. Although these three aims were interconnected, the decisions of the cartel authorities did not necessarily mirror this (Peters, 1981). If conflicts between price and output policy arose, the former would usually be favoured over the latter. All in all, the output and profit aims were regarded as corollaries of successful price stabilisation.[12]

Notwithstanding the impressive market shares and the tight organisation of the RWKS, the market structure of the coal mining industry in the Ruhr district displayed features that might have hampered a successful conduct by the cartel. First, the organisation had to deal with competition by outsiders. In total, only around 50 per cent of the coal output of its members was sold at cartel prices within the non-competitive regions (Wiedenfeld, 1912). For the remaining share of output, the RWKS had to compete with other coal producers in Germany and with imports from Great Britain (Walker, 1904). Furthermore, even within the non-competitive areas, the output of cartel outsiders became more and more substantial (see below). Second, there were many features that presumably increased negotiation and monitoring costs. First of all, the number of companies participating in the cartel was large.[13] Furthermore, there were remarkable differences in size[14] as well as substantial variations in cost situations[15]. Finally, demand and supply conditions were

11 The statements about the aims of the RWKS are based on the annual reports of the organisation (cited in Passow, 1911) and statements of cartel executives in Kontradiktorische Verhandlungen (1903).

12 The argumentation of the cartel authorities is in line with the reasoning of contemporary German economists. See, e.g., Liefmann (1897); Schmoller (1923).

13 At its foundation in 1893, the RWKS had no less than 98 members. In 1912, there still were 70 cartel members (Peters, 1989).

14 For example, in 1893, the minimum coal output of a cartel member was 13,944 metric tons. In contrast, the maximum was 2,926,729 tons. The median of the output of all 98 cartel members was 188,001 tons (calculated from figures in Jahrbuch, 1894).

15 Most of the cost differences were due to geology. Mines in the southern part of the Ruhr district were faced with thinner and less evenly stratified coal seams than those that operated in the northern part. In addition, their output showed a less favourable ratio of coal to stone. In part, these cost disadvantages were set off by the fact that the overburden in the north was thicker and production shafts had to reach deeper in order to access coal deposits (Bergmann, 1937; Brown, 1993: 203-229).

dynamic.[16] Third, the design of the first and second cartel contract promoted the creation of excess capacities (see below).

In order to evaluate the plausibility of the scenarios derived from the theoretical reasoning in section 2, at first we have to analyse if the RWKS was able to stabilise coal prices. Therefore, we consider two price series: one that displays prices charged in the non-competitive region and one that represents the overall sales price of coal from the Ruhr district (i.e., sales in the competitive as well as in the non-competitive region[17]). For both series, we test whether their variability declined after the formation of the cartel. Furthermore, we apply the same test to the variability of the Net National Product (NNP) deflator in order to distinguish cartel-related effects from economy-wide developments. The results of this exercise are displayed in Table 1.

Table 1: Price Stabilisation (Variance of Annual Percentage Changes of Coal Prices and the NNP Deflator, 1876–1892 and 1893–1913)

	Coal price (non-competitive region)	Overall sales price (non-competitive and competitive region)	NNP deflator
1876–1892	18.217	14.440	2.290
1893–1913	5.793	5.108	2.451
***F*-test (*p*-value)**	0.000	0.006	0.763

Note: coal price = price of fat coal at the exchange in Essen; overall sales price = total value of coal sales from the Ruhr district divided by sales in metric tons; *F*-test = *F*-test of variance equality; the *F*-statistic is given by $F = s_L^2 / s_S^2$ (where s_L^2 is the variance in the subgroup with the larger and s_S^2 is the variance in the subgroup with the smaller variance) and has N_L-1 numerator and N_S-1 denominator degrees of freedom (where N_L is the number observations in the subgroup with the larger variance and N_S is the number of observations in the subgroup with the smaller variance)
Source: Banken (2003), Data-CD-ROM; Hoffmann (1965).

The tests suggest that for both the coal price in the competitive region and the overall sales price, the variance of the annual changes was significantly lower after the formation of the RWKS. In contrast, the variability of changes in the NNP deflator remained almost the same. Thus, there is compelling evidence that the cartel was willing and able to stabilise coal prices, and we can reject scenarios (3) (monopolistic pricing without price stabilisation) and (4) (complete inefficacy of the RWKS) outlined in section 2.[18]

16 Between 1880 and 1913, German coal output increased by more than 6 percent annually (Jahrbuch, various issues). During the same period, the output of the German iron and steel industry – with a 40 percent share by far the largest consumer of coal from the Ruhr district (Passow, 1911) – grew by almost 6 percent per year (Hoffmann, 1965).

17 About 50 percent of the coal output from the Ruhr district was sold in the non-competitive region. The remaining part was sold in the competitive region (Wiedenfeld, 1912).

18 It should be noted that the RWKS was far less effective in controlling output. Comparing the production targets of the organisation to the actual total output of its members, Peters (1981) comes to the conclusion that the RWKS failed to meet these targets in 19 out of 20 years between 1895 and 1914 (in nine years actual output was below, in ten years above desired output).

The Foundation of the RWKS

The foundation of the RWKS in 1893 was preceded by more than 20 years of failed attempts to coordinate the behaviour of the mining companies in the Ruhr district. From the late 1870s onwards, numerous less ambitious collusive arrangements had been put in place. However, all of these arrangements were short-lived and eventually failed because they were confined to small geographical areas, limited in the scope of their control, and lacking effective mechanisms to sanction non-cooperative behaviour.[19] As a result, before the foundation of the RWKS the mining industry in the Ruhr district can be considered as a competitive industry (Holtfrerich, 1973).

Given the unfavourable pre-history, the negotiation process that finally led to the foundation of the RWKS was complicated and enduring. In January 1892, mining companies that represented almost 90 per cent of the output from the Ruhr district had joined the Association (*Gemeinschaft*) in order to negotiate a comprehensive cartel treaty that would overcome the shortcomings of the previous arrangements.[20] In the following months, these negotiations proved to be far from straightforward and were often more than close to collapsing. Then, at the end of September 1892, they gained momentum and a commission was installed that was intended to produce a draft version of a treaty. But even now, there still were drawbacks. In the first half of December 1892, it was declared impossible to persuade the vertically integrated iron and steel producers – called foundry mines (*Hüttenzechen*) – of the district to join the cartel.[21] Afterwards, it took another three months until the remaining mining companies from the district unanimously agreed to form the RWKS. Up to this date, the negotiations were again extraordinarily difficult. Two deadlines expired without the consent of all required companies having been reached.[22] Although most were willing to accept the draft contract, some were still undecided and others demanded special rights. As a result, in a meeting held on 28 January, it was ultimately demanded that all companies that had not yet approved to join had to do so until 16 February 1893. Otherwise, the negotiations would be terminated.[23] After this meeting, the approval of the remaining companies came more quickly than expected, so that the RWKS was officially founded on 9 February 1893.[24]

The First Revision of the Original Contract

Only 21 months after the foundation of the RWKS, in November 1894, the cartel authorities installed a commission to revise the original contract. Within this time period, two major short-

19 For a summary of collusion in the pre-RWKS years, see Pierenkemper (1979).
20 Unless indicated otherwise, accounts of negotiation processes rely on Verein (1904b).
21 See the issue of the *Kölnische Zeitung* dated 17 December 1892 (second morning issue). See also the issue of *Glückauf* dated 17 December 1892.
22 The first deadline was set to 22 December 1892 (*Kölnische Zeitung* dated 5 December 1892, morning issue). Afterwards, in a meeting held on the 16 December 1892 the commission extended this deadline until 20 January 1893 (*Kölnische Zeitung* dated 17 December 1892, second morning issue).
23 See the issues of the *Kölnische Zeitung* dated 29 January 1893 (Sunday issue) and 30 January 1893 (first and second morning issue).
24 See the issue of the *Kölnische Zeitung* dated 9 February 1893 (second morning issue).

comings of this contract had become apparent. At first, the pre-history of failed collusion hung like a sword of Damocles over the organisation. The cartel authorities felt that market participants and cartel members had to be persuaded that, in contrast to its short-lived predecessors, the RWKS was indeed powerful and intended to last for a prolonged period of time.[25] This problem was aggravated by the fact that in one of the last negotiation rounds in the run-up to the foundation of the cartel, the duration of the RWKS had been reduced from ten to only five years.

The second shortcoming was the design of the dynamic quota regime. The contract of 1893 stipulated two different ways for a cartel member to increase its production allowance. First, it could apply for a higher quota for its existing production facilities. In this case, the cartel authorities could refuse an increase, if they judged that the coal market was incapable of absorbing the additional output. Second, a cartel member could sink a new production shaft. Thereby, it could automatically raise its quota by 120,000 metric tons and, for the cartel authorities, there was no way to deny the increase. In the years 1893 to 1895, the members of the RWKS had made excessive use of this privilege for new shafts and had stretched the words of the respective paragraph to the maximum: new shafts were sunk and then closed down again, once the larger cartel quota was granted, ventilation shafts were turned into production shafts, and shafts were equipped with additional extraction lifts, as double shafts would be counted as two units of production (Peters, 1989).[26] The uncontrolled increase in individual production allowances severely complicated the control of output and the cartel authorities regarded it as the major threat to the existence of the whole organisation.[27]

The commission that was installed to revise the original contract issued its suggestions in early April 1895. After that, the advisory council of the RWKS discussed and modified the document throughout April and sent a final draft to the general assembly in a session on 5 May 1895.[28, 29]

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25 In a meeting of the advisory council (see footnote 26) on 30 May 1895, Tillmann, the chief executive of the mining company Tremonia, stated: "[The ten-year term is] essential for the syndicate to work effectively and for winning and retaining the trust of the Syndicate not just with its members, but with the entire rest of the business community." Original: "[Die zehnjährige Laufzeit ist] zu einer gedeihlichen Thätigkeit des Syndicats sowie zur Gewinnung und Erhaltung des Zutrauens zum Syndicate nicht bloß der Mitglieder, sondern auch der ganzen übrigen Geschäftswelt nothwendig." (Mining Archive, Bochum, inventory 33, no. 1: Minutes of the General Assembly, 1894–1896).

26 Between 1893 and 1895, the sum of the individual production allowances rose by more than seven percent annually; almost two thirds of these increases was due to the privilege for new production shafts (Mining Archive Bochum, inventory 33, no. 423: Annual Participation Figures; Pilz, 1910). All quota increases by 120,000 tons or a multiple of 120,000 tons were interpreted as quota increases due to new production shafts (see Peters, 1981).

27 In a meeting of the advisory council (see footnote 26) on 9 April 1895, Emil Kirdorf, head of the council and chief executive of the Gelsenkirchener Bergwerks-AG, stated that "no clause [of the first agreement turned out to be] [...] so critical for the Syndicate". Original: "[...] keine Bestimmung [des ersten Abkommens hat sich als] [...] so bedenklich für das Syndicat erwiesen". (Mining Archive, Bochum, inventory 33, no. 50: Minutes of the Advisory Council, 1895).

28 The most important bodies of the RWKS were the executive board, the advisory council, and the general assembly. The executive board was indirectly elected by the general assembly (via a supervisory board). It set the sales prices, defined the deductions from the redistributed revenues, and imposed the fines for non-compliance with delivery commitments. Membership and voting rights in the advisory council were granted on the basis of coal output. For each 1,000,000 tons of output, a cartel member could claim one seat in the council (small mines could combine their output to obtain a seat). In contrast to its denomination, *de facto* the advisory council was the most powerful of the cartel's bodies. It defined the basis for the price-setting of the

In this session, it also defined the prerequisite for the formal acceptance of the revised contract: the agreement of all members.[30] Then, the discussions in the general assembly continued for another two months, but despite an already overwhelming majority in favour of the revised contract, unanimous consent could not be reached, as some companies kept on requesting special treatment.[31] Thus, in a final meeting of the general assembly on 26 June 1895, it was ultimately declared that either all members sent binding notes of approval to the cartel authorities until 22 July or the negotiations would be terminated.[32] In effect, the two companies finally gave up their reservations, and in a session of the advisory council on 23 July 1895, the agreement of all members was announced.[33] In a meeting of the general assembly dated 31 July 1895, all members of the RWKS then unanimously voted in favour of the new document.

The revised contract came into effect on 1 January 1896. Compared to the original contract, there were two major changes. First, its duration was set to ten years. Second, the privilege for new production shafts was cut back, but not abolished. Now, the cartel authorities were allowed to judge the technical feasibility of new production shafts. However, they still could not refuse an increase with reference to their evaluation of market capacity. Moreover, the effectiveness of the new stipulations was diminished by transitional provisions attached to the revised contract that guaranteed grandfathering for 30 to 50 applications for quota increases on the basis of the original contract.[34]

The Second Revision of the Original Contract

By the turn of the century new challenges for the RWKS had emerged, in particular increasing outsider competition within the area that the cartel authorities considered as non-competitive. The most important outside threat were the foundry mines from the Ruhr district that had refused to join the cartel in 1892. In the first ten years of its operation, they had not only stabilised their position. In contrast, their market share in the coal output of the Ruhr district was ever increasing. Whereas in 1893 their output accounted for only 10 percent of the total output from the district, this share had grown to 19 percent by 1903.[35] The increase was partly due to the fact that the foundry mines had bought a substantial number of cartel members whose production would have been outside of the control of the organisation once the contracts of 1896 expired at the end

executive council, finally decided on applications for quota increases, and arbitrated disputes between the executive council and individual cartel members. Furthermore, it could install commissions for a wide variety of topics. In the general assembly, voting rights were also allocated on the basis of coal output. For every 10,000 tons of output, a member received one seat. The general assembly decided on the acceptance of new cartel members, had to agree on the common percentage reductions of production allowances, and imposed the fines for production in excess of cartel quotas.

29 See the issues of the *Kölnische Zeitung* dated 5 May 1895 (Sunday issue) and 12 May 1895 (Sunday issue).

30 The guidelines are printed in Verein (1904b).

31 See the issue of the *Kölnische Zeitung* dated 31 May (first morning issue).

32 See the issue of the *Kölnische Zeitung* dated 27 June 1895 (second morning issue).

33 See the issues of the *Kölnische Zeitung* dated 24 July 1895 (first morning issue and evening issue).

34 The transitional provisions of the second contract mention 28 shafts. In contrast, in the first morning issue of 4 November 1895 the *Kölnische Zeitung* mentions 40 to 50 shafts.

35 Calculated from figures provided in Verein (1904a), Verein (1904b), and Pilz (1910).

of 1905.[36] Apart from increasing outsider competition, the privilege for new shafts was still on the agenda, as the previous changes had proven to be insufficient for slowing down the uncontrolled increase of production allowances (Peters, 1981).

As a result of these new and old challenges, in February 1902 a high-ranked commission was installed to prepare another substantial revision of the cartel contract and negotiate with the outsiders in the Ruhr district, in particular with the foundry mines, about their inclusion in the organisation. It took more than one year until the commission was able to present a draft version of a new contract in the first half of May 1903. In July and September 1903, the draft was negotiated in three meetings of the general assembly and finally, in a meeting held on 30 September 1903, all members of the RWKS agreed on the revised document.[37] This time, however, their consent was not sufficient for the new contract to be formally accepted. A clause in the revised document demanded that in addition to all current members, the foundry mines of the Ruhr district had to join the cartel by 31 December 1903. Otherwise, the revision would remain irrelevant. In order to negotiate the terms of the foundry mines' participation, another commission was installed. In the end, it was successful and all companies whose participation had been made the *conditio sine qua non* for the coming into effect of the new contract finally joined the RWKS. As a result, on 29 December 1903 the general assembly could formally accept the third contract.[38]

Without a doubt, the most important change from the second to the third contract was the inclusion of the former cartel outsiders. However, this change came at substantial costs. In order to persuade the vertically integrated companies to join the cartel, they were granted cartel quotas that exceeded their actual output substantially (Wilhelm, 1966). Furthermore, the coal they self-consumed to run their blast furnaces and foundries remained outside of the quota system and was not subject to any delivery requirements. In effect it could not be controlled by the cartel authorities at all. These privileges were extraordinarily advantageous for the former outsiders: on the one hand, in times of booming demand for iron and steel they could use all the coal they extracted themselves; on the other hand, if demand for iron and steel was sluggish, they could insist on the obligation of the RWKS to buy the output they were allowed to produce according to their oversized cartel quotas (Wiedenfeld, 1912).[39] For the non-integrated companies in the organisation, these advantages of the foundry mines were a heavy burden. They could not fully participate in upswings of the iron and steel market and had to accept higher restrictions of their quotas when demand for iron and steel was low. In addition, they were disproportionately burdened with the financing of sales subsidies and overhead costs, as coal for self-consumption was also exempted from the percentage deduction on revenues. The severity of the conflict of interest be-

36 Stigler (1951) argues that – by raising prices above marginal costs – the RWKS itself set incentives for down-stream producers (i.e., iron- and steel-producing companies) to buy the suppliers of their input (i.e., coal), instead of buying it on the cartelised market.

37 See the issues of the *Kölnische Zeitung* dated 7 July 1903 (first morning issue), 12 July 1903 (Sunday issue), 13 July 1903 (first morning issue), 16 September 1903 (first morning issue), and 1 October 1903 (first morning issue).

38 See the issue of the *Kölnische Zeitung* dated 30 December 1903 (first morning issue).

39 One might conclude that the privileges of the foundry mines stimulated mining companies to integrate forward into iron and steel production. However, in the years 1904–1913, only one mining company made this decisive step.

tween foundry mines and non-vertically integrated mines is illuminated by the fact that – although the privileges were hotly disputed right from the start – both parties were not able to agree on their revision up to the First World War. As late as 1915, when the German Federal Government finally forced the RWKS members to sign a new contract, all preferential treatment of the foundry mines was abolished (Burke, 1979).

Apart from the incorporation of the foundry mines, the new cartel contract brought about two other significant changes. First, the privilege for new shafts was completely abolished. Second, the revised contract included clauses that were intended to deter entry and to deal with competition from cartel outsiders. The RWKS was allowed to buy unworked coal fields in the Ruhr district and the neighbouring regions, in order to prohibit their exploitation by potential outsiders. In addition, it could also engage in price wars with competing mining companies, if the cartel authorities judged this necessary to achieve the aims of the organisation.

4. Methodology

Event Studies

In section 3, we showed that the RWKS was willing and able to stabilise coal prices. As a result, we rejected scenarios (3) (monopolistic pricing without price stabilisation) and (4) (complete ineffectiveness of the RWKS) outlined in section 2. In order to evaluate the plausibility of the remaining scenarios (1) (mean preserving price stabilisation) and (2) (price stabilisation above the mean preserving level), next we have to analyse the effect of price stabilisation on the profitability of the cartel members. Therefore, in a first step, we employ event study methodology. Event studies examine the economic effect of an event by looking at changes of stock prices. The types of investigated events are manifold and range from announcements of stock splits and dividend payments to takeovers and regulatory activity (for summaries, see Binder, 1998; MacKinlay, 1997; Peterson, 1989).[40] Event studies make use of the fact that on an information-efficient stock market, stock prices should mirror expected profitability, and new information should be immediately reflected in them.[41] For the case investigated in this study, this means that if contemporary investors expected a change in the profitability of companies participating in the RWKS due to the formation of the cartel or due to the two major revisions of its original contract, these expectations should show up instantaneously in the stock price series of these companies. In particular, higher expected profits should result in a jump of stock prices.

40 In addition, event study methodology in combination with government bonds is also used to assess the effects of historical events or current political crises. Frey/Waldenström (2004) investigate the changing fortunes of the Allies and Nazi-Germany during the Second World War; Brown/Burdenkin (2000), Weidenmier (2000), and Willard et al. (1996) look at turning points in the US Civil War; Chaney (forthcoming) examines the pacification policy in Iraq after the US-led intervention in 2003.

41 For a treatment of stock market efficiency and the Efficient Market Hypothesis, see Copeland/Weston (1992).

In general, there are two ways of proceeding in an event study. Using the first approach, the event dates are determined *ex-ante* and exogenously, e.g., by consulting newspapers or other publications. Then, the stock return at the event date is compared to the 'normal return' in a time period that is unaffected by the event, usually a period preceding it. The difference between these two observations, the 'abnormal return', is then interpreted as the market reaction to the occurrence of the event.[42] In the second approach, the event dates are endogenously detected by using an econometric model to look for "turning points" (Willard et al., 1996) in the data at hand. Afterwards, the market reaction at these "turning points" is interpreted in the light of qualitative information.[43] In our study, we follow the second approach, as the negotiation processes preceding the three investigated cartel contracts lasted for extended periods of time and *a priori* we can not be sure at which stage of these processes the market reacted.

The basis of our three event studies – one for each investigated contract – is the well-known and widely used market model. Its parameter estimates constitute the 'normal return'. The model predicts that the return R of a company i at time t can be expressed by a company-specific constant (α_i), the covariance of the company's returns with those of a market portfolio ($\beta_i R_{mt}$) and an error term (ε_{it}):

$$(1) \qquad R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it}$$

In the three event studies, equation (1) is separately estimated for each investigated company. As a result, it is possible to account for different distributional forms of the residuals in the company-specific equations. First, sticking to the standard OLS framework, the error terms can be normally distributed with a mean of zero and a constant variance $\sigma^2_{\varepsilon_i}$:

$$(2) \qquad \varepsilon_{it} \sim N(0,\ \sigma^2_{\varepsilon_i})$$

Furthermore, it can also be accounted for the existence of autoregressive conditional heteroscedasticity in the error terms, i.e., for the fact that often stock returns cluster in time. In these cases the variance of the market model residuals can follow an ARCH (1) or GARCH (1,1) process, i.e., they can be normally distributed with a mean of zero and a conditional variance h^2_{it} (Engle, 1982; Bollerslev, 1986):

$$(3) \qquad \varepsilon_{it} \sim N(0,\ h^2_{it})$$

with

$$h^2_{it} = \alpha_0 + \alpha_1 * \varepsilon^2_{t-1}$$

or

$$h^2_{it} = \alpha_0 + \alpha_1 * \varepsilon^2_{t-1} + \beta * h^2_{it-1}$$

42 On the methodology of this approach, see Armitage (1995); Brown/Warner (1980, 1985); MacKinlay (1997).

43 The second approach is first and foremost used in studies that look at the level of bond prices (see the references in footnote 35), but can also be fruitfully applied to stock returns (see, e.g., Bittner, 2005; Cyree/DeGennaro, 2002).

In order to determine the correct specification of each company-specific equation, we use the ARCH-Lagrange Multiplier test with four to eight lags.[44] For each contract, the number of OLS, ARCH(1), and GARCH(1,1) company equations is displayed in Appendix Table 1.

The market model is estimated over a time period that covers approximately 600 trading days (or two years).[45] Roughly at the middle of this estimation period is the date at which the contract under investigation was formally accepted (the exact definition of this date will be provided in the empirical section). The window in which we search for abnormal performance due to the contract under investigation is also defined by the formal acceptance date. It starts 100 days prior to this date and ends 10 days afterwards. In other words, it ranges from day -100 to day +10. By the choice of this rather long window, we can be reasonably sure that the main stages of the respective negotiation processes are covered. Furthermore, by including periods after the formal acceptance dates, we can also catch possible retarded effects. Within the window we proceed in the following way: To model 'abnormal returns', the market model is augmented by a dummy variable (D) that is equal to one on seven days and equal to zero otherwise[46, 47]:

$$(4) \qquad R_{it} = \alpha_i + \beta_i R_{mt} + \gamma_i D_{it} + \varepsilon_{it}$$

At first, this augmented market model is estimated with the dummy centred on day -100. Afterwards, it is estimated with D_{it} centred on day -99. This procedure is repeated until the dummy is centred on day +10 and consecutively performed for all companies in the sample. At any step, we collect the value of γ_i. Furthermore, we perform a Wald test on the exclusion of the dummy variable from the model and retain the p-value of its F-statistic. Thus, in the end we have 111 coefficient estimates and 111 p-values for every investigated company.

Next, the company-specific p-values are aggregated in the cross-section using the method proposed by Fisher (1932). The result of this exercise is a series of χ^2-distributed test statistics with $2N$ degrees of freedom (where N is the number of units in the cross-section). Possible event date(s) are then detected by looking for maximums in this series, as these should represent dates at which several or all companies in the sample performed abnormally. Afterwards, these peaks are compared to qualitative information on the negotiation processes. If there is sufficient evidence that a maximum can be attributed to one of the steps in these processes we first evaluate the average γ_i-coefficient value at the respective date and count the number of significant coefficients to obtain an impression of the actual effect. Second, we apply a non-parametric binomial

44 The test results are not reported, but available on request.

45 At the stock exchange in Berlin, there usually were six trading days a week (Monday to Saturday).

46 The length of the event window has to be chosen arbitrarily. On the one hand, it must be long enough to discriminate between substantial "turning points" and "blips" (Willard, 1996). Furthermore, new information oftentimes trickles down slowly so that the full adjustment of the market to a new information set can take several days. On the other hand, if an excessively long window is chosen, this reduces the chance of detecting multiple breaks, as "turning points" of different sign can possibly offset each other. In order to check the robustness of our results to different specifications of the event window, re-estimated all event studies with symmetric windows covering three, eleven, 15, 21, and 31 days. The findings from these robustness checks will be presented alongside those of the seven-day specification.

47 In the event study of the second revision of the original contract, we include another dummy variable to account for the breakdown of the Imperial Ottoman Bank on 9 November 1895 (see Gelman/Burhop, 2008).

sign test to the estimated γ_i-coefficients at this date to assess whether the observed effect runs into the same direction for all investigated companies (i.e., whether the signs of the γ_i-coefficients are positive or negative throughout). Finally, we use correlation analysis to gain a deeper insight into the determinants of company-specific abnormal performance (the design of this analysis will be presented in the next section).

This methodology assumes that the event dates are identical for all companies. In this respect, it differs from Bittner's (2005) event study on the RWKS, which employs different company-specific event dates. We think that opting for a common event date is more plausible, since at the date when news about the state of the negotiation process became public knowledge, the same set of information should have simultaneously been available for the assessment of all considered companies' expected profitability.

Dynamic Panel Data Analysis

To cross-check the validity of the findings from the event studies, we will also assess the performance effect of the RWKS by a joint analysis of accounting figures as well as financial and output data. In this combined analysis, we use dynamic panel data models. The dependent variables are two measures of company performance. At first, we use the RoA, i.e., accounting profits divided by the book value of total assets, as a measure of company profitability. In addition, we also look at the expected profitability of the investigated companies as modelled by Tobin's *q* ratio (Tobin, 1969). The latter measure of company performance is superior to the former (or other accounting ratios like the RoE), because it is unaffected by arbitrary accounting conventions and manipulations. Furthermore, the *q* ratio also proxies monopoly rents (Lindenberg/Ross, 1981) and thus, more adequately captures possible effects of cartelisation. The *q* ratio is calculated by dividing the market value of a company by its replacement value. Market valuation is defined by the nominal value of outstanding stocks multiplied by their end-of-year stock price. The replacement value figures are calculated using the perpetuary inventory method of Lindenberg/Ross (1981). Thus, the book value of the companies in our sample is adjusted for investment, depreciation, price changes, and the technological progress of the current and of preceding periods.[48]

The regressors are the same for both independent variables. Cartelisation is modelled by a dummy variable that is equal to one in years when a company was a member of the RWKS and equal to zero otherwise. In addition to the cartel variable, we add a number of control variables that might influence company performance. First, we include the debt ratio – calculated as the book value of total debt divided by the book value of total assets – as a measure of leverage. A priori, the sign of this variable is indeterminate. High leverage can serve as a disciplining device for managers and, thus, have a positive effect on company performance (Grossman/Hart, 1982).

48 The formulation and data sources of the replacement costs series are laid out in the appendix of Burhop/Lübbers (forthcoming).

However, it is also possible that it forces the management of a company to forgo positive net present value investment projects (Myers, 1977). In this case, the effect on company performance would be negative. Second, the natural logarithm of the book value of total assets is included as a proxy for company size. A positive (negative) coefficient of this variable indicates positive (negative) economies to scale. Third, company growth – defined as the first difference of the log of total coal output[49] – is added to the equations. This variable proxies for growth opportunities and should have a positive effect on company performance. All three control variables are interacted with the RWKS dummy. The terms including company size and growth test a hypothesis often brought forward in the literature on the RWKS, namely that larger companies with greater growth opportunities were the chief beneficiaries of cartelisation, because – due to a superior access to external finance – they could most likely exploit the privilege for new shafts (Bittner, 2005; Goetzke, 1905; Peters, 1981). The interaction between the cartel dummy and leverage considers the possibility that companies with a high ratio of debt to total assets might have profited more, because as a result of decreasing price volatility after the formation of the RWKS, debtors demanded a lower risk premium for their commitments (Scherer/Ross, 1990). Finally, we include company and time fixed effects (α_i and η_t). The former account for company-specific characteristics that are invariant over time, e.g., geological conditions. The latter capture effects that are the same for all companies, but change over time, such as movements of the business cycle or technological progress. We also tested a dummy variable that would have accounted for the fact that some of the companies in the sample are vertically integrated foundry mines, while the majority of companies were only engaged in mining. Since this variable was insignificant in all estimated equations, the results of this exercise are not displayed (but are available on request).[50]

Dynamic is introduced into the model by including the first lag of the dependent variables among the regressors. For the choice of a dynamic model, there are both theoretical and practical reasons. Theoretically, it is straightforward to assume that current profitability is partly determined by past profitability and that expectations about profitability are influenced by former expected profitability. Furthermore, it is oftentimes suggested that managers in Imperial Germany used depreciations and reserves to smoothen profits and dividend payments over the business cycle (Hanf, 1978). Practically, a dynamic model is recommended, because the residuals of the static models show signs of significant autocorrelation.[51] Thus, we estimate the following models, where $\varepsilon_{i,t}$ is normally distributed disturbance term with an expected value of zero and constant variance:

49 As it was impossible to store larger quantities of coal for extended periods of time (see section 2), output growth should also be a good proxy for the growth of sales.

50 The finding that there are no systematic differences in performance between vertically integrated and non-integrated companies conflicts with the results of studies that use modern data from the United States and report significant diversification discounts in the 1960s and 1980s (Lang/Stulz, 1994; Servaes, 1996).

51 The test results are not reported but available on request.

(5) $RoA_{i,t} = \gamma\ RoA_{i,t-1} + \beta_1\ LEVERAGE_{i,t} + \beta_2\ \log(SIZE_{i,t}) + \beta_3\ GROWTH_{i,t} + \beta_4\ RWKS_{i,t} + \beta_5\ LEVERAGE_{i,t} * RWKS_{i,t} + \beta_6\ \log(SIZE_{i,t}) * RWKS_{i,t} + \beta_7\ GROWTH_{i,t} * RWKS_{i,t} + \alpha_i + \eta_t + \varepsilon_{i,t}$

and

(6) $q_{i,t} = \gamma\ q_{i,t-1} + \beta_1\ LEVERAGE_{i,t} + \beta_2\ \log(SIZE_{i,t}) + \beta_3\ GROWTH_{i,t} + \beta_4\ RWKS_{i,t} + \beta_5\ LEVERAGE_{i,t} * RWKS_{i,t} + \beta_6\ \log(SIZE_{i,t}) * RWKS_{i,t} + \beta_7\ GROWTH_{i,t} * RWKS_{i,t} + \alpha_i + \eta_t + \varepsilon_{i,t}$.

Notwithstanding that opting for a dynamic specification seems well-justified, the choice of the actual estimator is far from being straightforward. On the one hand, using Ordinary Least Squares (OLS) with fixed effects results in biased coefficient estimates. On the other hand, the existing unbiased estimators – e.g., the instrumental variable estimator proposed by Anderson/Hsiao (1981, 1982) or the Generalised Method of Moments estimators developed by Arellano/Bond (1991) – are designed for panels with a large number of observations in the cross-section (N) and few in the time dimension (T) and inefficient in large T small N settings (our panel covers 33 years and 33 cross-sections).[52] However, in our case, there are good reasons for using the OLS fixed effects estimator. First of all, its bias decreases as T becomes larger and will disappear if T approaches infinity (Nickell, 1981). Furthermore, the bias is larger in the estimates of the dynamic parameter γ than in the coefficient estimates of the other independent variables, which usually are the main focus of interest in empirical research. As a result, simulation studies show that for panels with a time dimension of 30 observations or more, the dynamic OLS fixed effects estimator is the best choice (Beck/Katz, 2004; Judson/Owen, 1999).

5. Data

Our dataset for the event studies includes daily stock prices of all 21 joint-stock mining companies that operated in the Ruhr district between 1892 and 1913 and that were listed at the stock exchange in Berlin. All companies were members of the RWKS since its foundation in 1893. The information on one of these companies had to be omitted, because its stock price series were too fragmentary to be considered in a quantitative analysis. Another company had to be dropped from the investigation, as it was liquidated soon after the foundation of the cartel. As a result, in the event study of the first RWKS contract we can examine 19 mining companies. For the second and the third contract, this number is reduced to 18 and 14 companies, respectively, as companies disappeared as a result of takeover activity.

The stock prices were collected from the *Berliner Börsen-Zeitung*. The stock market index in the market model is the weighted performance index constructed by Gelman/Burhop (2008). In order to make our stock price series compatible with the index, we applied the same performance

52 A corrected dynamic OLS fixed-effects estimator proposed by Kiviet (1995) produces both unbiased and efficient estimates. However, it cannot be applied to unbalanced panels.

modifications. This means that the original series were corrected for dividend payments, subscription rights, and broken period interest.[53] A positive side effect of this procedure is the elimination of outliers that are solely due to technical market reactions, which should have a positive effect on the fit of the regressions. Returns were calculated by transforming the index and the corrected stock price series into natural logarithms and then calculating first differences.

The qualitative sources needed to interpret the findings from the event studies are printed documents, a contemporary newspaper, and a contemporary journal. First of all, we used the detailed accounts in the data and source compendium *Die Entwickelung des Niederrheinisch-Westfälischen Steinkohlen-Bergbaues in der zweiten Hälfte des 19. Jahrhunderts* edited by the *Verein für die bergbaulichen Interessen im Oberbergamtsbezirk Dortmund*, the first and foremost lobby organisation of the mining industry in the Ruhr district and a fierce proponent of cartelisation. Furthermore, we consulted the *Kölnische Zeitung*, a daily newspaper published in the city of Cologne, around 40 km south of the Ruhr district.[54] Due to the close geographical proximity, it provided an extensive coverage of the mining industry in the district. In addition, it also reproduced rumours brought forward by other newspapers, so that it is very likely that in one way or another interesting news would actually appear in it. Finally, we read the weekly issues of the well-informed and low-tempered mining trade journal *Glückauf*.

As mentioned in section 4, a crucial prerequisite for the application of event study methodology is the information efficiency of the investigated stock market. For the case of the Berlin stock exchange in Imperial Germany, a study by DeLong/Becht (1992) questions this property. Using Shillers (1981) concept of excess volatility, they argue that stock prices in Imperial Germany followed their fundamentals too closely to be compatible with the concept of an information efficient market and attribute this finding to the dominant role of large joint-stock credit banks. However, Becht/DeLong consider annual data only and use an outdated annual stock price index designed by Donner (1934). As a result, more recent empirical studies based on investigations of daily data find that the information efficiency of the stock exchange in Berlin was comparable to that of modern stock exchanges in Europe and the United States (Baltzer, 2006; Gehrig/Fohlin, 2006; Gelman/Burhop, 2008).[55]

The annual accounting figures and *ultimo* stock market quotations that are required for the dynamic panel data analysis are available for the above-mentioned 21 companies as well. They were compiled from annual balance sheets and stock market data published in *Saling's Börsen-Jahrbuch* and *Der Deutsche Ökonomist*. From the same sources and from the data appendix of Feldenkirchen (1982), we also have accounting figures and *ultimo* stock quotations of nine foundry mines that joined the RWKS in 1904 and of three cartel outsiders – two foundry mines from Upper Silesia and one from the Aachen mining district. Output data was collected from Huske

53 For a detailed discussion of the different performance corrections, see Gelman/Burhop (2008); Ronge (2002).
54 Cologne was also the home of the most important financial market place in the Western part of Imperial Germany, the Cologne stock exchange.
55 Baltzer (2006) analyses cross-listings; Gehrig/Fohlin (2006) look at transactions costs; Gelman/Burhop (2008) investigate the autocorrelation of stock returns.

(1987), the *Jahrbuch für den Oberbergamtsbezirk Dortmund*, the *Jahrbuch für den Oberbergamtsbezirk Breslau*, and from archival sources in the Münster State Archive.

The resulting panel is unbalanced and covers years from 1881 to 1913. The included companies represent between 23.25 (in 1881) and 50.73 (in 1907) percent of the coal output from the Ruhr district and between 13.13 (in 1881) and 31.33 (in 1907) percent of total German coal output.[56] The sample of the event studies covers between 30.05 (in 1913) and 42.63 (in 1898) percent of the coal output from the Ruhr district and between 18.05 (in 1913) and 22.71 (in 1898) percent of total German coal output in the years 1892 to 1913.

6. Empirical Results

Event Studies

ORIGINAL CONTRACT

A crucial step in the application of our event study procedure is the definition of the formal acceptance date, because this date defines the overall estimation period as well as the 111-day period in which we search for abnormal performance. In the following, it will be defined as the first *a priori* known date, at which there could be no more doubts that all required companies had agreed to the contract under consideration. In the case of the original contract, this date is 9 February 1893, i.e., the foundation date of the RWKS. Defined by this date, the estimation period of the event study covers the 616 trading days between 2 January 1892 and 30 December 1894. The 111-day window in which we search for abnormal performance ranges from 14 October 1892 to 20 February 1893. The results of the event study of the original contract indicate two peaks in abnormal performance (see Figure 1). The first and largest is situated in the period between 8 and 15 December 1892 (i.e., that the dummy variable is centred on 12 December) and the second and slightly smaller one in-between 28 January and 4 February 1893 (i.e., that the dummy variable is centred on 1 February).

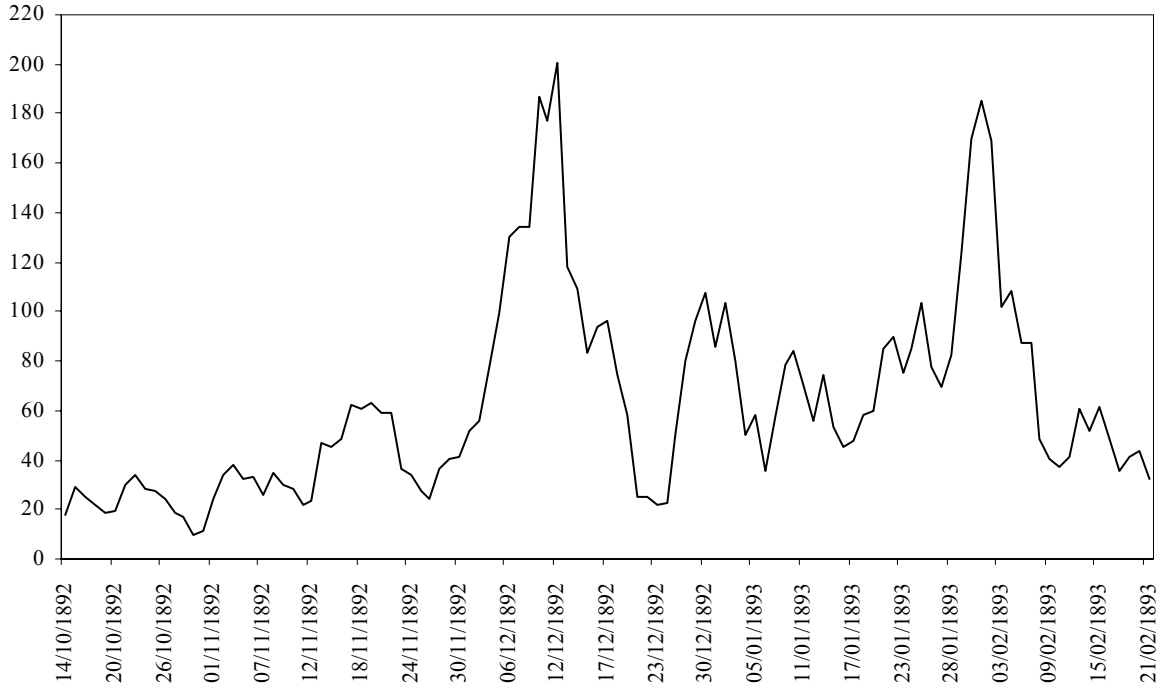
The first of these peaks is situated in a time period when the prospects for achieving a comprehensive agreement looked dim. In its session on 16 December 1892, the commission that led the negotiations on the draft contract would officially declare that the foundry mines of the Ruhr district were not willing to join the cartel. Furthermore, it would announce that the first deadline for the consent of all remaining companies could also not be sustained and would thus be extended until 20 January 1893. In the morning issue of 19 December 1892, the *Kölnische Zeitung* quoted a comment from the *Berliner Börsen-Courier* on the session of the commission it thought summarised the mood at the Berlin stock exchange quite accurately:

56 Significantly increasing the coverage of the panel was impossible, as most of the remaining German mining companies were organised as *Gewerkschaft*. In contrast to joint-stock companies, *Gewerkschaften* were not obliged to disclose information about their operations. Moreover, the balance sheets of those companies, which made them up voluntarily were not published with the same regularity as those of the joint-stock companies (for information on the organisational form "*Gewerkschaft*", see Friedrich, 1979).

"This desperately resembles a complete failure of syndicate endeavours."57

The results of the event study show a clear negative assessment of the situation by the stock market (for the results of all three event studies, see Table 2). The coefficient of the dummy variable centred on 12 December 1892 is negative in 18 out of 19 company-specific equations.[58] In 9 out of 19 cases it is negative and significant. Its average value is -1.06.[59]

Figure 1: Aggregated *p*-Values of Wald Tests (Original Contract)



The second peak is situated in the period between the meeting on 28 January 1893, where the last indecisive companies were ultimately demanded to agree to cartel formation and the foundation of the RWKS on 8 February 1893. Thus, it is straightforward to argue that at this time contemporary investors reacted to the prospective foundation of the organisation. Their assessment was positive. The coefficient of the dummy variable centred on 1 February 1893 is positive in all

57 Original: "Das sieht einem vollständigen Scheitern der Syndicatsbestrebungen verzweifelt ähnlich."

58 As a result, the binomial sign test rejects the hypothesis that positive and negative coefficients are the same in number.

59 Re-estimating the event study of the original contract with different specifications of the event window, we detected peaks in the same time periods that are suggested by the results of the seven-day specification using a three-, an eleven, and a 15-day event window. In all three cases, the average values of the γi-coefficients are smaller than in the original specification. Employing a 21- and a 31-day event window, we could only detect the second peak.

19 company-specific equations. In 12 out of 19 cases it is positive and significant. Its average value is 0.83.[60]

Although the event study shows opposite effects in the two detected event periods, the economic interpretation of the findings is almost the same. During the first period, contemporary investors expected that not having a cartel would reduce the profitability of the investigated mining companies. In the second period, when they were persuaded that cartel formation was ensured, they expected increasing profits. Thus, overall cartelisation was regarded as having a positive effect on company performance. However, it should be noted that the positive effect due to the prospective foundation of the RWKS hardly made up the former negative one.[61] All in all and in line with the results of Bittner's (2005) study, it must therefore be concluded that the foundation of the RWKS left the expectations of contemporary investors concerning the profitability of the cartel members almost unchanged.

Table 2: Results of Event Studies

	Original contract	**First revision**				**Second revision**
Event period	8/12/–15/12/1892	28/1/–4/2/1893	4/5/–11/5/1895	27/5/–4/6/1895	6/7/–13/7/1895	10/10/–17/10/1903
Average value of γ_i-coefficients	-1.061	0.828	0.142	0.162	0.040	0.853
Company-specific coefficients						
Negative and significant	18 (9)	0 (0)	7 (2)	8 (4)	9 (3)	0 (0)
Positive and significant	1 (0)	19 (12)	11 (2)	10 (6)	9 (2)	14 (10)
Binomial sign test (*p*-value)*	0.000	0.000	0.481	0.815	1.000	0.000

Note: Number of positive/negative and significant company-specific γ_i-coefficients in the respective event periods in parentheses; *Null hypothesis of the test is that positive and negative company-specific γ_i-coefficients in the respective event period are the same in number (i.e., the test evaluates whether the signs of the company-specific γ_i-coefficients in the respective event period are positive or negative throughout).

In order to test whether the measured effect was different for different companies, we make the company-specific dummy variable coefficient estimates subject to a simple correlation analysis.[62] More specifically, we investigate whether company-specific abnormal performance can be related to the discrete control variables of the dynamic panel data analysis, i.e., leverage, company size, and growth.[63] The underlying hypotheses are the ones presented in the discussion of

60 Naturally, the binomial sign test clearly rejects the hypothesis that positive and negative coefficients are the same in number.

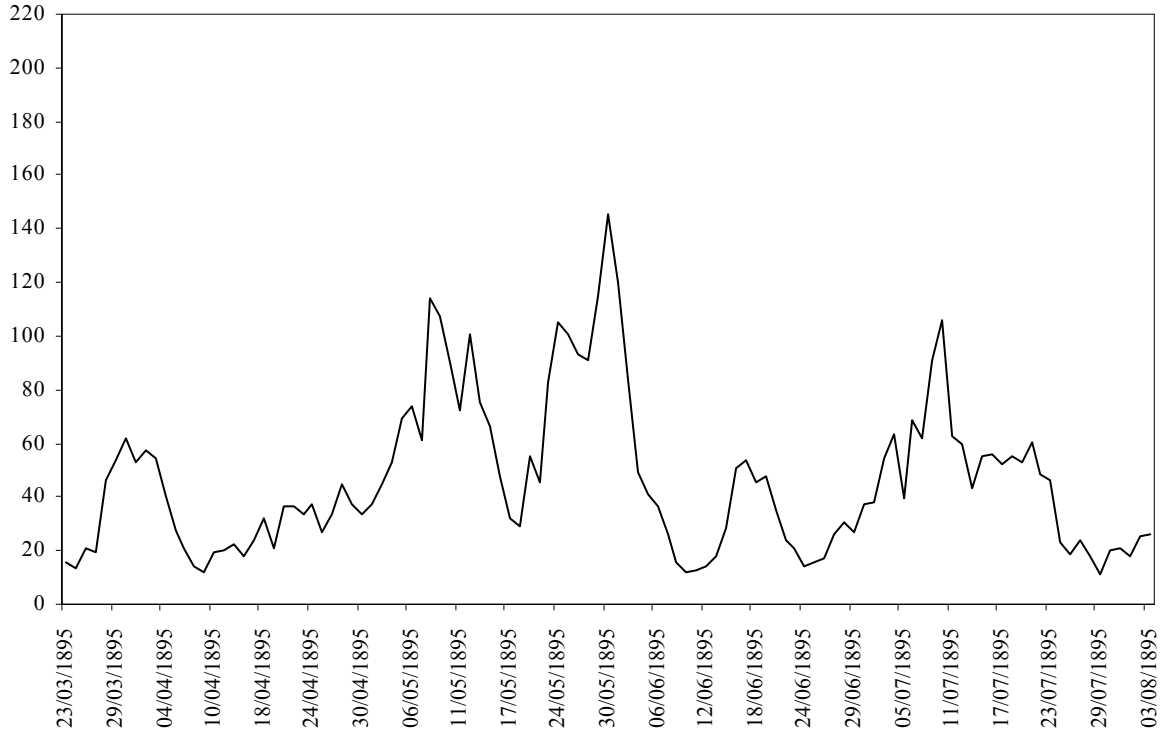
61 The larger average dummy variable coefficient in the first period is largely due to the extraordinary large coefficient in one company-specific equation. If the coefficients of this company is excluded in the calculation of the average dummy variable coefficients at both peaks, the absolute value of the one at the second peak will be slightly larger (-0.73 compared to 0.81).

62 We employ Spearman's rank correlation coefficient. Due to the small size of our sample, significance test are based on the *t*-distribution rather than the normal approximation. We also estimated the correlations using the *z*-standardised γi-coefficients instead of the un-standardised ones. As the results of both estimations are – with respect to significant correlations – the same, those using the *z*-standardised γi-coefficients are not reported (but available on request).

63 Leverage is the ratio of the book value of debt to the book value of total assets at the end of 1892. Company size is measured by the book value total assets at the end of 1892. Growth is approximated by the first difference of the natural logarithms of coal output at the end on 1892 and 1891.

the interaction terms in equations (5) and (6), i.e.: larger companies with greater growth opportunities profited more from cartelisation, because they were the chief beneficiaries of the privilege for new shafts; and: companies with a higher ratio of debt to total assets profited more, because their debtors might have demanded a lower risk premium as a result of decreasing price volatility after the formation of the RWKS. We confine the analysis to the coefficients of the dummy centred on 1 February 1893, because we have no exact information on the wording of draft versions of the cartel contract and in particular, we do not know at which stage in the negotiation process the privilege for new shafts was included. The results of the analysis do not support the hypotheses mentioned above, as we detect no significant correlation between company size, growth, and the company-specific coefficient estimates (see Appendix Table 3). Thus, contemporary investors seem to have made a sectoral rather than a company-specific judgement.

Figure 2: Aggregated *p*-Values of Wald Tests (First Revision)



First Revision

In the case of the first revision of the original contract, the formal acceptance date is 23 July 1895, when in a meeting of the advisory council it was announced that all cartel members had provided binding written statements to accept the revised document.[64] Given this date, we defined an estimation period of 609 trading days for the event study that ranges from 2 July 1894 to 30 June 1896. The window in which we search for abnormal performance covers the 111 trading days between 23 March and 3 August 1895. In the event study of the second contract, we identi-

64 Given the binding character of these statements, the actual vote on the revised contract in the general assembly on 31 July 1895 was rather unimportant.

fied three peaks in abnormal performance (see Figure 2). All of them are situated before the date on which this contract was formally accepted. Furthermore, all three are smaller than the ones we detected in the event study of the original contract. The first peak is located in the period between 4 and 11 May 1895 (i.e., that the dummy variable is centred on 8 May), the second between 27 May and 6 June 1895 (i.e., that the dummy variable is centred on 30 May), and the third between 6 and 13 July 1895 (i.e., that the dummy variable is centred on 10 July).[65]

Looking at the qualitative information on the negotiation process preceding the second contract, all three peaks can be associated with particular steps. At the first peak, contemporary investors presumably reacted to the meeting of the advisory council on 4 May 1895, in which a draft version of the new contract was sent to the general assembly for further discussion. The second and largest peak can be associated with the meeting of the general assembly on 30 June 1895, in which the overwhelming majority of the members agreed on the new contract and the last indecisive companies were ultimately demanded to approve. Finally, the third peak is situated between this meeting of the general assembly and the formal acceptance date. During this period contemporary investors possibly got early notice of the fact that the approval of all members was secured. This interpretation is supported by qualitative evidence. In its issue of 13 July 1895, *Glückauf* postulated that "agreement on the Syndicate contract can now be considered a given".[66]

The results of the event study give no clear-cut indication of contemporary investors' assessments of the second contract. On the one hand, the average coefficient values of the dummy variables are positive on all three occasions. On the other hand, there are positive as well as negative dummy variable coefficients in the company-specific equations, and in no case does the binomial sign test reject the Null hypothesis that positive and negative coefficients are the same in number. To put it in a nutshell, it seems impossible to argue compellingly for either a positive or a negative aggregate effect of the first revision of the original contract. Thus, the most likely interpretation is that the revisions made – slightly cutting back the privilege for new shafts and extending the duration of the contract to ten years – were not considered substantial by contemporary investors and, as a result, their neutral expectations concerning the performance effect of the RWKS persisted.

The results from the correlation analysis using the company-specific coefficient estimates provide some supplementary insights. In addition to the variables used in the analysis of the original contract,[67] we define three more variables. The first one is the total growth of the cartel quota

65 Re-estimating the event study of the first revision with different specifications of the event window, we were not able to detect the same three peaks suggested by the seven-day specification. With a three- and an eleven-day window, we detected only one peak. In both cases, it is situated in the time period that is covered by the second peak identified with the seven-day window. In the specifications using event windows of 15, 21, and 31 days we failed to identify any peaks that correspondent to one of the three peaks in the original specification.

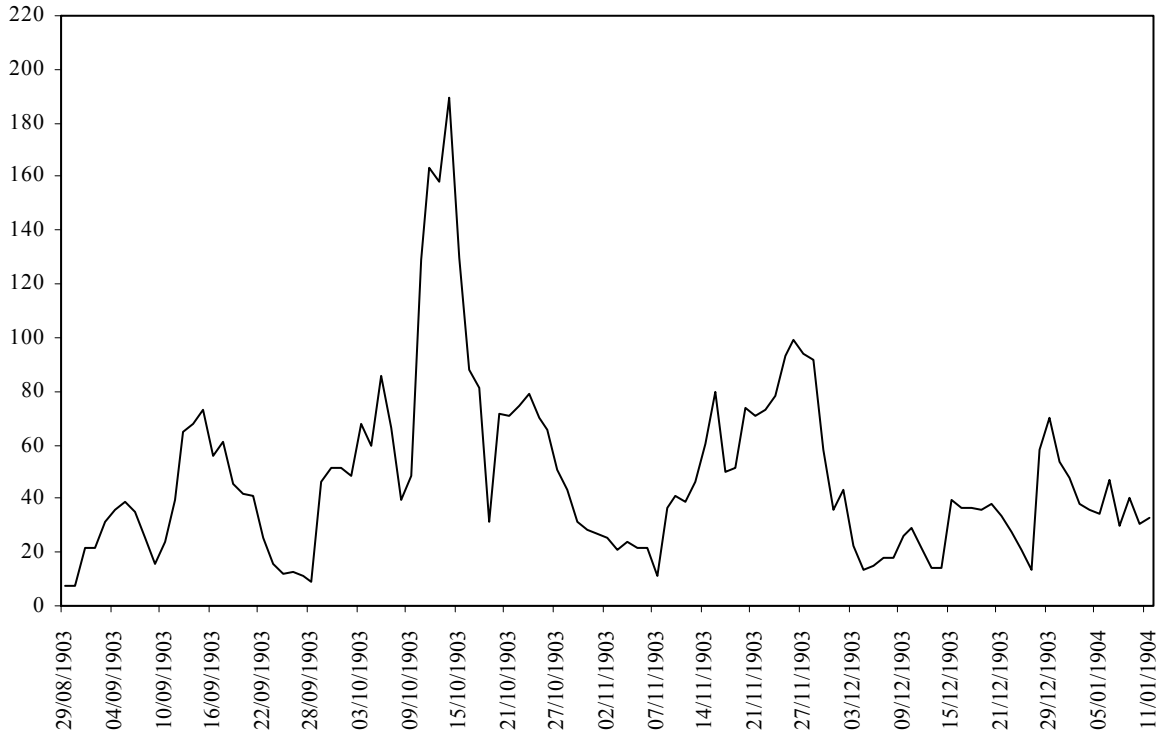
66 Original: "[…]der Abschluß des Syndicatsvertrages als gesichert gelten kann".

67 In the case of the first revision of the original contract, leverage is the book value of debt divided by the book value of total assets at the end of 1894. Company size is measured by the book value of total assets at the end of 1894. Growth is approximated by the first difference of the natural logarithms of coal output at the end on 1894 and 1893.

during the valid time of the original contract. It indicates the success of a company to improve its absolute and relative position in the cartel. The second variable is the share of quota increases due to new shafts in total quota growth. It measures how much a company relied on the privilege for new shafts in order to improve its position. The third variable is a dichotomous variable that is equal to one if a company was listed in the transitory provisions attached to the second cartel contract and equal to zero otherwise. As in the case of the original contract, most of the correlations are statistically insignificant (see Appendix Table 3). However, the analysis of the company-specific coefficients of the dummy centred on 10 July 1895 reveals one interesting fact. We observe a positive and significant correlation with the share of quota increases due to new shafts in total quota growth. Thus, the companies that were able heavily to exploit the privilege for new shafts during the period of the first contract profited more. Again, this implies that the privilege was not cut back effectively. Furthermore, it shows that rather than improving the situation of all cartel members, the first revision of the original contract – or more precisely, the lack of substantial revision – served the specific interest of only some.

Second Revision

Figure 3: Aggregated *p*-Values of Wald Test (Second Revision)



In the case of the second revision of the original contract, the formal acceptance date is 29 December 1903, when in a meeting of the general assembly all members of the RWKS as well as the newly-acceded foundry mines voted unanimously to accept the new document. Hence, the estimation period covers the 610 trading days from 2 January 1903 to 31 December 1904. The

111-day window in which we search for abnormal performance ranges from 29 August 1903 to 11 January 1904. In the event study, we identified one clear peak in abnormal performance (see Figure 3). As in the case of the second contract, it is situated considerably in advance of the formal acceptance date. The size of the peak is comparable to those in the event study of the original contract. It is located in the period between 10 and 17 October 1903 (i.e., that the dummy variable is centred on 14 October).

Comparing the results of the event study to the qualitative information at hand, it seems not too far-fetched to assume that during the detected period, contemporary investors became persuaded that the foundry mines were now willing to join the RWKS. In its issue of 10 October 1903, the mining journal *Glückauf* noted:

> "The Syndicate can now be expected to materialise entirely as planned."[68]

The market's assessment was positive throughout. The coefficient of the dummy variable centred on 14 October 1903 is positive in all 14 company-specific equations.[69] In ten out of 14 cases, it is also significant. Its average value is 0.85. Economically, these results suggest that contemporary investors expected increasing profits for the cartel members after the successful second revision of the original contract. However, one should note that the size of the average dummy variable coefficient is far from being impressive. The value of 0.85 implies that on average the second revision of the original contract increased the market valuation of the cartel members by around 6 percent in the seven days covered by the dummy variable. This is roughly equivalent to the 'abnormal returns' a takeover target in the mining industry of the Ruhr district would have realised over the same period (Lübbers, forthcoming). As in the case of the original contract, the correlation analysis revealed no significant results (see Appendix Table 3).[70]

In sum, the results of the event studies seem to support scenario (2) (price stabilisation above the mean preserving level) rather than scenario (1) (mean preserving price stabilisation) because overall, they do not indicate lower profits for the cartel members. In addition, the findings from the event study of the second revision of the original contract even point to a small positive performance effect.

Dynamic Panel Data Analysis

Before we come to a final conclusion regarding the scenarios outlined in section 2, we now augment the results of the event studies by the findings from the dynamic panel data analysis. Since

68 Original: "Es steht nun mehr zu erwarten, daß das Syndikat in dem ganzen Umfang, wie es geplant ist, zustande kommen wird."

69 Naturally, again the binomial sign test clearly rejects the hypothesis that positive and negative coefficients are the same in number.

70 Re-estimating the event study of the second revision with event windows covering three, eleven, 15, 21, and 31 days we also identified one peak in abnormal performance. In all five cases, it is situated in the same time period that is suggested by the results of the seven-day specification. In every alternative specification, the average value of the γi-coefficients are always smaller than in the original specification.

the focus of our investigation is on the performance effect of the RWKS, we are mostly interested in the coefficients of the dummy variable that models membership in the RWKS. It is insignificant in both the RoA equation and the *q* equation (see Table 3). All coefficients of the interaction terms are insignificant as well. These results suggest that the RWKS did not affect the performance of its members in any way.

Table 3: Regression Results I

Dependent variable	RoA	*q* ratio
Dependent variable (-1)	0.702 (0.000)	0.707 (0.000)
LEVERAGE	-0.027 (0.066)	-0.493 (0.000)
SIZE	-0.003 (0.336)	-0.051 (0.049)
GROWTH	0.000 (0.951)	0.013 (0.818)
RWKS	-0.017 (0.725)	-0.223 (0.335)
RWKS*LEVERAGE	0.003 (0.872)	-0.031 (0.825)
RWKS*SIZE	0.001 (0.679)	0.016 (0.248)
RWKS*GROWTH	0.009 (0.346)	0.096 (0.169)
LM	5.293 (0.259)	3.488 (0.480)
Adj. R^2	0.879	0.927
***F*-Test**	74.691 (0.000)	131.716 (0.000)
Cross-sections	33	33
Obs.	724	724

Note: estimated with panel corrected standard errors (Beck/Katz, 1995); *p*-values in parentheses; LM = χ^2 test statistic of Lagrange Multiplier test for autocorrelation of residuals with 4 lags.

For the control variables, the results obtained using the two different estimation methods are very similar, although there are differences in significance levels. First, the dynamic specification of the regression model seems well justified. In both equations, the coefficient of the lagged dependent variable is significantly different from zero. Thus, in line with our theoretical reasoning, current performance was influenced by past performance. Second, the coefficient of LEVERAGE is negative and significant in both cases (at the 10 percent level in the RoA equation and at the 1 percent level in the *q* equation). This supports the conclusion that a high ratio of debt to total assets was a hindrance to profitable investment rather than an effective disciplining device for managers. Third, the coefficient of SIZE is also negative in both equations, but only significant in the one with the *q* ratio as the dependent variable. Hence, there is weak evidence for negative returns to scale.[71] Finally, the coefficient of GROWTH is insignificant in both equations.[72]

The results of the event studies indicate that a positive performance effect of the RWKS should especially be expected in the valid time of the third contract, i.e., in the years 1904 to 1913. In order to test this proposition, we add another dummy variable (and the respective interaction

71 This finding is line with estimates of a production function for the mining industry in the Ruhr for the years 1881 to 1913 (Burhop/Lübbers, forthcoming).

72 The insignificance of the GROWTH coefficients is likely due to the fact that the variable does not distinguish between profitable and non-profitable growth opportunities. While the former should have a positive effect on performance, the effect of the latter should be negative. However, a proxy that could make this crucial distinction was not available to us.

terms) to equations (5) and (6). It is equal to one for all cartel members in the years 1904 to 1913 and equal to zero otherwise. The exercise does not show a significant difference between cartel members' performance in the years before and after 1903 (see Table 4). Thus, in this respect the findings of the dynamic panel data analysis do not confirm those of the event studies.

Table 4: Regression Results II

Dependent variable	RoA	*q* ratio
Dependent variable (-1)	0.698 (0.000)	0.709 (0.000)
LEVERAGE	-0.028 (0.055)	-0.483 (0.000)
SIZE	-0.003 (0.393)	-0.053 (0.048)
GROWTH	0.001 (0.934)	0.012 (0.837)
RWKS	-0.039 (0.410)	-0.255 (0.347)
RWKS (1904–1913)	0.039 (0.249)	-0.024 (0.921)
RWKS*LEVERAGE	0.008 (0.740)	-0.076 (0.665)
RWKS*SIZE	0.002 (0.367)	0.019 (0.263)
RWKS*GROWTH	-0.001 (0.965)	0.137 (0.202)
RWKS (1904–1913)*LEVERAGE	-0.006 (0.832)	0.083 (0.670)
RWKS (1904–1913)*SIZE	-0.002 (0.193)	-0.002 (0.904)
RWKS (1904–1913)*GROWTH	0.012 (0.328)	-0.050 (0.629)
LM	5.510 (0.239)	6.416 (0.170)
Adj. R^2	0.878	0.927
***F*-Test**	70.502 (0.000)	124.153 (0.000)
Cross-sections	33	33
Obs.	724	724

Note: estimated with panel corrected standard errors (Beck/Katz, 1995); *p*-values in parentheses; LM = χ^2 test statistic of Lagrange Multiplier test for autocorrelation of residuals with 4 lags.

Based on the findings of the event studies and those of the dynamic panel data analysis, we can not argue compellingly for a positive performance effect of the RWKS. However, there is also no hint that the cartel effected its members' profitability negatively. In combination with the evidence for a significant reduction in the variability of coal prices, this implies that the RWKS stabilised prices and was able and willing to do so at least slightly above the mean preserving level. Thus, scenario (1) (mean preserving price stabilisation) must be rejected, and scenario (2) (price stabilisation above the mean preserving level) remains as the only one that seems plausible.

7. Conclusion

With regard to the performance effects of cartels in general and price stabilisation cartels in particular, economic theory provides no clear-cut predictions. Thus, the fundamental question whether cartels are able to raise the profits of their members has to be answered by empirical investigations. The existing studies do not offer consistent results as well. While some of them find a positive performance effect of cartelisation, others argue for negative repercussions or discover no effect at all. In our study we contributed to the empirical literature by providing an in-

depth case study of the RWKS, one of the longest-lasting and supposedly most powerful cartels ever. In order to assess the performance effects of this organisation, we made use of the information content of stock prices and event study methodology to investigate the market reactions to its foundation and to the most important revisions made to the original cartel contract. Furthermore, we cross-checked the validity of the findings from the event studies by a dynamic panel data analysis of accounting, financial, and output data.

Based on our empirical findings, we cannot argue compellingly for either a positive or a negative performance effect of the RWKS. In line with earlier results of Bittner (2005), the event studies showed that contemporary investors expected neither the formation of the cartel nor the first revision of the original cartel contract to be performance enhancing. In the case of the second revision, we detected a positive effect, but its magnitude turned out to be far from impressive. The results from the combined analysis of accounting, financial, and output figures indicated neither a positive nor a negative effect of cartelisation on company performance – regardless of whether it is measured by the RoA or by Tobin's *q*.

Nonetheless, it would be premature to argue that the RWKS was ineffective throughout. A comparison of the variance of coal prices in cartel- and pre-cartel years suggested that the organisation was able to stabilise prices. Economic theory predicts that if it had done so at the mean preserving level, stabilisation should have been accompanied by a negative performance effect. The fact that none of our empirical findings supports this theoretical prediction indicates that the RWKS was at least able and willing to exert enough market power to raise prices far enough about the mean preserving level to offset the negative repercussions of stabilised prices.[73] Such a conduct would resemble the officially stated aims of the RWKS quite closely. However, it is also possible that the cartel intended to fetch higher monopoly rents but was simply not powerful enough to achieve this aim. Arguing for either of these alternatives would be highly speculative.

73 Although it is beyond the scope of our study, it should also be noted that price stabilisation is likely to be correlated with lower profit risk. For a risk-averse actor, such a reduction constitutes a valuable development in itself.

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Appendix

Appendix Table 1: Number of OLS, ARCH, and GARCH Equations in Event Studies

	Original Contract	First Revision	Second Revison
OLS	2	1	0
ARCH (1)	16	8	10
GARCH (1,1)	1	9	4

Appendix Table 2: Sample of Companies

No.	Company	RWKS	Years	ES 1	ES 2	ES 3
1	Aplerbecker Aktien-Verein für Bergbau	1893	1882–1913	Yes	Yes	Yes
2	Arenbergsche AG für Bergbau und Hüttenbetrieb	1893	1881–1913	Yes	Yes	Yes
3	Bochumer Bergwerks-AG	1893	1881–1913	Yes	Yes	Yes
4	Bochumer Verein	1904	1881–1913	No	No	No
5	Bonifacius	1893	1881–1898	Yes	Yes	No
6	Concordia	1893	1891–1913	Yes	Yes	Yes
7	Consolidation	1893	1890–1913	Yes	Yes	Yes
8	Courl	1893	1891–1898	Yes	Yes	No
9	Dannebaum	1893	1890–1899	Yes	Yes	No
10	Deutsch-Luxemburg. Bergwerks- und Hütten-AG	1904	1903–1913	No	No	No
11	Dortmunder Bergbau-AG	1893	1881–1893	No	No	No
12	Eschweiler Bergwerks-Verein	Outsider	1881–1911	No	No	No
13	Gelsenkirchener Bergwerks-AG	1893	1881–1913	Yes	Yes	Yes
14	Georgs-Marien-Bergwerks- und Hüttenverein	1904	1881–1913	No	No	No
15	Harperner Bergbau-AG	1893	1881–1913	Yes	Yes	Yes
16	Hibernia	1893	1881–1904	Yes	Yes	Yes
17	Hörder Bergwerks- und Hüttenverein	1904	1881–1906	No	No	No
18	Hoesch	1904	1902–1913	No	No	No
19	Hugo	1893	1881–1894	Yes	No	No
20	Kattowitzer AG für Bergbau und Hüttenbetrieb	Outsider	1890–1912	No	No	No
21	Kölner Bergwerks-Verein*	1893	1881–1913	Yes	Yes	Yes
22	König Wilhelm	1893	1881–1913	Yes	Yes	Yes
23	Louise Tiefbau	1893	1881–1907	Yes	Yes	Yes
24	Magdeburger Bergwerks-AG	1893	1881–1913	No	No	No
25	Massen	1893	1891–1910	Yes	Yes	Yes
26	Nordstern	1893	1890–1906	Yes	Yes	Yes
27	Phönix	1904	1897–1913	No	No	No
28	Pluto	1893	1881–1898	Yes	Yes	No
29	Rheinische Anthracit-Kohlenwerke**	1893	1890–1913	Yes	Yes	Yes
30	Rheinische Stahlwerke	1904	1901–1913	No	No	No
31	Schalker Gruben- und Hütten-Verein	1904	1900–1904	No	No	No
32	Schles. AG für Bergbau und Zinkhüttenbetrieb	Outsider	1881–1912	No	No	No
33	Union	1904	1881–1910	No	No	No

Note: Years = years in panel; RWKS = beginning of membership in the RWKS; ES 1 =event study original contract; ES 2 =event study second contract; ES 3 =event study third contract; *since 1911 Köln-Neuessener Bergwerks-Verein; **since 1907 Essener Steinkohlenbergwerke.

Appendix Table 3: Correlates of Company-Specific Coefficients

	Original contract	First revision			Second revision
Event period	28/1/–4/2/1893	4/5/–11/5/1895	27/5/–4/6/1895	6/7/–13/7/1895	10/10/–17/10/1903
Leverage	0.146	0.327	-0.049	-0.084	-0.341
	(0.552)	(0.185)	(0.848)	(0.742)	(0.233)
Size	0.340	-0.203	0.179	0.154	-0.178
	(0.154)	(0.418)	(0.478)	(0.542)	(0.543)
Growth	0.158	0.073	0.296	-0.245	0.077
	(0.519)	(0.773)	(0.233)	(0.328)	(0.794)
Quota growth		-0.212	0.255	-0.047	-0.095
		(0.399)	(0.306)	(0.853)	(0.748)
Quota growth (new shafts) / quota growth		0.308	0.058	0.528	0.198
		(0.214)	(0.821)	(0.024)	(0.498)
Transitory Clause		-0.208	-0.386	0.103	
		(0.408)	(0.113)	(0.684)	

Note: Spearman's rank correlation coefficients; *p*-values of *t*-test in parentheses; leverage = book value of debt divided by the book value of total assets at the end of 1892, 1894, and 1903, respectively; size = book value of total assets at the end of 1892, 1894, and 1903, respectively; growth = first difference of the natural logarithms of coal output in 1892 and 1891, 1894 and 1893, and 1903 and 1902, respectively; quota growth = growth of cartel quota during the valid time of the original contract and the first revision of the original contract, respectively; quota growth (new shafts) / quota growth = share of quota increases due to new shafts in total quota growth during the valid time of the original contract and the first revision of the original contract, respectively; transitory clause = listing in the transitory provisions of the first revision of the original contract.

Source: Jahrbuch (1894, 1897, 1904); Mining Archive, Bochum, inventory 33, no. 423: Annual Participation Figures; Saling's Börsen Jahrbuch (1893, 1895, 1904); Verein (1904b).