Collusion in the Copper Commodity Market: A Long-Run Perspective

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Abstract

Over the course of the last century and a half there have been many attempts to cartelize world commodity markets, sometimes orchestrated by national governments and other times by the dominant firms in the industry. Utilizing a newly constructed data set for the copper commodity market, over a long history, 1840 to 2012, we decompose the alleged time series into periods of attempted collusion, followed by an unwinding period. We investigate the dynamic properties of collusion or cartel behavior, emphasizing the dynamic structure across the complete sample record. For each of the identified collusive periods, we determine the cartel price distortion, comparing actual prices to computed but-for prices. From the computed but-for prices we estimate market wide damages. Each of the alleged collusive periods are found to differ in accordance with the mechanisms controlling supply either through output restrictions, stock accumulations, or both.

JEL classification: K2, L1

Keywords: Copper commodity markets, collusion, market distortions, economic damages.

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1 Introduction

The purpose of this paper is to estimate the dynamic market effects of attempted collusion, over the course of the history of the commodity copper global market stretching from 1840 to 2012. Based on information outside of the sample data, we specify the initial period of collusion along with evidence of its termination. Based on our specification, the potential effects of alleged collusive periods are market-wide, implicitly assuming that no purchasers of copper can escape any price elevations or distortions that might result from collusive actions.

Much of the literature on the market impacts of collusion focuses largely on reduced form pricing analysis. As noted by (Baker and Rubinfeld, 1999, p. 392) "the price effect of the alleged conspiracy is measured by the coefficient on a dummy variable that takes on the value of one during the period (or in the markets) in which the conspiracy is in operation." Recognizing the heterogeneity that exists for individual transactions between sellers and buyers, (Hartman and Doane, 1987, p. 352) propose a reduced form pricing hedonic approach that is capable of identifying and measuring "the commonality in a group of apparently heterogeneous products, services, or individuals." Along similar lines, (Brander and Ross, 2006, p. 342) advanced before and after comparisons, simply comparing "the price before the price-fixing conspiracy with the price that occurred after the price-fixing conspiracy became active." The before period is typically advanced as the control period in which non-collusive prices are presumed to be generated. Other empirical studies have used as a benchmark the post-collusive period, other product markets, and in some other instances other geographic markets which cover the same product or same service's scope. (Connor and Bolotova, 2006) In our analysis of the global copper market, the identification of a benchmark and how it is distinguished arise both in the context of pre-collusive prices as well as post-collusive prices.

Prior empirical studies have revealed that post-collusive prices are likely to have a different mean and variance compared to the pre-collusive prices. Bolotova et al. (2008)

conducts an empirical test of this hypothesis in the context of the citric acid conspiracy (1991-1995) and the lysine conspiracy (1992-1995). For citric acid, the mean post-collusive price is 12% higher than the pre-collusive price. The post-collusive standard deviation of citric acid is 55% lower than the standard deviation of the pre-collusive price. With regard to lysine, pre-collusive and post-collusive prices are similar but the post-collusive price standard deviation is 41% lower. The authors conclude that prices may or may not return to the pre-collusive price level and consequently using the post-collusive price as a proxy for the competitive price may underestimate the consequences of collusive actions. In the Vitamins Antitrust Litigation, Bernheim (2002), reaches a similar conclusion to the citric acid and lysine empirical analysis, finding that prices gradually returned to pre-collusive levels over a 12 month period. Fonseca and Normann (2012) conducted oligopoly experiments, finding evidence that industries continue to sustain artificially elevated prices even after collusive communication has been disabled.[1]

Harrington (2004) presents the theoretical foundations for strategic collusion in the post-cartel period centered upon U.S. antitrust policy. The formulated model predicts that the post-collusive price is higher when (a) firms assign more weight to damages (b) the cartel has a longer duration and (c) the industry is more concentrated. The author conducts an empirical analysis of the graphite electrodes cartel (1992-1997) and finds that two years after the collusion presumably terminated the price was still 20% above its pre-collusion level. Erutku (2012) implements the Harrington (2004) formulation in the context of the retail gasoline collusion in the province of Quebec (Canada). The author finds that the post-cartel price actually increases (relative to pre-cartel period) upon the filing of legal action, but then decreases as the antitrust case is slowly unwound.

Two surveys provide additional empirical results consistent with those outlined above. In a meta analysis, Connor and Bolotova (2006) find that the use of a post period benchmark underestimates overcharges when compared to other benchmarks (geographic or

[1]The long term effects of collusion on prices in this experiment cannot be quantified. The experiment uses 1 minute as a measure of a period. It is not possible to translate the experiment time-line to a real world time (as in months post collusion).

product) by approximately 11% because collusive distortions persist after the disbanding of the cartel. In a second survey, Levenstein and Suslow (2006) examine several cases of known cartels focusing on duration, causes for cartel breakdown, and the degree of impact. With regard to the impact on prices post cartel dissolution, the paper notes that there are studies that show manipulated price elevations even following antitrust prosecution. For example, Sproul (1993) finds that price levels four years after the indictment are 7 percent higher. In another empirical analysis emphasized by Levenstein and Suslow (2006), Froeb et al. (1993), notes that antitrust enforcement actions are not good indicators of cartel dissolution.[2]

In contrast to much of the literature that operates with reduced form pricing with reasonably clean benchmarks, we advance a dynamic structural model which covers both non-collusive as well as collusive episodes. We identify the distinguishing attributes from one collusive period to another with respect to actions taken by the alleged co-conspirators. These actions focus on output restrictions, stock-holding, and for some conspiratoral periods, both stock accumulation and output restrictions. In the structural model, output restrictions can be identified as supply shocks, while manipulative stock-holding is identified as demand shocks. Outside of the collusive periods, such shocks to the extent that they do exist would not reflect coordination among the various participants in the alleged conspiracy.

In the following section, we present the episodes of alleged collusion and the available factual support of how these episodes can be distinguished. In section 3, we specify the dynamic structural model, identifying two alternative treatments of the benchmark period: (i) the complete sample record distinguishing each collusive period versus (ii) a rolling-horizon benchmark period that treats all sample data as the benchmark period up to the point of the initiation of each new collusive period.

[2]There are number of potential explanations for the collusive unwinding period, including long-term contracts delaying price adjustments (Bolotova et al., 2008), tacit strategies that allow some collusive influence to persist (De Roos, 2006), high market concentrations (Harrington, 2004), imprecise dates that signify the end of a collusive era (Bolotova et al., 2008), and cost structures that may reflect collusion inefficiencies (Bolotova et al., 2008).

The empirical results of our dynamic structural model for each of the two benchmark specifications are presented in Section 4, drawing a sharp distinction between stock accumulations and output restriction actions. Since our model is a structural representation, we present both the probability distribution for prices as well as copper output levels. At this juncture, we present only economic damages resulting from price elevations. Of course a complete welfare analysis would measure both the price elevation as well as the "lost" output that emanates from each collusive period in which output restrictions are implemented. Given the dynamic nature of a structural model, we present both the consequences during the alleged collusive periods as well as the "unwinding period". We find a sharp distinction between output restrictions and stock accumulations with respect to the post-collusive period. Given the storable nature of copper, any stock accumulations during the conspiratorial period will ultimately find their way back onto the market, and thus are expected to result in lower prices, not higher prices, during the post-conspiratorial period. Our results reveal that economic damages are far smaller for stock-accumulations than for output restrictions. This is due in large part because there are far less periods of stock-accumulations than output restrictions over our sample record. However, the damage from output restrictions amount to an average of 11% of the value of output while stock-accumulations amount to 14% of the average value of world output during their respective periods. As expected, the economics damages during the unwinding periods are relatively smaller in the case of stock accumulations than output restrictions. Finally, the paper ends with section 5 that provides some concluding remarks.

2 Major events of alleged collusion in the global copper markets

2.1 Episodes of alleged collusion and each periods' factual support

Over the course of the last two centuries there have been many attempts to cartelize the world copper market through collusive action, mostly orchestrated by dominant firms. Due to its geology, reserves of copper are primarily found in a narrow range of countries, thereby highly concentrating this market in terms of world production across countries. The main producing countries are Chile, the U.S., Zambia, and Peru.

We have assembled a new data set on periods of alleged collusion in the copper market starting from 1820. We first went through narrative evidence from different sources and identified 19 periods of alleged collusion in the copper market. We excluded those periods that did not successfully achieve collusion (e.g. the negotiations between European and U.S. producers in 1895), that did not have a significant impact due to the involved parties' small world market share (e.g. Lakes copper producers' selling pool 1870-1886), or that were supposed to have only a very short or negligible effect according to the authors (e.g. output restriction by several U.S. producers in 1908). Given those exclusions, we end up with 10 treatment periods in our sample.

Section B in the appendix provides a list of these periods with its distinguishing characteristics. The collusive action periods began with the First (1825-1829) and Second Copper Trade Associations (1847-1866). These associations embodied the most important smelters in Great Britain, which produced more than 40% of world smelter output. These two cartels were followed by the formation of the Secretan Copper Syndicate (1888) and different international cartel agreements and associations lasting from the end of the 19th century to the interwar periods, ending with the Intergovernmental Council of Copper Exporting Countries (CIPEC), which existed from 1967 to 1988.

We distinguish between the official start and end dates of the cartels and that of alleged cartel action. We make this distinction because although cartels are often formally in place for a long time, they do not engage in substantial cartel action over the entirety of their lifespan. For example, CIPEC served as a forum for discussion and the dissemination of information during most of its existence and only took collusive action from late 1974 for 1976.

2.2 Distinguishing characteristics of each alleged episode

We distinguish between two main instruments used to manipulate prices, namely output restrictions and stock accumulations. Output restrictions decrease copper production by either imposing production quotas or export quotas. Stock accumulations function through a centralized agency that purchases copper from the market or participants of the cartel, and stockpiles the commodity until the right conditions arise for selling it.

We either collect data on the quantities of output restrictions and stock accumulations from primary and secondary sources, or we compute these quantities based on information about quotas and base years in the literature. When neither of the above two hold and we have information that there might have been alleged collusive action, we employ a binary dummy variable in order to distinguish this period from our benchmark period. There is only one collusive action period, the First Copper Trade Association (1825-1829), for which we have no information on the quantities of output restrictions or stock accumulations at all. For all the other periods, we have either information for the entire period (6 periods) or for the partial period (3 periods), which we then supplement with a binary dummy variable for those years where there is missing information. We have 17 years of data on the quantities of output restrictions, 4 years of data on stock accumulations, and 21 years where we apply the binary dummy variable. Of these 21 years, 16 years are from the first two episodes (1825-1829, 1847-1860).

In addition to these distinguishing characteristics, we have computed each cartel's respective share of world production for each year they are engaged in alleged collusive

action, as well as the shares of the top two outside producing countries. We have also collected information about the institutional setup of the cartels, e.g. how were the output restrictions enforced, or were stock accumulations centralized or not. Preliminary regressions, which are available from the authors upon request, show that these variables neither significantly impact price nor the output equation. However, we report the share values as a useful, additional distinguishing characteristic of the different collusive action periods in Appendix B.

3 Estimating the dynamic effects of alleged collusion

The purpose of our endeavor is to study the dynamics of collusive action and analyze its welfare effects. We construct counter-factual but-for price and output paths, which illustrate how price and output would have developed in the absence of collusive action. This implies that we need to identify the shocks which are driven by cartel action and distinguish them from the shocks that are driven by other factors. There are four steps: First, we obtain a benchmark period and the collusive treatment periods from a reduced form vector auto-regressive (VAR) model. Second, we compute the but-for price using a structural VAR model with long-run restrictions and a historical decomposition, which excludes the effect of collusive action. Third, we compute economic damages by employing the but-for price, the actual price and actual copper production, and finally we study the dynamics of the action and unwinding periods.

3.1 Specifying a Benchmark Period

In order to compute a but-for price, we estimate the effects of demand and supply on prices and output for a benchmark (or control) period that is not affected by the impacts of collusive action. Since we want to avoid well known problem of reverse causality from, for example, supply on prices and prices on supply, we need to estimate this in an endogenous setup. We first estimate a three variable reduced form VAR model following Kilian (2009)

and Stuermer (2013).

$$z_t = \Gamma_1 z_{t-1} + ... + \Gamma_p z_{t-p} + \Pi D_t + \Phi C_t + \epsilon_t \ . \tag{1}$$

The vector of endogenous variables is $z = (\Delta Y_t, \Delta Q_t, P_t)'$, where ΔY refers to the percentage change in world GDP, ΔQ denotes the percentage change in world production of the respective commodity, and P is the log of the respective real commodity price. The matrix of deterministic terms, D, consists of a constant, a linear trend, and annual dummies during the two World War periods and the three years immediately after each period.

We control for the effect of collusive action by adding the term C which includes exogenous variables. These variables account for the distinguishing attributes of each period of collusive action. This is necessary to obtain a benchmark period, which does not include any effects of collusive action.

We have collected data on the quantities of announced output cuts and effective stock accumulations. These two variables then enter the regression when we compute the percentage change in world output as a function of these two mechanisms, holding everything else constant. For the years when data on the quantities of output restrictions and stock accumulations are unavailable, we employ binary dummy variables to ensure that we obtain a benchmark period.

We impose linear constraints on the coefficients so that the output restrictions only affect the output equation and the stock accumulations only impact the pricing equation. The coefficients for the binary dummy variables are allowed to vary across the different collusive action episodes.

We estimate the reduced form model using an Estimated Generalized Least Squares (EGLS) Estimator (also known as Feasible GLS) following Luetkepohl (2007). We first run the coefficients for for the complete sample record. In a second step, we run regressions with a segmented, rolling benchmark period.

3.2 Computing the but-for price

We compute the but-for price by disentangling three different shocks that drive the price of copper through a historical decomposition. Following Stuermer (2013), we use long-run restrictions to identify three different structural shocks to the real price of the commodity concerned: "commodity supply shocks," e.g., a disruption in the physical production of the respective commodity due to strikes or cartel action; "world output-driven demand shocks," which include shocks in global demand for all commodities due to, e.g., an unexpected strong growth of world GDP; and "other demand shocks." The last includes all shocks that have no correlation with "commodity supply shocks" and "world output-driven demand shocks". Stuermer (2013) interprets these "other demand shocks" as mainly capturing unexpected changes in inventories.

This identification scheme allows us to leave the short-run relationships unrestricted. The restrictions on the long-run effects assume that shocks to the supply of a certain commodity and "other demand shocks" do not have long-run effects on world GDP. "Other demand shocks" do not affect commodity production in the long run, which is based on the notion that changes in inventory demand only increase capacity utilization, but do not lead to capacity expansions of existing mines.

We obtain the three identified structural shocks from a Cholesky composition of the reduced form residuals. This implies that the structural shocks do not include variation for which we have controlled for by the variables for collusive action.

The historical decomposition of the price is obtained from multiplying each of these shocks by the respective coefficients of the endogenous variables in the reduced form regression and the Cholesky decomposition and then summing up the effects of each of these shocks over time. As these coefficients are obtained from the benchmark period, the historical decomposition shows the contribution of each of these shocks to the fluctuations of the copper price over time. It illustrates, for example, what would have been the evolution of the price if it had only been driven by supply shocks, absent of any collusive action.

This methodology identifies three different drivers for changes in supply: First, changes

in supply that are endogenously determined by e.g. a change in price. Second, changes in supply that are driven by exogenous shocks, e.g. strikes or wars. Finally, changes in supply that are driven by cartel action. Hence, this methodology also distinguishes between, e.g., production cuts, which an entity might undertake as a reaction to lower prices and not influenced by any desire to undertake collusive action, and any changes in supply that are driven by interest in deriving economic benefits by means of collusive action.

We add up the contributions of each of the three shocks and obtain the the but-for price of copper. This provides us with the counter-factual development of the price, controlling for the effect of collusive action.

3.3 Analyzing the dynamics of collusive action and unwinding periods

We compute the average lengths of the periods of collusive action. We also analyze the delayed effects of the collusion following its conclusion: namely the unwinding period. We define this period as the time spanning from the end of collusive action until the year when the actual and the but-for price merge. We also report the average length of the unwinding periods.

3.4 Computing economic damages of collusive action

To compute the price damage of collusive action periods, we first map the but-for price, which is in logs, to real 2013 US-Dollars. We then subtract the but-for price from the actual real price in 2013 US-Dollars and multiply the difference with the quantity of production in each of the years of collusive action except for the world war periods. We run the same procedure for the unwinding periods. To obtain a comparable measure across time, we compute the share of the damage in the actual market value of the commodity production during the action and unwinding periods.

4 Empirical Results

4.1 The Complete Sample Record

We estimate the effects of collusive action periods on the output and the pricing equation in a reduced form VAR model. We differentiate between the effects of output restrictions and stock accumulation. We have collected actual data on the quantities of these two types of restrictions for most of the collusive action periods. These enter the equations as percentage change in world output, i.e. the change in world output caused by the respective restrictions, holding everything else constant. For the periods where data on the quantitative effect of restriction is not available, we have created binary dummy variables.

Table 1 in the appendix provides estimates for the effects of these variables in the reduced form VAR system. [3] Specification 1 shows the effect of the announced output restrictions on world output. Announced output restrictions equivalent to a one-percentage-change in world output are correlated with a 0.3 percent change in world output. This coefficient is highly significant. This suggests that announced output restrictions are only realized, on average, 32% of the announced output cut. The reason for this could be threefold. First, cartel participants do not follow up on their promises to cut according to quotas. Second, outside competition is increasing output, and hence partially offsets the reduction in output by cartel members. Third, cartel participants do not cut actual output produced, but instead the output sold on the market, thereby accumulating inventories on their production sites.

The coefficients for the binary variable, which cover periods of collusive action without information on the respective restrictions of output, are insignificant. There are two possible explanations for this result: First, during these periods, there were simply no output restrictions of substantial size in place. The periods 1847, 1899-1900, and 1927-1929 are prior to the duration for which we have gathered information on output restrictions, and

[3] The coefficients for the entire system are available from the authors upon request.

could serve as a sort of formation period before the cartel implements real action. Second, this might be driven by a misspecification of these dummies, as they assume equal effects within the respective action periods.

In the second specification, we present the estimated coefficient for stock accumulation on price. As we do not have a separate equation for movements in stock accumulations due to a lack of data, we estimate the effect on price directly. In contrast to the information about quantities of output restriction, the data on stock accumulation comprise realized stock accumulation. During all examined periods, these stock accumulations were conducted by a centralized institution or a designated firm, which made cheating by participants difficult and provides us with records of their stock accumulations. The estimated coefficient is positive and highly significant. A cartel's stock accumulation, equivalent to a one-percent decrease in world output, is attributable to an increase in the price of copper by approximately 0.5 percentage points. The binary dummy variable for stock accumulation in 1899 to 1900 is not statistically significant. Actually, the narrative accounts only provide evidence for some small amount of stock accumulation at the end of 1900.

In the third specification, the effects of output restrictions and stock accumulations are jointly estimated. Results are in line with those of specifications 1 and 2, which is reassuring.

4.2 The Segmented, Rolling Benchmark Period

We implement a rolling window regression to check the robustness of our results with regard to sub-periods. To obtain a longer time series, we extend the data-set to reach back to 1820 and include a binary dummy variable for the First British Copper Smelter Cartel from 1825 to 1829. This longer time horizon has the disadvantage of less precise data, especially for world GDP, and higher transportation costs which led to higher disintegration of the copper market. However, we believe it is informative to include this earlier period and it makes regression with a rolling window for the collusive action periods in the mid-19th century feasible.

The coefficient for the effect of output restrictions on world output is negative and statistically significant for all estimated sub-periods (see table 2 in the appendix), which is consistent with our expectations. However, there is some change in the coefficient across time. In the sub-periods spanning up to 1912, this coefficient is larger than 1.8, but drops below 1.0 afterward. There are three periods that contain information on quantities of output restrictions. In the first period (1848-49), the Second British Copper Cartel terminated primarily the production of two smelters to reduce supply, which is a highly effective and sustained way of reducing output. In the second period (1893) and third period (1901), we need to check whether we have collected data on the announced quantities of output restrictions or the actual quantities of output restrictions. With regard to the binary dummy variables, results do not change overall. Their coefficients remain mainly insignificant. The coefficient for the dummy variable related to the years 1899-1900 is statistically significant and positive. This is counter-intuitive, since we would expect this sign to be negative. However, as explained earlier, the coefficient might capture an increase in output, resulting in the cartel's reaction in 1901, for which we have data on output restriction. A similar story could be behind the positive and statistically significant coefficient for the years 1927 to 1929, which shows up in the entire period from from 1821 to 2012. The coefficient for the binary dummy for stock accumulation on price is positive and significant across the different sub periods.

The coefficient for stock-accumulations is positive and statistically significant across all sub-periods. Overall, the regressions for the segmented, rolling benchmark period basically confirm the results from the regression on the entire sample. The evolution of the coefficient on output restrictions across the different sub-periods necessitates further research.

4.3 Which Hypotheses of Alleged Collusion are Supported by the Sample Records

All periods of alleged collusion in this sample are supported by our results, with the exception of the second period of the Second British Copper Cartel (1852-1860). However, this might be explained by the difficulty in creating a reliable variable over this time period. In the other periods, the variables for output restrictions and stock-accumulations appear to reflect the effect of collusive actions on output and price. The binary variables for output restrictions are mainly not significant. See chapters 4.1 and 4.2 for further explanation of this result. The confirmation of most of these periods is not a surprise, as we have already sorted out those periods of alleged collusion, which have no sound evidence of an effect based on narrative evidence.

4.4 Implied Economic Damages

Based on the structural VAR model, we compute the but-for price for copper as described in chapter 3. This provides us with the counter-factual development of the price under the assumption that there has not been any of the collusive action for which we control. Using the actual, the but-for price and world copper output, we are able to compute price damage that occurs to the users of copper.

The price damage from the action periods sums up to $46 billion (in 2013 currency), which is about 12% of the total market value during these periods, as specification 3 in table 1 in the appendix shows. The average length of action periods is about three years. This implies that it has either not been possible to, or that members of cartels were not willing to sustain cartel action for longer than three years on average. The average length of the unwinding periods is nearly twice as long. The accumulated damages from these periods sum up to about $190 billion, equivalent to about 12% of the total market value during these periods. This shows that the cartel action caused substantial damages to consumers. The largest share of the computed damage does not occur in the action period

but in the unwinding period.

Specifications 1 and 2 in table 1 show the computed damages and average lengths for each periods of output restrictions and of stock accumulations separately. The total damage in US-$ is far smaller for the stock accumulations than for the output restrictions, as there are far less periods of stock accumulations and output restrictions in our sample. The computed damage in terms of share of world output correct for the number of sample periods. While the damage from output restrictions amounts to an average of 11% of the value of world output in the respective period, it is 14% of the value of world output in the case of stock accumulations. At the same time, the damage during the unwinding period is relatively smaller in the case of stock accumulations than in the case of output restrictions. There are also substantial differences in the average lengths of the action and unwinding periods. Periods of stock accumulations are only halve as long as periods of output restrictions. In contrast the unwinding periods are on average far longer in the case of stock accumulations than in the case of output restrictions.

5 Conclusion

This paper provides empirical evidence on the dynamic market effects of attempted collusion, covering the historical timeframe of the copper commodity global market spanning from 1840 to 2012. Our results reveal that economic damages are far smaller for stock accumulations than for output restrictions. This is due in large part because there are far less periods of stock accumulations than output restrictions over our sample record. However, the damage from output restrictions amount to an average of 11% of the value of world output, while stock accumulations amount to 14% of the average value of output during their respective periods. The economics damages resulting from stock accumulations are relatively smaller than that of output restrictions during the unwinding periods. We intend to apply this framework to the tin, zinc, and lead commodity global markets. We also aim at computing the market supply damage in a latter version of the paper,

allowing us to pursue a complete welfare analysis.

References

Andrews, E. B. (1889). The late copper syndicate. *The Quarterly Journal of Economics*, 3(4):508–516.

Baker, J. B. and Rubinfeld, D. L. (1999). Empirical methods in antitrust litigation: Review and critique. *Boalt Working Papers in Public Law*.

Bernheim, B. D. (2002). Expert report of B. Douglas Bernheim. *Re Vitamins Antitrust Litigation, MDL No*, 1285.

Bolotova, Y., Connor, J. M., and Miller, D. J. (2008). The impact of collusion on price behavior: Empirical results from two recent cases. *International Journal of Industrial Organization*, 26(6):1290–1307.

Brander, J. A. and Ross, T. W. (2006). Estimating damages from price-fixing. *Canadian Class Action Review*, 3(1):335–369.

Connor, J. M. and Bolotova, Y. (2006). Cartel overcharges: survey and meta-analysis. *International Journal of Industrial Organization*, 24(6):1109–1137.

Crowson, P. (2007). The copper industry 1945-1975. *Resources Policy*, 32(1):1–18.

De Roos, N. (2006). Examining models of collusion: The market for lysine. *International Journal of Industrial Organization*, 24(6):1083–1107.

Edelstein, D. (1999). *Metal prices in the United States through 1998*, chapter Copper, pages 39–42. US Department of the Interior, US Geological Survey.

Elliott, W. Y., May, M. E. S., Rowe, J. W. F., Skelton, A., and Wallace, D. H. (1937). *International control in the non-ferrous metals*. Macmillan New York.

Erutku, C. (2012). Testing post-cartel pricing during litigation. *Economics Letters*, 116(3):339–342.

Fonseca, M. A. and Normann, H.-T. (2012). Explicit vs. tacit collusion. the impact of communication in oligopoly experiments. *European Economic Review*, 56(8):1759–1772.

Froeb, L. M., Koyak, R. A., and Werden, G. J. (1993). What is the effect of bid-rigging on prices? *Economics Letters*, 42(4):419–423.

Gates, W. B. (1969). *Michigan copper and Boston dollars: an economic history of the Michigan copper mining industry*. Russell & Russell.

Harrington, J. E. (2004). Post-cartel pricing during litigation. *The Journal of Industrial Economics*, 52(4):517–533.

Hartman, R. S. and Doane, M. J. (1987). The use of hedonic analysis for certification and damage calculations in class action complaints. *Journal of Law, Economics, & Organization*, 3(2):351–372.

Herfindahl, O. C. (1959). *Copper costs and prices: 1870-1957*. Baltimore, Published, P, 1959. Published for Resources for the Future by Johns Hopkins Press.

Kilian, L. (2009). Not all oil price shocks are alike: Disentangling demand and supply shocks in the crude oil market. *The American Economic Review*, 99(3):1053–1069.

Knight, C. L. (1938). *Secular and Cyclical Movements in the Production and Price of Copper...*, volume 185. University of Pennsylvania.

Lenz, R. (1910). *Der Kupfermarkt unter dem Einflusse der Syndikate und Trusts*. Verlag für Fachliteratur.

Levenstein, M. C. and Suslow, V. Y. (2006). What determines cartel success? *Journal of Economic Literature*, 44(1):43–95.

Mikesell, R. (1979). *The World Copper Industry: Structure & Economic Analysis*. John Hopkins University Press.

Nappi, C. (1979). *Commodity market controls: a historical review*. Lexington Books.

Newell, E. (1988). *The British copper ore market in the nineteenth century with particular reference to Cornwall and Swansea*. PhD thesis, University of Oxford.

Pettengill, R. B. (1931). The United States copper industry and the tariff. *The Quarterly Journal of Economics*, 46(1):141–157.

Radetzki, M. (2008). *A handbook of primary commodities in the global economy*. Taylor & Francis.

Richter, F. E. (1916). The amalgamated copper company: A closed chapter in corporation finance. *The Quarterly Journal of Economics*, 30(2):387–407.

Schmitz, C. (1986). The rise of big business in the world copper industry 1870-19301. *The Economic History Review*, 39(3):392–410.

Sproul, M. F. (1993). Antitrust and prices. *Journal of Political Economy*, 101(4):741–754.

Stuermer, M. (2013). 150 years of boom and bust: what drives mineral commodity prices? *German Development Institute Paper*, (5).

Temporary National Economic Committee, Congress of the United States (1940). *Investigation of Concentration of Economic Power, Part 25, Cartels*. U.S. Government Printing Office, Washington D.C.

The Economist (1868). Commercial history and review of 1867. *The Economist*.

Toomey, R. R. (1985). *Vivian and Sons, 1809-1924: A Study of the Firm in the Copper and Related Industries*. Garland.

Valenzuela, L. (1990). Challenges to the british copper smelting industry in the world market 1840-1860. *Journal of European Economic History*, 19(3):657–686.

A Regression Results

Specification	1	2	3	
Equation	Output	Pricing	Output	Pricing
Output restrictions (%)	-0.331		-0.328	
	(-3.993)		(-3.948)	
Stock accumulations (%)		0.526		0.514
		(2.721)		(2.647)
Binary dummy 1847&1850	-0.057		-0.057	
	(-1.025)		(-1.028)	
Binary dummy 1852-1860	0.005		0.005	
	(0.195)		(0.176)	
Binary dummy 1899-1900	0.023	0.179	0.032	0.186
	(0.411)	(1.596)	(0.604)	(1.649)
Binary dummy 1927-1929	0.07		0.069	
	(1.532)		(1.513)	
Damage: action periods (bn 2013 $)	42.3	4.6	46.4	
Damage: unwinding periods (bn 2013 $)	178.3	11.3	193.5	
Damage: action periods (% of world output)	11	14	12	
Damage: unwinding periods (% of world output)	11.2	10	12.5	
Avg. length of action periods (y)	3.556	1.5	3.091	
Avg. length of unwinding periods (y)	5.375	8	5.8	
df	134	137	133	
t	168	158	168	

Table 1: Estimation results for the collusive action variables in the VAR (equation 1). Specification 1 includes variables for output restrictions. These variables only have an effect on the output equation. Specification 2 includes variables for stock accumulations. These variables only have an effect on the pricing equation. Specification 3 includes variables for both types of collusive action. They affect the output and the pricing equation respectively. The other estimated coefficients are available from the authors upon request. t-values in parentheses.

	1821-2012		1821-1977		1821-1963		1821-1939		1821-1932	
	Q	P	Q	P	Q	P	Q	P	Q	P
Output restrictions (%)	-0.319		-0.433		-0.425		-0.419		-0.513	
	(-3.925)		(-4.835)		(-4.517)		(-4.254)		(-4.498)	
Stock accumulations (%)		0.515		0.507		0.521		0.532		0.513
		(2.753)		(2.988)		(3.607)		(3.813)		(3.687)
Binary dummy 1825-1829	-0.042		-0.040		-0.040		-0.017		-0.016	
	(-1.377)		(-1.291)		(-1.207)		(-0.500)		(-0.488)	
Binary dummy 1847&1850	0.015		0.019		0.017		0.011		0.005	
	(0.251)		(0.307)		(0.262)		(0.162)		(0.082)	
Binary dummy 1852-1860	0.065		0.093		0.092		0.053		0.073	
	(1.728)		(2.429)		(2.253)		(1.204)		(1.676)	
Binary dummy 1899-1900	0.04	0.191	0.042	0.204	0.039	0.202	0.014	0.216	0.015	0.218
	(0.758)	(1.752)	(0.801)	(2.065)	(0.699)	(2.397)	(0.241)	(2.627)	(0.273)	(2.650)
Binary dummy 1927-1929	0.079		0.029		0.015		-0.021		-0.056	
	(1.78)		(0.623)		(0.317)		(-0.413)		(-1.030)	
Action periods:										
Damage (bn 2013 $)	46.1		29.8		-.6		-18.1		-14.7	
Damage (% of world output)	11.6		7.5		-3.8		-12.8		-13.6	
Avg. length (y)	3.25		3.545		3.5		3.889		4	
Unwinding periods:										
Damage (bn 2013 $)	197.8		196.4		3.2		1.3		1.0	
Damage (% of world output)	12.3		18.5		16		0.7		0.6	
Avg. length (y)	5.818		5.091		5.444		6.333		5.5	
df	152		117		103		89		82	
t	188		153		139		115		108	

Table 2: Estimation results for the collusive action variables in the VAR (equation 1) using a rolling window for specification 3. The estimated equations include variables for both types of collusive action. The variables affect the output and the pricing equation respectively. The other estimated coefficients are available from the authors upon request. t-values in parentheses.

	1821-1923		1821-1913		1821-1901		1821-1893		1821-1888	
	Q	P	Q	P	Q	P	Q	P	Q	P
Output restrictions (%)	-0.857		-1.807		-1.930		-1.807		-2.048	
	(-5.146)		(-2.129)		(-2.155)		(-2.129)		(-2.01)	
Stock accumulations (%)		0.56		0.56		0.621		0.56		0.684
		(4.159)		(4.284)		(5.688)		(4.284)		(6.092)
Binary dummy 1825-1829	-0.005		-0.001		0.002		-0.000		-0.001	
	(-0.173)		(-0.038)		(0.01)		(-0.038)		(-0.025)	
Binary dummy 1847&1850	-0.037		-0.031		-0.035		-0.031		-0.031	
	(-0.734)		(-0.753)		(-0.813)		(-0.753)		(-0.694)	
Binary dummy 1852-1860	0.069		0.08		0.081		0.08		0.089	
	(1.948)		(2.787)		(2.454)		(2.787)		(2.512)	
Binary dummy 1899-1900	0.041	0.213	0.028	0.246	0.038	0.260	0.028	0.241		
	(0.885)	(2.667)	(0.767)	(3.203)	(0.947)	(3.857)	(0.767)	(3.203)		
Action periods:										
Damage: (bn 2013 $)	1.89		3.91		4.61		3.91		1.4	
Damage: (% of world output)	3.4		9.4		11.1		9.4		6.3	
Avg. length: (y)	3.71		3.83		4.6		3.83		5	
Unwinding periods:										
Damage: (bn 2013 $)	-7.94		-0.24		-2.29		-0.24		2.13	
Damage: (% of world output)	-1.4		-0.4		-4.8		-0.4		7.1	
Avg. length: (y)	3.71		5		5.6		5		5.75	
df	73		68		57		68		50	
t	98		88		77		88		69	

Table 2 (continued): Estimation results for the collusive action variables in the VAR (equation 1) using a rolling window for specification 3. The estimated equations include variables for both types of collusive action. The variables affect the output and the pricing equation respectively. The other estimated coefficients are available from the authors upon request. t-values in parentheses.

	1821-1860	
	Q	P
Output restrictions (%)	-1.41	
	(-0.368)	
Stock accumulations (%)		0.602
		(5.442)
Binary dummy 1825-1829	-0.003	
	(-0.0912)	
Binary dummy 1847&1850	-0.023	
	(-0.482)	
Binary dummy 1852-1860	0.093	
	(2.311)	
Action periods:		
Damage: (bn 2013 $)	1.52	
Damage: (% of world output)	7.8	
Avg. length: (y)	6.33	
Unwinding periods:		
Damage: (bn 2013 $)	-1.2	
Damage: (% of world output)	-7.9	
Avg. length: (y)	4.67	
df	45	
t	64	

Table 2 (continued): Estimation results for the collusive action variables in the VAR (equation 1) using a rolling window for specification 3. The estimated equations include variables for both types of collusive action. The variables affect the output and the pricing equation respectively. The other estimated coefficients are available from the authors upon request. t-values in parentheses.

B Collusive Periods in the World Copper Market

First Copper Trade Association

Cartel Period: Aug 1824 - 1829 (Toomey, 1985, pp. 321-7)

Output Restrictions: Aug 1824 - 1829 (Toomey, 1985, pp. 321-7)

Stock accumulations: None

Quantities of output restrictions or stock accumulations: None

Functioning: Price fixing; companies decided on the base price for sheeting and a tariff for more downstream production; the cartel basically controlled manufactured but not over unmanufactured copper (Toomey, 1985, pp. 321-2).

Effect on price: No information

Share in World Production: 70% (own computation), Fox, Williams, Mines Royal, Nevills, Williams, Grenfell, from Sep 1824: English Copper Company, Vivians, Shears, from March 1825: British Company, Jul 1927: Freemans, Crown, joined (Toomey, 1985, pp. 321-7)

Second Copper Trade Association

Cartel Period: June 1844 - Jan 1867 (Toomey, 1985, pp. 331-8)

Output Restrictions: 1847 - 1850, 1852 - 1860 (Toomey, 1985, pp. 334-5)

Stock accumulations: None.

Quantities of output restrictions or stock accumulations: I attribute the slump in annual UK production in 1848 to the closure of the Cambrian works in late 1847 (See Schmitz, 1986, p. 64)

Functioning: Price fixing, production controls by regulation of ore purchases by a quota system, output control by buying and extinguishing smelter capacity, accumulation of stocks (see Toomey, 1985, pp. 332-5; Valenzuela, 1990, pp. 669-71); "The basis of the Second Association was the regulation of ore purchases by a quota system. The quotas were fixed on the average of the proceeding two years' ore purchases. The final agreement was to divide the trade as follows: Mines Royal 4%, English Copper Company 14%, Vivians 21.5%, Freemans 8.7%, Grenfells 13.6%, Nevills 11.75% and Williams, Foster and Company 26.45%. The Ravenhead Company and Newto, Keates and Company of Liverpool were later admitted with a quota equivalent to 900 tons of metallic copper per year each. The system was monitored by statistics of ore purchases on the open market. Private contracts were made collectively by the Association and then the ores divided among the smelters according to the quotas. At the end of each quarter adjustments were made to bring actual purchases into line with quota allowances. A tariff of prices for smelted copper was established and monthly meetings were held to decide upon the prices the smelters would quote for their products. The formation of the Association did not put an immediate end to rivalries by the smelting firms. By 1847 the members of the Association were facing a considerable revival in the fortunes of the copper trade. In the years immediately after 1844, demand for copper had not been growing very rapidly but the smelting firms had fought amongst themselves to increase their output of the metal: the result was low prices and minimal profits. However in 1847 demand for copper was greatly increased due to the metal's use in patent sheathing, railway engine manufacture and brasswork. The smelters had difficulty in satisfying this demand since supplies of ore imports were in a temporary decline.The Association took a positive step towards the control of the output of copper in 1847 when it purchased the lease of the Cambrian works.The works were leased to the Nevills of Llanelli produced that they were used "for any purpose other than that of copper smelting.The unsettled political conditions of the following year lead to depression in the market for copper; the ending of copper production from the Cambrian works provided a convenient adjunct to the Association's policy of reduction of output. The members were also forced to extinguish some of their own furnaces and accumulate stocks of metal in order to maintain prices in face of the decline in demand. The ability

of the combined smelting houses to ride out the difficulties of the 'year of revolutions' testifies to the strength of their collusion at this period." (Toomey, 1985, pp. 332-3)

Effect on price: "Up to the end of 1863, the bulk of the produce of the Chili mines came to this country in the shape of ore and regulus, which naturally fell into the hands of the British smelters, a very powerful and wealthy body and few in number, which gave them commanding influence over the market; enabling them to regulate prices from time to time reasonably consistent with supply and demand, and allowing themselves a certain margin of profit this profit was popularly considered to be excessive Some of those [miners] in Chili were induced to smelting their ores on the spot, and so obtain the profits arising both from mining and smelting the English smelters are no longer able to exercise any control whatever over prices a violent competition, before unknown" (The Economist, 1868, p. 29)

Share in World Production: 32-39% (own computation); controlled at least 70% of British smelter production. (Valenzuela, 1990, p. 669)

Notes: Newell (1988, p. 188) states August 24, 1844 as the date for the first secret meeting.

Secrétan Copper Syndicate

Cartel Period: Oct 1887 - Mar 1889 (Andrews, 1889, p. 508)

Output Restrictions: None

Stock accumulations: Oct 1887 - Mar 1889 (Andrews, 1889, p. 508)

Quantities of output restrictions or stock accumulations: The syndicate bought not less than 160,000mt of copper (Andrews, 1889, p. 511). It held 140,000mt of copper at the end of 1888 according to Gates (1969, p. 80).

Functioning: The syndicate agreed with major producers to purchase a specified maximum production at a fixed price over a period of three years (Herfindahl, 1959, p. 74; Andrews, 1889, pp. 508-10). Syndicate stocks were disposed off gradually and in a controlled manner (Herfindahl, 1959, p. 76). It hereby imposed production limits on the companies (Gates, 1969, p. 79).

Effect on price: Prices rose sharply in 1888. A report by the Engineering and Mining Journal on January 12, 1889, showed that there has a been strong overproduction in 1888 as the high price swelled production and lowered consumption. The syndicate collapsed in Mar 1889 and prices declined. Excessive warehouse stocks depressed prices until fall 1892 (Herfindahl, 1959, p. 77), copper stocks doled out over a period of 3-4 years (1892-3) (Richter, 1916, p. 259).

Share in World Production: 80-85%; U.S. producers, Rio Tinto (Spain), the two Cape copper companies (Andrews, 1889, p. 509); according to Lenz (1910, p. 45) there were contracts with the most important producer in Japan, producers in Venezuela, the most important producers in Australia, producers in Chile, the two companies in South Africa, and nearly all important North-American producers. Lenz (1910, p. 45) provides an estimate of 78% of world production. Andrews (1889, p. 509) and Herfindahl (1959, p. 74) of 80-85%. The authors do not specify whether this number relates to 1887 or 1888. I assume 80% world production in 1888. When summing up per country data, the share of outsiders is larger than 20%. But this might be due to the use of country instead of company data. See also discussion in Richter (1916, p. 258).

Notes: Comptoir D'Escompe, France's largest bank beside the Bank of France, as well as a group of investors, including the Paris Rothschilds, provided funding (Andrews, 1889, p. 510). The responsible manager of the Comptoir D'Escompe committed suicide when the Comptoir D'Escompe collapsed as well (including a bank run) (Andrews, 1889, p. 513). There were substantial agreements between producers in rolling out the stocks over a couple of years (Andrews, 1889, p. 510; Herfindahl, 1959, p. 76). There was also a

short agreement among U.S. copper producers to limit output and deliberate price fixing (Andrews, 1889, p. 516).

The 1892 Agreement between the American Producers' Association and the European Producers' Committee

Cartel Period: Jul 1892 - Jul 1893 (Herfindahl, 1959, p. 78)

Output Restrictions: Jul 1892 - Jul 1893 (Herfindahl, 1959, p. 78)

Stock accumulations: None

Quantities of output restrictions or stock accumulations: Production and export quotas: U.S. production should not exceed 140,000 long tons and exports should not exceed 40,000 long tons. European producers had to reduce output by 5%. (Herfindahl, 1959, p. 78-9) "World output was reduced in 1893 by some 35 million pounds." (Gates, 1969, p. 83) This is equivalent to 15,876 mt of copper. This strong reduction is clearly observable in the world smelting production presented in Gates (1969, p. 198) and Knight (1938, p. 147) but to lesser extent in the data presented and used here by Schmitz (1986).

Functioning: Agreement between the two newly founded associations that U.S. production should not exceed 140,000 long tons and exports should not exceed 40,000 long tons. European producers had to reduce output by 5%. (Herfindahl, 1959, p. 78-9) Attempts to renew the agreement failed in 1893 "principally on account of some factors making demands which the other producers did not feel warranted in granting" (Herfindahl, 1959, p. 80, quoting the Engineering and Mining Journal).

Effect on price: "...doubtful that the 1892 agreement had any important effect on the price?" (Herfindahl, 1959, p. 79). However, there is strong disagreement with other authors, who claim it was "the first really effective world copper combination to curtail production" (Gates, 1969, p. 83).

Share in World Production: 75% of world copper production (Gates, 1969, p. 84). Herfindahl (1959, p. 75) mentions a more precise number of 75% of the world output of new copper from 1892 to 1903.

Notes: The American Producers Association was formed in 1892 and continued operation until 1903 (Herfindahl, 1959, p. 77). Herfindahl (1959, p. 78) comes to the conclusions that it basically collected and disseminated data, except for 1892/1893 where it was directly used for the purpose of restricting output. The European Producers' Committee included the principal copper mining companies in Spain, Portugal, Germany, the Cape Colony, Mexico and Australia was also formed in 1892 (Herfindahl, 1959, p. 77 quoting several mining journals). No end is given in the literature.

Amalgamated Copper Company

Cartel Period: Apr 27, 199 - Jun 7, 1915 (Richter, 1916, p. 387)

Output Restrictions: Apr 27, 1899 - 1901 (Richter, 1916, p. 387; Herfindahl, 1959, pp. 81-3)

Stock accumulations: Apr 27, 1899 - 1901 (Richter, 1916, p. 387; Herfindahl, 1959, pp. 81-3)

Quantities of output restrictions or stock accumulations: "during 1901 the output was restricted by about 25 million pounds?" (Gates, 1969, p. 88) This is equivalent to 11,340 mt. In 1900 stockholding increased but not substantially (Lenz, 1910, p. 87). From the end of 1900 to the end of 1901, stockholding of the company increased from 93 to 210 million pound (Herfindahl, 1959, p. 82).

Functioning: Centralized selling company and output restrictions; holding company included several important U.S. mining companies and acted as a selling agent (Herfindahl, 1959, pp. 80-1). It "dominated the United States and world copper markets through a complex corporate network." (Schmitz, 1986, p. 396) Other producers in the world and in Michigan undersold the Amalgamated Copper Company and world output increased steadily. Amalgamated's inventories increased from 93 million pounds at the end of 1900 to 210 million at the end of 1901. Amalgamated concluded that it could not hold the price up and there were unsuccessful attempts to negotiate output restrictions. Disintegration was complete with the demise of the American Producers Association in 1903. No more monthly statistics. (Herfindahl, 1959, pp. 81-2, partly quoting several authors)

Effect on price: The copper price rose immediately from 11-13 cents of 1898 to 17-18 cents in 1899 (Herfindahl, 1959, p. 81). The price stayed high until Dec 1901. However, competitors undersold Amalgamated and its allies. As a consequence, the inventories of Amalgamated went up and reached a peak in 1901. The Amalgamated Copper Company concluded that it could not hold up the price and released copper from its inventories, which depressed the price. The co-operation with other companies disintegrated completely with the demise of the American Producers' Association in 1903. (Herfindahl, 1959, pp. 81-3) The firm was finally liquidated in 1915. (Schmitz, 1986, p. 396)

Share in World Production: 20-40% (own computation); the holding controlled about 20% of world production, in addition cooperated with some foreign producers in 1899 (Herfindahl, 1959, p. 81). According to Gates (1969, p. 87) this was about 95,000 tons of copper per annum, which is in line with my world production data at the time. A year later, a new company was set up which handed the sales for Amalgamated and 'associated interests' totaling about 70 per cent of U.S. output (Gates, 1969, p. 87). Herfindahl (1959,

pp. 124-5) has also compared the share of the cartel in world output. He comes to lower numbers.

Notes: Founded and directed by Standard Oil/Rockefellers (Richter, 1916, pp. 288, 402). After the firm got dissolved in 1915, it took over the name of one of its subsidiaries, the Anaconda Copper Mining Company (Herfindahl, 1959, p. 80).

Price manipulations by large U.S. producers

Cartel Period: 1912-1913 (Elliott et al., 1937, p. 399)

Output Restrictions: 1912-1913 (Elliott et al., 1937, p. 399)

Stock accumulations: No information available.

Quantities of output restrictions or stock accumulations: None

Functioning: Price manipulation through pegged prices of the large copper producers and output restrictions (Herfindahl, 1959, p. 90 quoting several mining journals and Elliott et al., 1937, p. 399) "...a modest essay in price manipulation in 1912-1913." (Elliott et al., 1937, p. 399)

Effect on price: Increase of the price in 1912 and then strong decrease in 1913 (Herfindahl, 1959, pp. 90-1)

Share in World Production: 40% (own estimate); large U.S. companies

Copper Export Association

Cartel Period: Dec 1918 - 1923 (Herfindahl, 1959, pp. 93-5)

Output Restrictions: May 1921 - Feb 1922 (Herfindahl, 1959, p. 95)

Stock accumulations: Apr 1919 - 1921(Herfindahl, 1959, pp. 93-5)

Quantities of output restrictions or stock accumulations: Purchases into the stockpile: 50000 short tons in April 1919 and 200,000 short tons in Feb 1921 (Herfindahl, 1959, p. 95). Statistics about the unwinding of stocks and production cuts in Temporary National Economic Committee, Congress of the United States (1940, pp. 13404 and 13429).

Functioning: Association acted as a sales agent for export sales. There were two direct pooling procedures: in April 1919 the Association took over the U.S. government's stockpile (50,000 tons). In February 1921 the Copper Export Association acquired ownership of 200,000 tons of copper. There was also concerted cessation of production from May 1921 to about Feb 1922. The association broke up in 1923 "for all practical purposes" (Herfindahl, 1959, p. 95) owing to "defections, price chiseling, and outside competition" (Herfindahl, 1959, p. 95 quoting TNEC Hearings, 1941, p. 13, 164).

Effect on price: The Copper Export Association effectively influenced the market price during its existence. (Herfindahl, 1959, p. 95)

Share in World Production: 65% (own computation); 89% of U.S. production, 65% of world production in 1919 (Herfindahl, 1959, p. 93); detailed data in (Temporary National Economic Committee, Congress of the United States, 1940, p. 13404).

Notes: Webb-Pomerene Institution

Copper Exporters Inc/ Copper Institute

Cartel Period: Oct 1926 - 1939 (Herfindahl, 1959, p. 100)

Output Restrictions: Oct 1926 - mid 1932, Dec 1937 - Oct 1938, Jan 1939 - Jul 1939 (Herfindahl, 1959, pp. 100-4, 115)

Stock accumulations: None.

Quantities of output restrictions or stock accumulations: First period: In the fall of 1930, at which time moderate restriction of output, about 15 per cent, apparently was agreed upon in May 1931 further restrictions were discussed. Agreement was finally reached in late 1931 to restrict about to about a quarter of 1929 capacity. Still further restriction, to about a fifth of 1929 capacity, was discussed and agreed upon in March 1932. (Herfindahl, 1959, p. 105) From December 1930 world production was curtailed by 23,666 short tons per month. (Temporary National Economic Committee, Congress of the United States, 1940, p. 13472) Second period: Production decreased by 16.9% according to Herfindahl (1959, p. 115) Third period: Production decreased by 22.4% according to Herfindahl (1959, p. 115)

Functioning: Price setting with a loose, voluntary agreement to restrict output, provisions that the relative share of members in sales remains constant. Monetary penalties after July 1930. Included both U.S. and foreign firms. Selling prices outside the U.S. were determined by a New York committee after consultation with a Brussels committee representing the foreign members. Members were expected to adhere to the prices set by the committee. (Herfindahl, 1959, pp. 100-2) "Restrictions of output was the subject of discussion by 'world copper producers' at New York in the fall of 1930, at which time moderate restriction of output, about 15 per cent, apparently was agreed upon in May 1931 further restrictions were discussed. Agreement was finally reached in late 1931 to restrict about to about a quarter of 1929 capacity. Still further restriction, to about a fifth of 1929 capacity, was discussed and agreed upon in March 1932. These discussions were held under the auspices of the Copper Institute - which had been established in 1927 to collect data and develop a system of cost accounting - or were arranged by the larger producers." (Herfindahl, 1959, p. 105) The imposition of a U.S. import tariff in mid 1932 showed the growing divergence of interest between U.S. and foreign producers and brought the Copper Exporters Inc de facto to an end. (Herfindahl, 1959, p. 105) From the narrative I assume that this implies that the collusion in the framework of the Copper Institute disintegrated from mid 1932 onwards. (Herfindahl, 1959, p. 106) excludes the years 1929-1933 because of effective collusion.

Effect on price: First period: In 1926, 1927 and possibly a part of 1928 "it may well be that CEI's existence prevented prices from declining further?". From 1929 to April 1930

the association successfully stabilized prices. U.S. stocks increased rapidly. The price broke in Apr 1930 owing to price cutting by some firms. There were renewed attempts to restrict output within the framework of the Copper Institute. The imposition of a U.S. import tariff in mid 1932 brought the CEI de facto to an end. (Herfindahl, 1959, pp. 103-5) Restrictions could not prevent a very large decline in the price of copper, which reached about 5 cents in mid-1932. There was strong growing divergence and weakened community of interest among producers. (Herfindahl, 1959, p. 105) Cartel successful in restricting some output at certain periods. It had some effect on the price. (Herfindahl, 1959, p. 119)

Share in World Production: First period: 73-90% (own computation); 65-95% of world production according to different sources quoted in (Herfindahl, 1959, p. 100). Detailed data on member firms and their output in U.S. Government (1941, p. 13441-61). 90% of world production (Pettengill, 1931, p. 148); (Herfindahl, 1959, p. 105) states that theses are approx the same participants as those of Copper Exporters Inc. Second period: 46-53% (own computation); formal members and associated firms accounted for 50% of world production. (Herfindahl, 1959, p. 125) Third period:48% (own computation); formal members and associated firms accounted for 50% of world production. (Herfindahl, 1959, p. 125))

Voluntary Production Cuts by U.S. firms

Cartel Period: July 1962 - late 1963 (Crowson, 2007, p. 15)

Output Restrictions: July 1962 - late 1963 (Crowson, 2007, p. 15)

Stock accumulations: None

Quantities of output restrictions or stock accumulations: 10-15% of Zambian mine output, cutbacks by U.S. not clear. (Crowson, 2007, p. 15) I have taken the actual decrease in output from 1962 to 1963.

Functioning: Voluntary production cuts; "cutbacks in production or sales were introduced in mid July, both in the United States and Africa. Production was reduced by 10-15% in Zambian mines. The cutbacks were reversed late in 1962." (Crowson, 2007, p. 15)

Effect on price: Reduced oversupply and helped stabilize prices (Edelstein, 1999, p. 39)

Share in World Production: 38% (own computation derived from data on primary production in Zaire, South Africa, U.S., South Rhodesia, and Zambia from Schmitz (1986); I took just U.S. and Zambian production as there are no details on the other countries. I used primary (blister) copper.); U.S. and African producers (Crowson, 2007, p. 15)

Intergovernmental Council of Copper Exporting Countries (CIPEC)

Cartel Period: Jun 8 1967 - 1988 ((Nappi, 1979, p. 103)

Output Restrictions: Dec 1, 1974 (Announcement on Nov 19) - Dec 7, 1977 (Nappi, 1979, p. 104)

Stock accumulations: None

Quantities of output restrictions or stock accumulations: "On November 19, 1974, CIPEC announced that, for the six months following December 1, 1974, its member countries would reduce monthly exports by 10% from earlier 1974 levels. In April 1975 CIPEC raised the quota applied by member countries to 15%." (Nappi, 1979, p. 104). According to (Mikesell, 1979, p. 106) there were also production cutbacks. Divergence of views in 1976: A CIPEC directive set a 15% cut in production for the first semester of 1976, but there was a strong increase in Chilean production. The same phenomenon occurred in 1977. (Nappi, 1979, p. 114)

Functioning: Export and production quotas; served as forum for discussion and dissemination of information during the first years. Ongoing nationalization of copper firms in these countries (see Nappi, 1979, p. 103). "On November 19, 1974, CIPEC announced that, for the six months following December 1, 1974, its member countries would reduce monthly exports by 10% from earlier 1974 levels. In April 1975 CIPEC raised the quota applied by member countries to 15%." (Nappi, 1979, p. 104). According to Mikesell (1979, p. 106) there were also production cutbacks. Divergence of views in 1976: A CIPEC directive set a 15% cut in production for the first semester of 1976, but there was a strong increase in Chilean production. The same phenomenon occurred in 1977. (Nappi, 1979, p. 114) "On December 7, 1977 CIPEC delegates could not agree on emergency measures to harden world copper prices." (Nappi, 1979, p. 116)

Effect on price: "not fully observed" and "unsuccessful in stimulating a price rise" (Mikesell, 1979, pp. 187-215) "The effects of this first intervention were very modest." (Nappi, 1979, p. 104)

Share in World Production: 21-23% (own computation); Chile, Peru, Zaire, Zambia (since 1975 Australia, Mauritania, Papua New Guinea became associated members, Yugoslavia and Indonesia became full members). Controlled about 37% of world mine output in 1975 according to Radetzki (2008, p. 158) (see also discussion in Nappi, 1979, p. 114). My computation show that it is less in terms of refined production.

Notes: Some functions (such as data dissemination) of the CIPEC were continued by the International Copper Study Group formed in 1993 (see Radetzki, 2008, p. 158)