CEO Overconfidence and Collusion*

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Abstract

We explore whether there is a relationship between CEO overconfidence and collusion. Overconfidence may make managers compete if they expect to be able to outperform their competitors, or it may push them to collude if they expect not to be caught/convicted or if their expected sanction is low. On the other hand, there may be a feedback effect in the sense that CEO overconfidence may increase during the duration of the cartel while the cartel remains undetected. Further, this growth in overconfidence may lead to the cartels being discovered. Overconfidence is defined, as in Malmendier and Tate (2005), as the tendency to hold too much firm risk, in a "habitual" (*longholder*, and *net buyer*) or short-term (*holder 67*) manner. We document that: (1) there is a positive and highly significant relationship between overconfidence and collusion, and (2) cartel participation granger causes overconfidence (*holder 67*) (and not the other way around). We then examine the mechanisms underlying this relationship.

Keywords: Corporate governance; cartels; managerial incentives; revealed preferences; overconfidence.

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1 Introduction

[TBW]

We consider the effect of managerial overconfidence, which is a behavioral bias of managers that usually refers to the underestimation of failure (e.g., Malmendier and Tate (2015)). In that regard, it has been shown that overconfident managers tend to underestimate risk, which is discussed in various contexts like acquisitions (e.g., Malmendier and Tate (2008)), innovation (e.g., Galasso & Simco (2011)), and corporate investment (e.g., Malmendier and Tate (2005)).

In the context of collusion, this effect could go in two different directions. One possibility is that overconfident managers choose not to collude, as they might expect that, by competing, they can outperform their competitors. This would be in line with the literature suggesting that many cartels are "defensive cartels" that form in declining industries.

One other possibility is that overconfident managers may prefer to collude if they underestimate one or more of the following: (i) the likelihood that other cartel members will deviate from the agreement and report the cartel, (ii) the likelihood of detection by the authorities, (iii) the likelihood of a large fine. In any of these cases, managers would be more likely to engage in a collusive agreement as they underestimate the corresponding risks. Thus, overly confident managers may tend to form and stabilize collusive agreements compared to less overconfident managers. In other words, overconfidence in managers may lead to a higher probability of engaging and starting a collusive agreement.

2 Literature Review

Our work contributes to two strands of literature. First, we contribute to the literature on the role and liability of individuals involved in cartel agreements. Harrington (2006) and Connor (2011) describe how, in convicted cartels in the US, decisions are typically taken by very top managers but implemented by intermediate management. However, Gonzalez et al. (2019) find little evidence that managers of convicted (listed) cartel firms in the US, between 1990 and 2014, are held accountable by either corporate governance or the legal system. Instead, the authors find that managers of convicted cartel firms are given greater job security and receive large bonuses, while rarely facing individual prosecution. More broadly, Dyck et al. (2010) examine whistleblowers' incentives to reveal misbehaviors.

Other authors have examined the relationship between cartel formation and corporate governance. Han et al. (2008) find that when CEO tenure is low (or turnover is high), firms are more likely to be involved in collusive agreements and these tend to be more stable. Han (2010) shows theoretically that short-term CEO employment contracts (compared to long-term contracts) and debt-financed firms (compared to equity-financed firms) improve cartel stability.

Second, we contribute to the literature on the role of personal managerial characteristics in decision-making, particularly regarding "unjustified" beliefs based on available information (Baker and Wurgler, 2006). Malmendier and Tate (2005) and Malmendier and Nagel (2005) find that CEOs tend to overestimate the success of their corporate decisions, while Itzhak et al. (2013) show that CEOs underestimate the variance of stock market returns and other financial signals. The overconfidence of CEOs also increases the likelihood of mak-

ing value-destroying mergers, especially when these are diversified (Malmendier and Tate, 2008). In addition, Malmendier and Tate (2005) also show that the level of education and educational background of CEOs directly affect firm strategic decisions.

More precisely, we contribute to the literature on the effect of CEO turnover on corporate governance (eg. Jenter and Kanaan (2015), Fisman et al. (2006), Jenter and Lewellen (2015)). In particular, Jenter and Kanaan (2015) show that the likelihood of a CEO being fired depends on the performance of the industry and not just its firm. This suggests that shareholders do not reward and/or punish managers for individual firm performance while filtering out industry performance. The authors examine CEO turnover taking into account personal CEO characteristics such as their age and tenure.

The literature has provided some evidence in favor of tougher sanctions, particularly in the EU. In the event study carried out by Aguzzoni et al. (2013), the authors show that the overall antitrust actions in cartel convictions reduce the firm's market value by less than 5%, of which fines account for less than 9% of this loss. A follow-up study by Mariuzzo et al. (2020) shows that where there is a reputational penalty, increasing fines reduces the effect of the public sanction, whereas in the absence of a reputational penalty, the effect of cartel fines steps in. More recently, Marvão and Spagnolo (2018) describe the recent trend of EC leniency inflation. By exploiting the difference between CEOs and/or firms that report the cartel and apply for leniency and those that do not, we also contribute to the recent but extensive literature on the economics of leniency programs (LP), starting with the contri-

butions by Motta and Polo (2003), Spagnolo (2004), Aubert et al. (2006), Buccirossi and Spagnolo (2006), Harrington (2013), Chen and Rey (2013) and many others.[1]

3 Data, Sample and Key variables

3.1 Data

The cartel data employed in the empirical analysis is an excerpt from John Connor's Private International Cartels dataset.[2] This excerpt covers the years of 1984 to 2011 and is limited to publicly reported information on 180 cartels convicted between 1985 and 2011 by the DOJ, involving 470 non-anonymous individual firms.

The financial and compensation data used in this study come from four sources: Compustat's Annual and Quarterly Industrial Files; ExecuComp; and the Hoberg and Phillips Data Library. The Hoberg and Phillips Data Library provides a text-based network industry classification, giving each firm a list of firm-year specific competitors, with associated similarity 'scores.' The scores are based on the cosine similarity between two firms' product disclosures.[3]

We further add data on the position and post-cartel career path of the managers convicted by the US DOJ, (ii) the CEOs of cartel members convicted by the US DOJ, and (v)

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[1]A review of the empirical and experimental evidence of the effectiveness of LPs is offered in Marvão and Spagnolo (2015).

[2]Private International Cartels spreadsheet by John M. Connor, Purdue University, Indiana, USA (January 2012). The dataset was modified in several ways: the anonymous firms and groups of firms were dropped to be able to account for different measures of recidivism; some of the variables were resized; where possible, data was checked (and corrected) against the DOJ case documents; the imprisonment variable was updated with John Connor's criminal dataset, obtained in 2016 and several other variables were dropped due to inconsistent or missing data.

[3]See: **??**, and **?**.

the shareholders of cartel members mentioned in the EC reports. This data was obtained from *Bloomberg*, Who's Who in Finance and Industry and other online sources.

3.2 Sample Selection

We use two data sources in building our measures of overconfidence. First, we use data from Thompson for the period of 1998 to 2013 (to match the same time period as in Malmendier and Tate (2015). Second, we use data from Compustat for the period of 1998 to 2016. We drop all observations with missing data on sales, ticker symbols, or SIC codes. We match this set, as feasible, to the cartel dataset, using firms' ticker symbols.[4] Our final sample consists of 11,450 firm-year observations from 2987 unique firms, of which 76 firms were cartel members at some point over our sample period.

One other concern with the data is the possibility of sample selection bias. Since cartels are prohibited by the Sherman Act, they are secret, so the available data include only cartel members that were prosecuted and convicted. This problem of selection on the unobservables cannot be overcome in our setting, but its existence is acknowledged in the interpretation of the results.

To the extent that undetected cartels exist, and differ from detected cartels along relevant dimensions, our results may be biased (e.g., if overconfidence plays a role in the detection of the cartel). This problem is not unique to our study; an analogous concern applies to all studies where variable codings are jointly contingent upon both the presence and *detection* of the feature of interest.[5]

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[4]Where possible, we use the US ticker symbols developed by Standard & Poor's (S&P) to identify each firm. We use the latest available symbol for each firm, to reflect mergers and acquisitions. For example, Exxon's US ticker symbol was "XON" but after the 1999 merger with Mobil Oil, it changed to "XOM".

[5]Common examples include fraud/financial misreporting (e.g., AAER issuances); insider trading; etc.

3.3 Variables

Below we outline the variables used in our main analyses. Definitions for all variables can be found in Table 1 in the Appendix.

3.3.1 Cartel Membership

We measure cartel membership with a dummy variable equal to one for all firm-years that are identified as being part of a cartel membership window. A firm's cartel membership window spans from the first year for which the firm was successfully prosecuted for antitrust violations, to the year of the final antitrust enforcement action.[6] We refer to this measure as $CARTEL$. For supplemental analyses, we decompose $CARTEL$ into $CARTEL$ ($primary$) and $CARTEL$ ($secondary$), which reflect whether or not a cartel operates in a firm's primary industry.

We further construct the indicator variable, $BUST$, to reflect firms' transitions from being cartel members to non-cartel members (i.e., when final enforcement actions are successfully brought against the firms).[7] $BUST$ which takes a value of one if $CARTEL_{i,t-1} = 1$ and $CARTEL_{i,t} = 0$.

3.3.2 Managerial overconfidence

The literature defines overconfidence as optimism, i.e., the overestimation of a firm's relative or absolute performance (e.g. Malmendier and Tate (2005, 2008)) or as over precision,

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[6]Many firms are involved in multiple cartels (known as "repeat offenders" or "serial colluders"). In these cases, the cartel membership window covers involvement in all cartels that the firm is convicted of participating in. For example, if the firm was involved in one cartel from 2006 to 2010, and another cartel from 2008 to 2013, the firm's cartel window spans from 2006 to 2013.

[7]It is conceivable that cartels manage to sustain even after cartel member firms are caught, convicted and fined. To the extent that regulatory interventions are ineffectual, it would reduce the power of our tests.

i.e., the excessive precision of one's benefits, as reported through surveys (e.g. Itzhak et al. (2013)).

We take the first definition and follow the approach in Malmendier and Tate (2005) who developed three option-based measures of overconfidence. These measures are based on the premise that CEOs who recurrently delay exercising fully vested in-the-money stock options are overconfident, relative to the market's evaluation, about the prospects of their firm. As such, these measures exploit the underdiversification of CEOs.

We construct four measures of overconfidence: [1]*Longholder* (using data from COMPU-STAT)) and *Longholder Thomson* (using data from Thomson), [2] *Holder67*, [3] *Holder67 Restriction*, and [4]*Net Buyer*. *Net Buyer* uses the timing of the acquisition of firm stock, whereas the other measures use the timing of option exercises. We discuss these in further detail below.   We build the overconfidence measures using data from COMPUSTAT (see table 1). Data on stock prices comes from CRSP, such that our sample is restricted to publicly traded firms.

Longholder

Longholder focuses on the expiration date of option packages rather than the end of the vesting period. We classify a CEO as overconfident (for all of his years in the sample) if he ever holds an option until the last year of its duration.
Given that the typical option in the sample has 10 years' duration and is fully vested (at the latest) by year 5, the CEO chooses to hold, rather than exercise, the option for at least 5 years. Thus, this measure measures **habitual failure to diversify**, or a **personality**, and not a time-varying, overconfidence effect.

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The Execucomp data (pre-2006) does not include details about individual option packages. For instance, there is no data on individual grant dates, expiration dates, or strike prices. Therefore, it is not possible to assess the timing of exercise relative to expiration (or grant) dates, and the "average moneyness" used in *Longholder* is a direct function of stock prices. To overcome this issue, Malmendier and Tate (2015) update this measure of overconfidence using data from Thomson Reuters's Insider Filings for the 1996-2012 time period.

Holder 67

Holder 67 considers the status of each individual option package in our sample at the end of the vesting period. We examine the first year in which all the packages in the sample are at least partially exercisable (year 1996), and compute the percentage in-the-money for each package.

To keep comparability across packages with vesting periods of different duration, we examine the first year in which all of the packages in the sample are at least partially exercisable, year 5. We then compute the percentage in-the-money for each package. Risk aversion and underdiversification predict that CEOs should exercise options immediately after the vesting period if the amount inthe- money is beyond a rational benchmark.

We take 67% in-the-money during the fifth year as our threshold. If an option is more than 67% in-the-money at some point in year 5, the CEO should have exercised at least some portion of the package during or before the fifth year. This threshold corresponds to a risk aversion of three in a constant relative risk-aversion (CRRA) utility specification and

to a percentage of wealth in company equity equal to 66.

Therefore, this measure targets CEOs who "habitually" exercise options late.

Holder 67 Restriction

To build this measure, we take the *Holder 67* measure and restrict the sample to CEOs who at least twice during the sample period had options that were valued above the threshold during the fifth year. This restriction guarantees that every CEO in the subsample had the opportunity to be classified as overconfident and, thus, limits the degree of unobserved overconfidence in the control group.

However, this also restricts considerably the sample of overconfident CEOs.

Net Buyer

[4] *Net Buyer* exploits the tendency of some CEOs to purchase additional company stock despite their already high exposure to company risk. Specifically, we consider the subsample of CEOs who keep their position as CEO for at least 10 of the 15 years in our sample.

CEOs are identified as overconfident if they were net buyers of company equity during their first five years in our sample, that is, if they bought stock on net in more years than they sold on net during their first five sample years.

We exclude the first five years of the CEOs' tenures. Thus, we use disjoint subsamples of CEO years to establish overconfidence and to measure its potential effects on investment. This approach ameliorates endogeneity concerns, but at the cost of (again) reducing sample

size substantially.

Overall, the *Holder 67* measures place no restriction on how long the CEO must hold the option beyond the fifth year and, thus, can capture short-term delays in option exercise, rather than an "habitual" tendency to hold too much risk (*a fixed overconfience effecr*.

4 Empirical Analysis

4.1 Baseline Results

We begin our analysis by examining the relations among overconfidence use, cartel membership, and industry concentration. We do so with variants on the following regression specification:

$$Overconfidence_{i,t} = \beta CARTEL_{i,t} + \mu_i + \tau_{j,t} + \varepsilon_{i,t}, \tag{1}$$

where $Overconfidence_{i,t}$ is an indicator variable equal to one if the CEO in firm i is overconfident in year t, $CARTEL_{i,t}$ is an indicator variable equal to one if firm i is a cartel member in year t, and μ and τ are firm and SIC-year fixed effects. Across our first set of tests, specifications differ with respect to the measure of overconfidence (*Holder67, Longholder* and *Net Buyer*), the fixed effect structure, the use of control variables, and the sample.

4.2 Cartel start, end and instrumental variable results

In table 2, we examine how overconfidence (the *Longholder* measure from Thomson) affects, not only collusive periods but also the start and end of the cartel.

Although we find a highly significant positive association between overconfidence and collusive behavior, these relationships are not statistically different from zero if we instrument the respective variables.

4.3 Mechanism

4.3.1 Direction of correlation

$$CARTEL_{i,t} = \beta overconfidence_{i,t} + \mu_i + \tau_{j,t} + \varepsilon_{i,t}, \tag{2}$$

4.3.2 Granger Causality

$$overconfidence_{i,t+1} = \beta_1 CARTEL_{i,t} + \beta_2 overconfidence_{i,t} + \mu_i + \tau_t + \varepsilon_{i,t}, \tag{3}$$

$$overconfidence_{i,t-1} = \beta_1 CARTEL_{i,t} + \beta_2 overconfidence_{i,t} + \mu_i + \tau_t + \varepsilon_{i,t}. \tag{4}$$

4.3.3 Changes in overconfidence

We test for the effect of changes in overconfidence measures using variants on the following regression specification:

$$\delta overconfidence_{i,t} = \beta BUST_{i,t-1} + \mu_i + \tau_{j,t} + \varepsilon_{i,t}, \tag{5}$$

4.3.4 Changes in CEO

We test for the effect of CEO changes using variants on the following regression specification:

$$\delta overconfidence_{i,t} = \beta \delta CEO_{i,t-1} + \mu_i + \tau_{j,t} + \varepsilon_{i,t}, \tag{6}$$

We examine the post-cartel career path of CEOs criminally prosecuted by the DOJ. Table 2 describes these cases, which relate to 2.4% of the indicted individuals (22) by the US DOJ (1990-2014).

The indicted CEOs became CEOs between the age of 18 and 64 and were between 44 and 75 years old at the time of the fine. While some left up to 6 years before the first cartel fine, some remained in power up to 18 years after the fine. Only 6 (of 20) left within one year of the fine. In fact, although several CEOs left the company (9/18), others took up different positions within the firm. The length of the prison sentences are all very different, ranging from pecuniary fines or hours of community service to 72 months in prison (although in the latter case, the individual was released after 36 months).

Although CEOs of convicted cartel firms are rarely indicted in the cartel fining decisions, cartel agreements are often coordinated and/or allowed at a senior level of the firm (or subsidiary). Below, we explore the DOJ decisions to analyze at what level the cartel decisions are (according to these reports) made. We present a summary of the results in table 3.

Some of the most commonly named individuals are division managers (17% in DOJ cases), typically sales and marketing manager; as well as lower level staff. The latter include salesmen, dealers, brokers and traders and while these individuals have a crucial role in

coordinating the prices or quantities set within the cartel agreement but are unlikely to be the ones creating the agreement.

4.4   Propensity Score Matching

4.5   Propensity Score Matching Algorithm

5   Conclusion

[TBW]
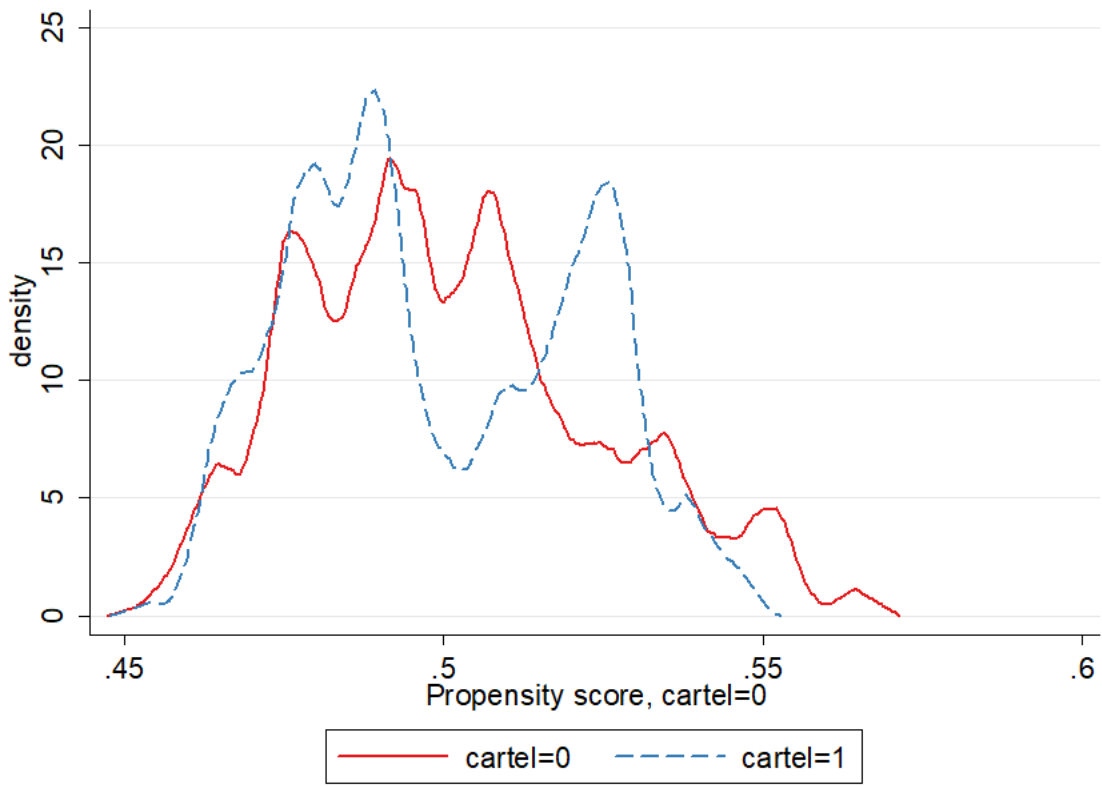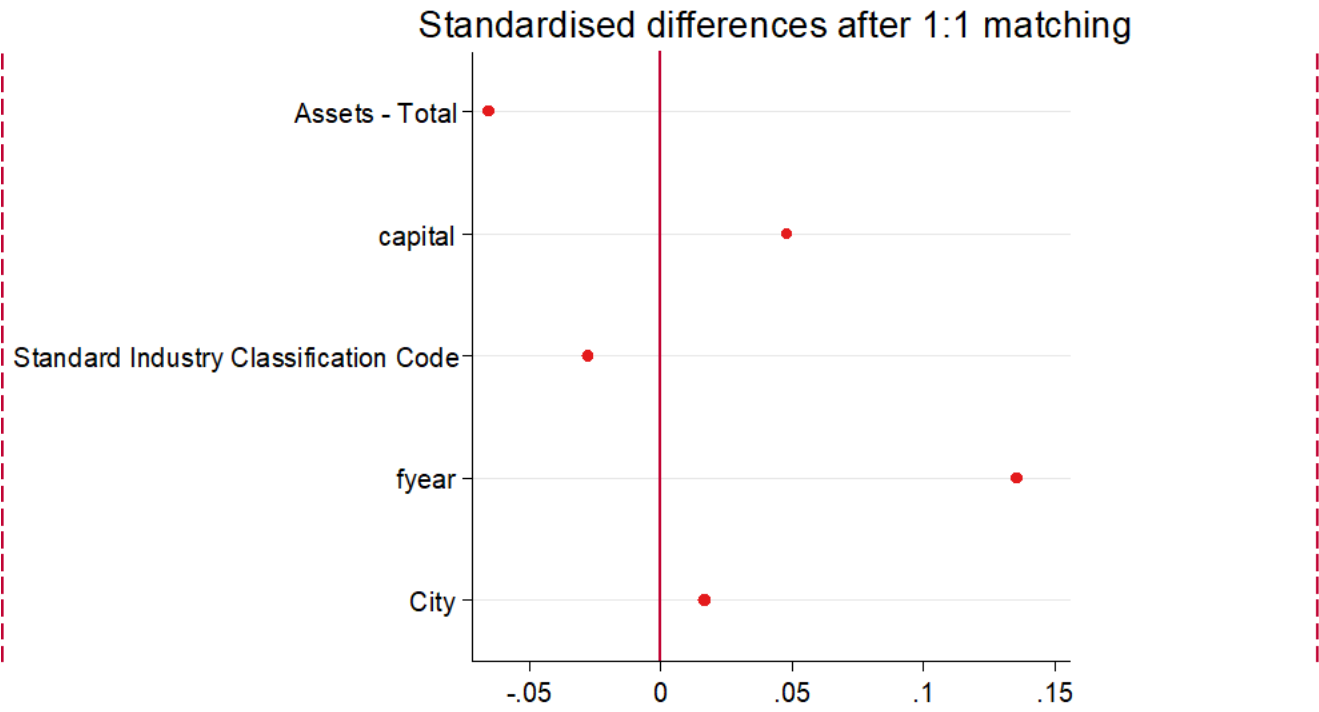
Figure 1: Caption

Table 1: COMPUSTAT items

Compustat variable	item	Proxy for: (Malmendier et al.)
[**A**] total assets	6	book value assets
[**C**] capital expenditures[*]	128	investment
[**E**] earnings before extraordinary items[*]	18	cash flow
[**D**] depreciation	14	
[**CE**] common equity	60	
[**K**] property, plants, and equipment	8	proxy for capital
[**L**] total liabilities	181	
[**P**] fiscal-year closing price	199	
[**PV**] preferred stock par value	130	
[**PL**] preferred stock liquidating value	10	
[**PR** preferred stock redemption value	56	
[**BS**] balance sheet deferred taxes and investment tax credit	35	
[**S**] common shares outstanding	25	
[**SE**] stockholders' equity	216	
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[**ME**] Market equity=[S]*[P]	.	.
[**BE**] book equity=[SE or CE]+[PS or A] -[L] -[PL or PR or PV] +[BS]	.	.
[**MA**] Market value assets=[A]+[ME]-[BE]	.	.
Q=[MA]/[A]	.	.

[*] Normalized beginning-of-the year capital. Given that our sample is not limited to manufacturing firms. Also normalized by assets (as robustness). Cash flow trimmed at the 1% level.

Appendix:

Table 2: Cartel convictions by the US DOJ where CEOs were indicted.

DOJ Case	Year	Cartel member	CEO jail time	Post-cartel
Stamp Auctions	2002	Earl P.L. Apfelbaum Co.	0	current CEO
Concrete, ready-mix	2005	Beaver Materials Corp.	27	current CEO
Intl. freight forwarding	2005	Pasha Group	0	current CEO
Federal Creosote Superfund	2008	Bennett Environmental Inc.	63	current CEO
Concrete, ready-mix	2005	Irving Materials , Inc.	5+5(home)	Chairman
Air cargo, fuel surcharge	2007	Cargolux Airlines Intl.	13	SVP Global Sales
LCD screens	2008	Chunghwa Picture Tubes Ltd.	7	Chairman
LCD screens	2008	Chungwha Picture Tubes (CEO 2)	9	director and chairman
TV tubes (CRT)	2009	Chunghwa Picture Tubes (CEO 1)	7	chairman
Auto parts (lights)	2011	Maxone Vehicle Lighting	6	chairman
Plastic dinnerware	1994	Dispoz-o Plastics	21	retired
Graphite Electrodes	1998	GrafTech	17	retired
Graphite Electrodes	1998	SGL Carbon	0	retired
Carbon/ Graphite Electrical	2002	Morgan Crucible Co.	18	retired
Construction Wastewater	2002	American Int. Contractors	36	retired
E-Rate Internet program	2003	Multimedia Communication S.	60	retired
Nigeria liquid natural gas	2010	M. W. Kellogg	30	retired
Shipping, Parcel Tankers	2003	Odfjell Seachem	4	CEO new firm
Military bandages	1998	Fraass Survival Systems Inc.	5	n/a
Cable-stayed bridges	1999	Dywidag-Systems Intl. USA	0	n/a
Auction houses	2000	Sotheby's	0(1000h c.s.)	n/a
Tomatoes, processed	2008	SK Foods Group	72(out at 36)	n/a

Table 3: Position of individuals involved in EC and DOJ cartel cases

Position	DOJ cases	(%)
Chairman	10	2.69%
Vice-Chairman / CEO	18	4.84%
President (of firm or subsidiary)	45	12.10%
VP / Senior VP / Exec.VP	54	14.52%
VP of section / division	11	2.96%
Directors	53	14.25%
senior executives / management	5	1.34%
General manager	41	11.02%
Division / region manager(or head)	62	16.67%
executive salesman	63	16.94%
Outside the firm	10	2.69%
Total	372	

Table 4: Y=cartel(t), X=overconfidence(t)

Panel A	[1]	[2]	[3]	[4]
longholder	0.017	0.008	0.008	0.008
	(0.021)	(0.020)	(0.020)	(0.020)
N	26535.000	18395.000	18390.000	18390.000
R-squared	0.035	0.030	0.021	0.041
Panel B	[1]	[2]	[3]	[4]
holder67	-0.003	0.000	0.000	-0.000
	(0.008)	(0.005)	(0.005)	(0.005)
N	26535.000	18395.000	18390.000	18390.000
R-squared	0.035	0.030	0.021	0.041
Panel C	[1]	[2]	[3]	[4]
holder67_restriction	0.010***	0.013***	0.007***	0.012***
	(0.004)	(0.003)	(0.003)	(0.003)
N	26535.000	18395.000	18390.000	18390.000
R-squared	0.035	0.031	0.021	0.042
Panel D	[1]	[2]	[3]	[4]
netbuyer	0.005	0.001	0.022***	0.000
	(0.003)	(0.004)	(0.005)	(0.004)
N	26535.000	18395.000	18390.000	18390.000
R-squared	0.035	0.030	0.025	0.041
Panel E	[1]	[2]	[3]	[4]
Longholder_Thomson	0.042***	0.047***	0.049***	0.047***
	(0.013)	(0.013)	(0.013)	(0.013)
N	8771.000	8771.000	8771.000	8771.000
R-squared	0.019	0.022	0.041	0.042
CEO controls	no	yes	yes	yes
firm controls	yes	yes	yes	yes
year FE	yes	yes		yes
sector FE			yes	yes

Table 5: Y=cartel(t), X=overconfidence(t-1)

Panel A	[1]	[2]	[3]	[4]
llongholder	-0.014***	-0.012***	-0.011***	-0.011***
	(0.003)	(0.003)	(0.003)	(0.004)
N	21,548	14,999	14,995	14,995
R-squared	0.023	0.024	0.018	0.035
Panel B	[1]	[2]	[3]	[4]
lholder67	-0.003	-0.003	-0.003	-0.003
	(0.007)	(0.007)	(0.007)	(0.007)
N	21,548	14,999	14,995	14,995
R-squared	0.023	0.024	0.018	0.035
Panel C	[1]	[2]	[3]	[4]
lholder67_restriction	0.008**	0.008**	0.004	0.007**
	(0.004)	(0.003)	(0.003)	(0.003)
N	21,548	14,999	14,995	14,995
R-squared	0.023	0.025	0.018	0.036
Panel D	[1]	[2]	[3]	[4]
lnetbuyer	0.004	0.001	0.008**	0.000
	(0.003)	(0.003)	(0.004)	(0.003)
N	21,548	14,999	14,995	14,995
R-squared	0.023	0.024	0.019	0.035
Panel E	[1]	[2]	[3]	[4]
LLongholder_Thomson	0.041***	0.046***	0.048***	0.046***
	(0.012)	(0.012)	(0.012)	(0.012)
N	9,460	9,460	9,460	9,460
R-squared	0.019	0.022	0.039	0.040
year FE	yes	yes		yes
sector FE			yes	yes
Firm controls	yes	yes	yes	yes
CEO controls	no	yes	yes	yes

Table 6: GRANGER CAUSALITY Y=cartel(t), X=overconfidence(t)

Panel A	cartel(t+1)	cartel(t-1)
longholder	-0.001	-0.003**
	(0.001)	(0.001)
cartel	0.776***	0.855***
	(0.024)	(0.023)
N	14,250	14,781
R-squared	0.691	0.645
CEO controls	yes	yes
firm controls	yes	yes
year FE	yes	yes
sector FE	yes	yes

Table 7: Y=overconfidence(t), X=cartel(t-1)

Panel A	Longholder[1]	[2]	[3]	[4]
Pcartel	0.002	0.002	0.002	0.002
	(0.003)	(0.005)	(0.004)	(0.005)
N	25660.000	14992.000	14988.000	14988.000
R-squared	0.002	0.003	0.001	0.004
Panel B	Holder67[1]	[2]	[3]	[4]
Pcartel	-0.013	-0.012	-0.015	-0.015
	(0.013)	(0.014)	(0.014)	(0.014)
N	25660.000	14992.000	14988.000	14988.000
R-squared	0.001	0.003	0.003	0.005
Panel C	Holder67Rest[1]	[2]	[3]	[4]
Pcartel	0.026	0.023	0.002	0.016
	(0.018)	(0.019)	(0.019)	(0.020)
N	25660.000	14992.000	14988.000	14988.000
R-squared	0.015	0.016	0.006	0.018
Panel D	NetBuyer[1]	[2]	[3]	[4]
Pcartel	0.052**	0.030	0.122***	0.029
	(0.021)	(0.030)	(0.035)	(0.030)
N	25660.000	14992.000	14988.000	14988.000
R-squared	0.220	0.262	0.023	0.263
Panel E	Longh(Thomson)[1]	[2]	[3]	[4]
cartelnew	0.195***	0.210***	0.221***	0.213***
	(0.053)	(0.049)	(0.050)	(0.050)
N	8771.000	8771.000	8771.000	8771.000
R-squared	0.058	0.102	0.099	0.112

Table 8: Y=overconfidence(t), X=cartel(t)

Panel A	Longholder[1]	[2]	[3]	[4]
cartel	0.002	0.003	0.003	0.003
	(0.003)	(0.005)	(0.005)	(0.005)
N	25660.000	14805.000	14801.000	14801.000
R-squared	0.002	0.004	0.001	0.004
Panel B	Holder67[1]	[2]	[3]	
cartel	0.000	0.004	0.003	0.002
	(0.012)	(0.010)	(0.010)	(0.010)
N	25660.000	14805.000	14801.000	14801.000
R-squared	0.001	0.004	0.004	0.006
Panel C	Holder67Rest[1]	[2]	[3]	
cartel	0.062***	0.076***	0.040***	0.072***
	(0.017)	(0.013)	(0.012)	(0.013)
N	25660.000	14805.000	14801.000	14801.000
R-squared	0.016	0.020	0.010	0.021
Panel D	NetBuyer[1]	[2]	[3]	
cartel	0.041*	-0.023	0.170***	-0.024
	(0.023)	(0.032)	(0.033)	(0.031)
N	25660.000	14805.000	14801.000	14801.000
R-squared	0.220	0.264	0.032	0.265
Panel E	Longh(Thomson)[1]	[2]	[3]	
Pcartelnew	0.225***	0.244***	0.246***	0.248***
	(0.051)	(0.047)	(0.048)	(0.048)
N	6451.000	6451.000	6451.000	6451.000
R-squared	0.060	0.105	0.099	0.115

Table 9: Cartel found - 5y

	L1xf	L2xf	L4xf
longholder	-0.001***	-0.001***	-0.001*
N	28523.000	28517.000	28517.000
R-squared	0.005	0.001	0.006
	HR1xf	HR2xf	HR4xf
holder67_restriction	0.001	-0.000	0.001
N	28523.000	28517.000	28517.000
R-squared	0.005	0.001	0.006
	H1xf	H2xf	H4xf
holder67	-0.001	-0.001	-0.001
N	28523.000	28517.000	28517.000
R-squared	0.005	0.001	0.006
	N1xf	N2xf	N4xf
netbuyer	-0.000	0.002**	-0.000
N	28523.000	28517.000	28517.000
R-squared	0.005	0.001	0.006
	f1	f2	f3
longholder_Thomson	0.007***	0.008***	0.008***
	(0.002)	(0.003)	(0.003)
N	8992.000	8992.000	8992.000
R-squared	0.004	0.006	0.008
year FE	yes		yes
sector FE		yes	yes

Table 10: Cartel found, with controls - 5y

	L1xcf	L2xcf	L4xcf
longholder	-0.000*	-0.001***	-0.000
	(0.000)	(0.000)	(0.000)
N	16079.000	16074.000	16074.000
R-squared	0.005	0.001	0.006
	HR1xcf	HR2xcf	HR4xcf
holder67_restriction	0.002***	0.001***	0.003**
	(0.000)	(0.000)	(0.002)
N	16079.000	16074.000	16074.000
R-squared	0.005	0.001	0.018
	HR1xcf	HR2xcf	HR4xcf
holder67_restriction	0.002***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)
N	15697.000	15691.000	15691.000
R-squared	0.004	0.001	0.005
	N1xcf	N2xcf	N4xcf
netbuyer	-0.003**	-0.000	-0.002**
	(0.001)	(0.001)	(0.001)
N	16079.000	16074.000	16074.000
R-squared	0.005	0.001	0.006
	f1c	f2c	f3c
longholder_Thomson	0.008***	0.009***	0.008***
	(0.003)	(0.003)	(0.003)
N	8992.000	8992.000	8992.000
R-squared	0.005	0.006	0.008
year FE	yes		yes
sector FE		yes	yes

Table 11: Cartel detected - 5y

	L1xd	L2xd	L4xd
longholder	-0.130*	-0.214***	-0.066
N	325	325	325
R-squared	0.249	0.047	0.276
	HR1xd	HR2xd	HR4xd
holder67_restriction	-0.022	-0.030	-0.010
N	325	325	325
R-squared	0.248	0.046	0.276
	H1xd	H2xd	H4xd
holder67	-0.186	-0.183	-0.126
N	325	325	325
R-squared	0.253	0.050	0.278
	N1xd	N2xd	N4xd
netbuyer	0.038	-0.036	0.033
N	325	325	325
R-squared	0.251	0.048	0.278
	d1	d2	d3
longholder_Thomson	-0.018	-0.010	-0.020
	(0.030)	(0.027)	(0.028)
N	499.000	499.000	499.000
R-squared	0.056	0.026	0.090
year FE	yes		yes
sector FE		yes	yes

Table 12: Cartel detected, with controls - 5y

	L1xcd	L2xcd	L4xcd
longholder	0.037	-0.098	0.085
	(0.063)	(0.121)	(0.077)
N	154.000	154.000	154.000
R-squared	0.448	0.194	0.481
	HR1xcd	HR2xcd	HR4xcd
holder67_restriction	-0.042	-0.184	-0.040
	(0.118)	(0.138)	(0.122)
N	154.000	154.000	154.000
R-squared	0.448	0.202	0.481
	H1xcd	H2xcd	H4xcd
holder67	-0.852***	-0.887***	-0.860***
	(0.213)	(0.104)	(0.265)
N	154.000	154.000	154.000
R-squared	0.471	0.225	0.504
	N1xcd	N2xcd	N4xcd
netbuyer	0.101*	-0.064	0.085
	(0.058)	(0.055)	(0.063)
N	154.000	154.000	154.000
R-squared	0.460	0.199	0.488
	d1c	d2c	d3c
longholder_Thomson	-0.018	-0.010	-0.020
	(0.030)	(0.027)	(0.028)
N	499.000	499.000	499.000
R-squared	0.056	0.026	0.090
year FE	yes		yes
sector FE		yes	yes

Table 13: Instrumental variable test

	(1)	(2)	(3)	(4)	(5)	(6)
	Cartel		Cartel start		Cartel end	
	OLS	IV	OLS	IV	OLS	IV
Longholder_Thomson	0.046***	0.033	0.008***	0.001	-0.024	-0.025
	(0.012)	(0.038)	(0.003)	(0.006)	(0.030)	(0.110)
Observations	9,460	9,460	8,992	8,992	499	499
Firm controls	Yes	Yes	Yes	Yes	Yes	Yes
CEO controls	Yes	Yes	Yes	Yes	Yes	Yes
FE Industry	Yes	Yes	Yes	Yes	Yes	Yes
FE Year	Yes	Yes	Yes	Yes	Yes	Yes

Note. This table shows the estimation results of the complementary log-log model of equation (2). The coefficients display the marginal effects at the mean of all other explanatory variables. The outcomes of each regression are three different indicators. 'Cartel' takes the value one if the firm is part of a collusive agreement at time t and zero in any period before and after the collusion period. 'Cartel start' takes the value one only in the first period of a collusive agreement, zero for all periods a firm was not part of a cartel and missing otherwise. 'Cartel end' indicates the very last period of a collusive agreement, zero for all cartel periods before within the collusion time and missing otherwise. The firm controls include the lagged variables for cash scaled by assets, sales scaled by assets, capital intensity scaled by assets, return on assets, cash flow scaled by assets, dividend payments scaled by assets as well as leverage. CEO controls include the logarithm of age and tenure. Moreover, each regression includes a set of industry and year-fixed effects. Standard errors clustered at the firm level are in parentheses. Significance: * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

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