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Cartels Facing Competition in Public Procurement: An Empirical Analysis

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Abstract

We analyse bidder collusion in public procurement. Our focus is on less than all-inclusive cartels. Using public information on convicted bid-rigging schemes taken from the decisions of the French Competition Authority, we have constructed an original database on 33 different cartels operating in 114 public work tenders. Our empirical work tackles the question of external cartel stability. Our goal is to investigate the impact of outside bidders on cartels by testing a proposition derived from the auction theory literature. We show that the number of outside firms is a significant determinant of the low cartel bid and does not significantly impact the cartels' probabilities of being awarded contracts. We believe that these results provide further evidence of the existence of cost asymmetries between cartels and outside firms. We conclude by arguing that policies which aim at stimulating the entry of small businesses in the market may have a positive effect on social welfare especially when a collusive scheme is suspected.

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1 Introduction

Public procurement accounts for a substantial share of the public sector's provision of goods and services, representing up to 10% of French GDP and close to 16% of European countries' GDP. Tendering procedures are used to compensate for the lack of competition in the field by introducing competition for the field, guaranteeing lower prices along with the same (or a higher) level of quality. Yet, bidder collusion is a pervasive problem in public procurement (Pesendorfer (2000)). Collusion distorts prices and/or quality by lowering the level of competition for the market through tacit or explicit agreements between firms. Over the period ranging from 1991 to 2010, the French Competition Authority issued more than 220 decisions for collusion cases in public procurement leading to the fining of more than 750 different firms. [1]

One particular case of bid-rigging inspired the idea behind this paper (Autorité de la Concurrence (2001)). In 1989, the French city of Le Havre invited tenders using a first-price sealed-bid auction for electrical work in a city school. The contract was estimated at 9 275€ by the administration's engineer. On the 12th September 1989, the tender commission unsealed the nine bids received for this particular tender and discovered a post-it note on the bid submitted by the firm *SFEE*. On this note figured the exact price submitted by *SFEE* along with the name of another firm, *Simon & Lacherey*, participating in the same tender. Suspecting a bid-rigging scheme, the tender commission alerted the French Competition Authority. After an extensive investigation, the French Competition Authority prosecuted *SFEE* and *Simon & Lacherey* on the grounds of bid rigging on three different markets. For this particular contract, *Simon & Lacherey* submitted a serious bid, 9 546€, *SFEE* submitted a high complementary bid of 21 200€ while six other bidders submitted bids ranging from 9 970€ to 12 964€. [2] However, the ninth firm, *Normandie Electricité*, outbid the cartel with an offer of 8 629€ and was awarded the contract.

While it is easy for cartels to identify competitors in classical markets, the same cannot be said for public procurement as potential competitors may choose to compete or not in each tender. Determining the exact number of outside bidders (or outsiders, hereinafter) that cartels face on a particular tendering procedure may therefore be complicated to anticipate. A mis-anticipation of the level of competition may enable the

1. See www.autoritedelaconcurrence.fr for all the decisions issued by the French Competition Authority starting from 1991.

2. It is interesting to note that the serious bid submitted by *Simon & Lacherey* is only slightly above the engineer's estimate while the complementary bid submitted by *SFEE* is approximately 2,3 times this estimate and over 60% above the second highest competitive bid.

possibility, for a cartel outsider, of winning the contract. This issue is linked to what economists have called the external stability of cartels (Güth (1986)). While the internal stability of a cartel raises the question of members breaching the cartel's agreement, the external stability of a cartel concerns the possibility for a cartel to be outbid by non-members.[3] Throughout this paper, we focus on the latter.

Understanding how cartels deal with outside bidders is a challenging question with potentially crucial implications for public policy as outside competition may limit cartel profits. These questions have been partially overlooked in the existing economic literature. Two complementary arguments justify this lack of attention. First, it is widely believed that cartel members enjoy cost asymmetries over outside firms. These asymmetries may be due to the fact that only efficient firms are invited to join the cartel, but they can also be due to the selection of the low cartel bidder. Marshall et al. (1994) summarise the latter argument : "If all bidders are *ex ante* homogenous then collusion among subsets of bidders is very likely to generate asymmetries between participants at an auction". Second, a widespread assumption in theoretical models is that cartels have information on the number of outsiders and on their cost distribution. Thus, if the low cartel bidder enjoys cost asymmetry over other participants, then he might be able to adapt his offer to the number and costs of outside firms, therefore lowering the probability of being outbid by a cartel outsider.

We provide the very first empirical study focusing exclusively on these questions. We first concentrate on the assumption that cartels adapt their offers to the number of outside firms. Given the strict anonymity rules of French public procurement, that is bids are sealed, the identity of bidders is kept secret and valuations are private, we argue that this assumption concerning information available to the cartel may be too strong. We thus first aim at testing whether cartels adapt their low-bid to the number of outside firms. We then study the impact of the number of outside firms on the cartel's probability of being awarded contracts. Our goal there is to determine whether increased competition by outside firms may prevent cartels from winning procurement contracts.

To compute our tests, we have constructed an original database using public information available in the decisions of the French Competition Authority from 1991 to 2010. To the extent of our knowledge, such a database has not yet been constructed nor exploited in the economic literature.[4] We have gathered data on 114 construction procurement contracts where 33 different cartels have been prosecuted. Available

3. A more thorough distinction between both cartel stabilities is available in Fehl and Guth (1987).

4. A recent paper by Arai et al. (2011) mobilizes a database constructed using information taken from the decisions of the Japan Fair Trade Commission. However, the data they have gathered is on cartel organisation. A more thorough presentation of their work is available in our literature review.

information includes, in particular, the type of tendering procedure used, the number and amounts of the lowest bids submitted by colluders and competitive bidders, the engineer's estimate of the value of the contract as well as the identity of the winning bidder. [5]

We first show that despite the strict anonymity rules of French public procurement, cartels are able to adapt their offers to the number of outside firms. This may be due to information pooling among cartel members: if one firm may not have enough information to precisely estimate the number of firms that will bid for a particular contract, a small number of firms may estimate this number more precisely (see e.g. Clarke (1983) on information sharing among cartel firms). An alternative explanation can be drawn from the growing body of work that links collusion to corruption (Lambert-Mogiliansky (2011)). Cartel members may corrupt the auctioneer in order to access information on the bidders or to lower their bids if an outside firm has outbid them. [6] We then show that this adaptation of the low-bid to the number of outsiders enables cartels to limit their losses due to outside firms. In our discussion, we point out the potentially positive effects of public policies such as allotment procedures aiming at stimulating competition in public procurement by notably raising the number of small businesses participating in the tenders. Indeed, we argue that increasing the number of small firms bidding at an auction may lower the bids even in the presence of a cartel.

The paper is organised as follows. In the next section, we discuss the relevant literature on auctions and collusion and specify how our work departs from it. In section 3, we offer a presentation of the database we have constructed and perform a simple statistical test aiming at providing additional support to the quality of our dataset. We adapt the framework developed by Maskin and Riley (2000) to derive a testable proposition and discuss our empirical methodology in section 4. In section 5, we take our tests to the data and present our results. Section 6 discusses the results while our last section concludes with practical implications of public policies.

2 Partial Collusion and Data on Collusion

Theoretical results on partial collusion (i.e. when the cartel is not all-inclusive) in auction procedures plead for the use of first-price auctions, the most used procurement procedure at the French and European levels (Chong et al. (2009)). Most notably, Fehl and Guth

5. An extensive presentation of the data available will be made in Section 3.

6. For instance, Ingraham (2005) provides an example of a corruption scandal in the New York City construction of public schools where the auctioneer manipulated the amounts of the offers of the bribing firms to allow them to win the contracts.

(1987) study the external stability of cartels in different auction types. They show that this stability is at its lowest in non-incentive compatible pricing rules such as the first-price auction. Moreover, Brisset (2002) shows that when a partial collusive scheme is active, the public buyer's revenue will be higher in first-price auctions than second-price auctions.

The existence and the implications of cost asymmetries between cartel members and outside firms have also been studied in the economic literature. Using data from two cartels of milk supply to public schools in the 1980's, Pesendorfer (2000) studies the difference in the distribution of bids from cartel members and outsiders. He shows that the *ex ante* cost distribution of cartel bids is stochastically inferior to that of outside firms. This result is compatible with the hypothesis of cost asymmetries between collusive and non-collusive firms. Some theoretical contributions have shown that accounting for cost asymmetries, it is impossible to derive the general form of the cartel's optimal bid (Maskin and Riley (2000)). To circumvent this caveat, Marshall et al. (1994) use numerical methods to approximate these functions.

Most empirical studies on collusion (with the exception of meta-analyses such as Connor and Bolotova (2006)) use data from a single public buyer to study a particular cartel (Porter and Zona (1993, 1999), Bajari and Ye (2003), Lee and Hahn (2002) and Ishii (2009)). To the best of our knowledge, only one other paper on collusion uses a dataset comparable to ours. Yet, contrarily to our work, Arai et al. (2011) study the organisation of collusive agreements using decisions from the Japan Fair Trade Commission. The authors analyse collusive schemes using seven organisational indicators and show that in practice, the schemes studied are relatively simple and generally use no more than two of the seven indicators. Moreover, in 20% of the cases, the organisations of the collusive agreements only cared about equity in the division of the spoils. Yet, the authors argue that their results might be biased as simple schemes may be easier to detect.

Our study departs from previous work for several reasons. First, the dataset we have constructed is original and, to the extent of our knowledge, unique in the literature. Indeed, we use information on public procurement procedures where a collusive scheme has been fined by a Competition Authority. Our dataset contains information on 33 different collusive schemes, enabling us to capture the problems outside firms cause to cartels in a wide diversity of environments. Furthermore, we propose an empirical test enabling us to assess the validity of commonly used hypotheses in the theoretical literature. Finally, we conclude our study with practical recommendations for public policies.

3 Collusive Agreements in the French Construction Industry

3.1 Data

The relative absence of work focusing on collusion in public procurement is due to the lack of reliable data on such secretive practices. Yet the internet website of the French Competition Authority now gathers every decision issued since 1991. Moreover the descriptions of the procurement processes in which a collusive scheme was active are more and more detailed. Thus it allows us to get access to a reliable source of data on collusion. Over the period ranging from 1991 to 2010, we have focused on the 221 decisions concerning collusion in the attribution of public contracts. Each of these decisions focused on one cartel operating in at least one market. For the sake of homogeneity, we have restricted ourselves to the construction industry that accounted for 135 of the 221 decisions. Moreover, we only retained the 88 decisions where the Competition Authority proved there was collusion.

The data gathered benefits from a certain diversity compared to previous empirical work. Indeed we have gathered information on 33 different cartels with heterogeneous numbers of members, outsiders and cost distributions. These cartels operated in a wide variety of markets, from simple painting jobs to more elaborate civil engineering. We believe that this diversity enables us to better apprehend the problems caused by outside firms to cartels. Yet we still retain a certain degree of homogeneity, as recommended by the literature.[7] We could have constructed a dataset from more than one country or from different sectors. Yet, by restricting ourselves to French cases in public work procurement, we maintain a relatively homogeneous institutional framework.

3.2 A decision from the Competition Authority

We now provide a description of the structure of a standard French Competition Authority decision. Although the quality and the quantity of information may vary, there is nevertheless a similar pattern in organisation. Notably, the first page sums up basic information including the title and the reference number of the decision, the instigator of the case and a list of people who were interviewed during the investigation. In a first part, facts about every market in which the cartel is suspected to have been active are given. Unfortunately, the amount of information about each market is random and

7. Indeed, as we have already noted, a large part of previous empirical work have relied on case studies following recommendations from Hendricks and Porter (1989).

somewhat unpredictable.[8] This description is then followed by an impartial exposition of the potential evidence of bid-rigging, either observed or found during the dawn raids.

The second part discusses the investigation and the evidence found. Since firms tend to contest the legal formality of the procedures used to retrieve evidence, a first section addresses these claims. A second section provides a detailed discussion of the evidence exposed for every market in which the cartel has been suspected of operating along with the declarations of the main actors (most notably CEOs and employees of suspected and outside firms as well as the public purchaser). On the basis of the evidence and the declarations, prosecution for bid-rigging on each particular market is discussed. A third part calculates the financial sanctions to each firm. The maximum fine is now 10% of a firm's turnover.[9] However, a variety of other factors are taken into account, most notably the gravity of the collusive practices, the estimation of the damages to the economy as well as legal precedents and the role of each colluding firm in the scheme.[10] A final part sums up the names of prosecuted firms as well as their individual financial sanctions.

3.3 Data gathered

Using information provided in the selected decisions of the French Competition Authority, we have gathered 249 observations, each of which accounts for a construction public tender where a single collusive scheme was sanctioned. Since our focus is on incomplete cartels in first-price sealed bid auctions, 44 observations of all-inclusive cartels and 11 observations of negotiated procedures were dropped, leaving us with a total of 194 public tenders. However, due to lack of information, 80 more observations were dropped leaving us with our final sample of 114 distinct public tenders.

Table 1, shown in the appendix, summarises all the available variables and provides basic descriptive statistics. We have notably gathered data on the public buyer which we have divided, in accordance with Chong et al. (2009), between central buyers (i..e. the State, public administrations and public firms) and local buyers (i.e. regions,

8. The amount of information varies from the name and date of the tendering procedure to a detailed analysis including, in particular, the engineer's estimation as well as the identity of every bidder and the amount submitted.

9. In 2001, during the period we study, the maximum fine was raised from 5% of a firm's turnover in France to 10% of its overall turnover.

10. For more information on the way the financial sanctions are calculated, we refer the reader to the notice "*on the Method Relating to the Setting of Financial Penalties*" issued by the French Competition Authority, available online at http://www.autoritedelaconcurrence.fr/doc/notice_antitrust_penalties_16may2011_en.pdf

counties and municipalities) with the variable *Local*. We also have information on the engineers' estimations (*Estimate*), the number of colluders (*Nb_Colluders*) and outsiders (*Nb_Outsiders*) as well as the lowest bids of each of these two groups (resp. *Cartel_Bid* and *Outside_Bid*). We also have identified the firm who submitted the winning bid and whether this firm was part of the cartel (*Cartel_Win*). Approximatively 38% of the contracts in our dataset were awarded by local buyers. Overall cartels were awarded slightly more than 80% of these contracts. In the tenders, there was a mean of 4.3 cartel members bidding for the contracts and 3.6 outside bidders. Interestingly, there was a lower average number of outside firms when the cartel was not awarded the contract than when the cartel was (respectively, an average of 3.27 and 3.73 outside firms, yet this difference is not statistically significant). Due to missing observations, we could only collect 99 of the 114 observations of the lowest outside offers. Over this sample, the lowest outside bid was on average 3% above the lowest cartel bid.

In order to be more confident of the quality of our data, we use Benford's Law to show that cartel bids were more likely to have been manipulated than outside bids. This law provides the reference frequency distribution of single digits numbers according to their position in a figure. Benford's Law is based on the observation that the number 1 occurs more often than the number 2 as a first digit of real-life data if the data was not manipulated. The same observation can be made for, respectively, the number 2 and the number 3, and so forth. This law has been previously used to detect frauds and manipulations of real-life data such as the manipulation of the Libor rate by banks (Abrantes-Metz et al. (2011, 2012)) or bid-rigging schemes in public procurement (see Vellez (2011)). Results are shown in Table 2 and in Figure 1 and Figure 2, for the two first significant digits of, respectively, cartel bids and outside bids. On these figures, the red line symbolises the reference frequency distribution while the bars show the distribution of our data. Both the observation and the goodness of fit tests tell us that manipulations of the bids are likely to have occurred in the case of cartel bids but not in the case of outside bids, thus comforting us in the quality of our data. [11]

11. Our graphics and the tests shown in Table 2 and in Figure 1 and Figure 2 are performed on two different samples of observations (99 observations of the lowest bids from outside firms and 114 observations of the lowest bids from cartels). However we obtain the same results when performing both analyses on the 99 observation sample.

4 Framework and Empirical Methodology

4.1 Framework and Proposition

The following framework focuses on first-price sealed-bid auctions. Consistent with previous work, we use the independent private values paradigm to model construction procurement (Pesendorfer (2000), Bajari and Ye (2003)). Furthermore we focus on asymmetric auctions to analyse collusive behaviour among bidders. It has been argued that, when facing outside competition, cartel members should enjoy *ex ante* asymmetries because, in order to make extra profits, cartel members need to shade their bids up by more than outsiders do. [12] Therefore cartels may only invite efficient firms to join. Moreover cartels are likely to select their most efficient firm to submit their low bid. [13] This selection is likely to create further asymmetries as the chosen cartel firm will enjoy, on average, lower costs than most competitive bidders.

Consider n bidders competing for a public procurement contract. Each bidder's valuation v_i is private information while for other participants it is a random variable $\tilde{v_i}$ with cumulative distribution function (c.d.f.) $F(.)$. A coalition is formed between k of the n bidders ($2 \leq k < n$). The low-cost individual from the coalition is chosen to be the only participant in the auction while the other $n-k$ bidders act non-cooperatively. We are therefore left with a total of $n-k+1$ bidders. As previously argued, the choice of a single participant among a subset of bidders will create asymmetries between participants. We describe the single coalition bidder as "strong" (s) with c.d.f. $F_s(.)$ and postulate that $F(.)$ first-order stochastically dominates $F_s(.)$. We assume the coalition is unobservable to outsiders. The $n-k+1$ remaining bidders then simultaneously submit a bid b_i for the contract.

To sum up, the cartel has three pieces of information available: the precise valuation of its low-cost bidder (v_s), the number of outsiders ($n-k$) and F(.), their valuation distribution. Cartels are supposed rational and will therefore use all the information available to them to maximize their profits. This leaves us with an equilibrium cartel bid b_s of the form:

$$b_s = f[v_s, n-k, F(.)] \tag{1}$$

12. Cartel bids should at least reflect the costs of organising the scheme and the probability of being detected and sanctioned. Moreover, in order for the collusive scheme to be profitable for its members, a low cartel bid should include a larger primer than that of outsiders.

13. Since this is not the goal of this paper, we do not discuss the way the low-cost coalition member is chosen. See Marshall and Marx (2007) for thorough discussions of this topic in similar settings.

The preceding framework tells us that in order to bid optimally, cartels need to correctly evaluate their own valuation of the contract as well as the number of outside bidders and their valuation distribution. This paper does not seek to prove whether cartels use incentive-compatible mechanisms to choose their low-cost bidder. Moreover, we are unable to estimate the cost distribution of outside firms using the limited data at hand. Instead, we are interested in knowing if cartels at least anticipate the number of outsiders and if this anticipation is done in such ways that it maximises cartel profits. Thus we aim at testing the following proposition.

General Proposition: *When facing competition, cartels should adapt their low bids to the number of outside firms so as to maximise their expected profits.*

4.2 Empirical Methodology

In order to test our general proposition, we perform two different sets of regressions. First, our goal is to assess whether the number of outside firms influences the level of the low cartel bid. In order to do so, we estimate the following equation :

$$Cartel\_Bid_i = Nb\_Outsiders_i\alpha_i + X_i\beta + \mu_i \tag{2}$$

Where $Cartel\_Bid_i$ is our dependent variable. $Nb\_Outsiders_i$ is the variable we are primarily interested in and α_i its associated coefficient. X_i is our set of covariates (including the number of colluding firms (*Nb_Colluders*), the public engineer's estimation of the amount of the contract (*Estimate*) and whether the contract was awarded by a local public buyer (*Local*)) and β its vector of coefficients. μ_i is the error term.

To be consistent with our general proposition, cartels should anticipate $Nb\_Outsiders_i$, the number of outsiders, which should have a negative impact on $Cartel\_Bid_i$, i.e. the higher the number of outsiders, the lower the serious cartel bid.

Proposition 1: *The number of outside firms should have a significant and negative impact on the amount of the low cartel bid.*

We are unable to directly show whether the resulting adaptation of the low cartel will lead cartels to maximise their profits. However, we can proxy the maximisation of profits by analysing the contract losses of cartels. Indeed, to a large extent, cartel profits are determined by whether collusive firms were awarded contracts or not. Thus, in our second test, our goal is to test whether the resulting adaptation of the low cartel bid (if any) enables cartels to limit their contract losses due to outside firms. We estimate the following equation:

$$P(Cartel\_Win_i = 1 | Nb\_Outsiders_i, X_i) = \Phi(Nb\_Outsiders_i \alpha_i + X_i \beta) \qquad (3)$$

Where $Cartel\_Win_i$ is our dependent variable. Φ is the standard normal c.d.f.. $Nb\_Outsiders_i$ is our variable of interest and α_i its associated coefficient. X_i is our set of control variables including *Nb_Colluders*, *Estimate* and *Local* and β its associated vector of coefficients.

To be consistent with our general proposition and supposing cost asymmetries, if cartels correctly anticipate and adapt their bids to the number of outside firms, then the number of outside firms should not have a significant impact on $Cartel\_Win_i$, i.e. cartel losses should be independent of the number of outside firms bidding for the contract.

Proposition 2: *If Proposition 1 holds and assuming cost asymmetries, the number of outside firms should not impact the cartels' ability of winning contracts.*

When estimating the two previous equations, we are likely to face an omitted variable bias. Indeed, the number of outsiders bidding for the contract may be correlated with unobserved characteristics of the contracts, of the environment or of the cartel operating which may all have an impact on our dependent variables. For instance, since outside firms are likely to be less efficient firms, a lower number of outside firms may participate in the call for tenders if the contract is complex.[14] Yet, the complexity of the work to be done is, in itself, likely to affect both the cartel's bid and its probability of winning the contract. Also, a lower number of outside firms may enter the market if, for example, an efficient cartel is known to be active. As for the complexity of the contract, the efficiency of the cartel will also directly affect both its bid and its probability of being awarded the contract. Thus, we suspect that, in both sets of regressions, our variable *Nb_Outsiders* might be endogenous.

We choose to deal with the endogeneity issue using two methods. First, we attempt to correct the omitted variable bias by estimating our regressions using fixed effects by cartel. Indeed, not only will these fixed effects capture the unobserved characteristics of the cartels but it may also capture some of the unobserved characteristics of the contracts and of the environment. Indeed, a given cartel is likely to compete for

14. Though we control for the engineer's estimation of the contract which is one of the proxy commonly used for the complexity of the works, we lack other proxies to better capture the complexity of the contract such as the estimated duration of the contract or the amounts subcontracted (Bajari et al. (2009); Chong et al. (2009)).

similar contracts, in a given sector and in a given period of time. Since all of these characteristics are likely to be captured, we thus believe that the addition of cartel fixed effects will, at least, attenuate the omitted variable bias we are facing. Second, we have constructed an instrument, *Instr_Out*, to deal with the endogeneity issue. A valid instrument should be both relevant (correlated with the variable to be instrumented) and exogenous (uncorrelated with unobserved factors affecting the dependent variable). Prior to the construction of the instrument, we divided our contracts into three sectors of activity that suited our data well (road construction, architecture work and civil engineering) and distinguished between five geographical zones in which the contracts were tendered. [15] For each observation, *Instr_Out* is designed to capture the log of the mean number of outside firms that cartels face in the same sector as the one from the current observation yet in different geographical zones. *Instr_Out* is thus correlated to *Nb_Outsiders* as it captures a proxy of the degree of competition that other cartels face in the same sector. In this sense, *Instr_Out* should have a significant and positive impact on *Nb_Outsiders*. Our instrument is also designed to exclude observations that may have an impact on unobserved factors of the current call for tenders by not making use of information from the same region. Thus, we are confident in the fact that *Instr_Out* is both relevant and exogenous. In the following section, we take our tests to the data.

5 Results

5.1 How Cartels Bid?

Results from the regressions of *Cartel_Bid* on *Nb_Outsiders*, our variable of interest, and other covariates are reported in Table 3. For every set of regressions, we show two alternative specifications with the second also accounting for the number of firms from the cartel submitting an offer for the contract. This variable is not included in the first specification as we fear that, similar to *Nb_Outsiders*, *Nb_Colluders* may be endogenous. Results from our OLS regressions are shown in Models 1 and 2, while in Models 3 and 4 we add fixed effects by cartel. First stage regressions in Models 5 and 7 are, respectively, associated with our 2SLS regressions shown in Models 6 and 8. In the

15. Sectors are an adapted version of the four sectors distinguished in Lee and Hahn (2002). The number of sectors was reduced to three as none of our observations were for railroad works. We used the geographical zones created by the ARCEP, the French regulator of telecommunications, that divides the French territory into five distinct geographical zones. For more information, see http://www.arcep.fr/index.php?id=8146#c7916.

former models, our instrument is significant and has the expected sign. Moreover, our F-Statistic is above the rule of thumb of 10 (Staiger and Stock (1997)) telling us that we need not worry about a weak instrument issue. In our OLS regressions, *Nb_Outsiders*, our variable of interest has the expected sign yet it is not significant. However, we find that once the cartel fixed effects are taken into account, the coefficient associated with *Nb_Outsiders* becomes statistically significant. This finding is reinforced by our results from our 2SLS regressions where our variable of interest also shows a negative and statistically significant coefficient. Thus, we do find that, once we have satisfyingly corrected the endogeneity issue associated with our variable *Nb_Outsiders*, cartels adjust their bids to the number of outside firms: as the number of outsiders increases, cartels bid more and more aggressively. This finding is in line with Proposition 1.

5.2 Cartel Wins

Results from the regressions of *Cartel_Wins* on *Nb_Outsiders*, our variable of interest, and other covariates are reported in Table 4. Again, we show the same two specifications for every set of regressions. We report Probit regressions in Models 9 and 10. In Models 11 and 12, we use an Limited Probability Model (LPM) estimator with fixed effects by cartel. [16] Our first stage regressions in Models 13 and 15 are, respectively, associated with our 2SLS regressions reported in Models 14 and 16. [17] Since Models 13 and 15 are exactly similar to Models 5 and 7 of Table 3, our instruments are still significant and have the expected sign and we can rule out a weak instrument issue. In every specification reported in Table 4, *Nb_Outsiders* is associated with a coefficient that is not statistically different from zero. This finding is in line with Proposition 2.

5.3 Alternative Specifications

In our regressions, we have used the actual number of outside bidders as our variable of interest. However we have little evidence to back up our claim that the cartel bids (or the cartel wins) should linearly depend on the number of bidders. If, to our knowledge, most papers do use the actual number of bidders in their estimations of bids in public procurement, other papers have used other (non-linear) forms, such as the log of the

16. Unfortunately, we are unable to run probabilistic regressions as there is no consistent estimator for unconditional fixed effects probit models.

17. Estimating the same specifications using an ivprobit regression yields qualitatively and quantitatively the same results, yet the user-written Stata command Stata "ivreg2" (Baum et al. (2007)) gives us additional qualitative information on our first stage regressions.

number of bidders (see e.g. De Silva et al. (2003) or Price (2008)).[18] In our case, it may be tempting to believe that a change from 1 to 2 outside bidders might force cartels to a greater adjustment of their bids than an change from 7 to 8 outsiders. A similar argument may be made for the probability of cartels being attributed the contract. Thus, we have re-estimated equations shown in Table 3 and Table 4 using the exact same specifications, yet replacing the number of outside bidders by its logarithmic value.[19] Results from these specifications are shown in Tables 5 and 6. Regressions shown in these tables comfort us in our analysis as they do not change our main findings.

When estimating our second set of regressions, we intend to proxy whether the resulting adaptation of cartels' bids to the number of outside bidders enabled them to maximise their profits. In these tests, we use a dummy variable assessing whether the cartel was attributed the contract or not as our dependent variable. Yet, to better proxy profit maximisation, we should also account for the value of the contracts won or lost. To do so, we ran additional specifications of the estimations shown in Table 4 by weighting the estimations on the contracts' estimated values.[20] These results are shown in Table 7. Again, these results do not change our main finding: the coefficient associated with the variable *Nb_Outsiders* is still not statistically different from zero.

6 Discussion and Limitation

We have shown that, in accordance with classical theoretical assumptions, cartels are able to adapt their low-bids to the number of outside firms. By doing this, they lower their contract losses due to outside firms. Apart from its direct implications, this result seems to root in favour of cost asymmetries between cartel and outside firms. These cost asymmetries may be even larger than expected if we take into account the fact that cartels suffer additional costs compared to outside firms (e.g., costs of organizing the cartel, costs to cover the probability of being detected and punished, etc.). However, as Pesendorfer (2000), we are unable to determine whether these cost asymmetries are *ex ante* cost asymmetries or due to the selection of the low bidder by the cartel.

A more direct implication of this result is that policies that aim at increasing com-

18. In a few studies, other functional forms of the number of bidders have been used. In particular, some studies add the square term of the number of bidders along with the actual number of bidders (see e.g. Lundberg (2005)). However we are unable to do so in this study as such estimations would require at least one additional instrument. This impossibility may be viewed as a current limitation of our study.

19. To be consistent, the number of colluders was also replaced by its logarithmic value.

20. To allow for weightings, Probit specifications were re-estimated using LPM.

petition to fight collusion may lower the bids from the cartels and therefore increase social welfare. Since cartels have the ability to anticipate and adapt to outside bids, increasing the number of bidders will result in lower cartel bids. We believe that policies such as allotment or decreasing pre-qualification requirements that are likely to increase the participation of small firms may yield particularly positive results when a collusive scheme is suspected. Indeed, as small firms are less efficient, they may not be invited to join the cartel. Thus, these firms are likely to act as outside firms that will force the cartel to lowers its bid.

However a puzzling question remains. Given the strict anonymity rules of French public procurement, how are cartel members able to anticipate outsiders' information? A first answer may come from information sharing among cartel members (see e.g. Clarke (1983)). If a single firm may not have enough information to anticipate its competitors' costs, an aggregation of information from every cartel member may enable them to foresee both the number of outside firms and their average valuation of the contract. An alternative answer may be found in the growing literature linking collusion to corruption. Lambert-Mogiliansky and Kosenok (2009) show that, in order to decrease the uncertainty inherent in public procurement contracts, cartels may capture public authority representatives. Although they primarily define uncertainty as asymmetric information among cartel members and stochastic government demand, we believe that the possibility for a cartel to be outbid by an outsider may equally qualify as environmental uncertainty. Therefore cartels could capture public authority representatives to either provide them with information regarding other competitors or adjust their bids during the unsealing stage as it was the case in the New York City corruption scandal analysed in Ingraham (2005).

Our results currently have one important limitation. Indeed, we know our data is truncated since we only observe cartels that have been detected by a Competition Authority. In particular, we are concerned with the way the Competition Authority screens for potential collusion in public procurement since it may induce biases in our database. That is, if one specific aspect of bid-rigging or market characteristic is closely examined in order to detect collusion, in particular if econometric tests are performed to screen for collusion, we may end up with an overrepresentation of this aspect or characteristic in our database. If this were the case, we would likely be able to use information about the tests to correct our data. However, our talks with some representatives of the Competition Authority have led us to believe that econometric methods are not used. In fact, cases dealt with by the French Competition Authority are either filed by an ex-cartel member through the leniency programme or by a public entity or a cartel outsider as a

complaint. Although this may induce fewer biases than if econometric tests were used, we still fear that our data may be biased. Since many reasons can motivate an ex-cartel member or a cartel outsider to report uncompetitive behaviour, we are unable to correct this potential bias. Therefore, the reader should bear in mind that this is a possible limitation of our results.

7 Concluding Remarks

We analyse less than all-inclusive cartels in construction-work procurement tenders. Our goal is to understand the impact of the number of outsiders on cartel behaviour. Using a database on 33 different cartels constructed using publicly available information in the decisions of the French Competition Authority, we first show that the number of outsiders is a significant determinant of the cartel's low bid. Moreover, we show that the number of outside firms does not significantly impact the probability of cartels being awarded contracts.

Therefore, we conclude that the number of outsiders does not impact the ability of cartels to win procurement contracts because the latter anticipate the number of outsiders, thus allowing cartels to bid accordingly. If cartels are able to adjust their bids in such ways, we believe this provides further evidence of the existence of cost asymmetries between cartel members and outsiders. Unfortunately, it is impossible to distinguish between asymmetries that arise from the selection of the low-cost bidder by the cartel and those that are due to *ex ante* cost asymmetries between cartel members and outside firms. Nevertheless, we believe this result yields additional attestation of the efficiency of cartels. If our results are correct, we believe that policies that aim at fighting collusion by encouraging the entry of small businesses in the market may be efficient in lowering cartel bids. Therefore, public policies such as allotment or decreasing pre-qualification requirements should be encouraged, especially when a collusive scheme is suspected.

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References

Abrantes-Metz, R. M., Kraten, M., Metz, A. D., and Seow, G. S. (2012). Libor manipulation? *Journal of Banking & Finance*, 36(1):136–150.

Abrantes-Metz, R. M., Villas-Boas, S. B., and Judge, G. (2011). Tracking the libor rate. *Applied Economics Letters*, 18(10):893–899.

Arai, K., Ishibashi, I., and Ishii-Ishibashi, R. (2011). Research and analysis on bid rigging mechanisms. *Japan and the World Economy*, 23(1):1–5.

Autorité de la Concurrence (2001). Décision 01-d-17.

Bajari, P., McMillan, R., and Tadelis, S. (2009). Auctions versus negotiations in procurement: An empirical analysis. *Journal of Law, Economics, and Organization*, 25(2):372.

Bajari, P. and Ye, L. (2003). Deciding between competition and collusion. *Review of Economics and Statistics*, 85(4):971–989.

Baum, C. F., Schaffer, M. E., Stillman, S., et al. (2007). ivreg2: Stata module for extended instrumental variables/2sls, gmm and ac/hac, liml and k-class regression.

Brisset, K. (2002). Entente partielle dans un appel d'offres au premier prix. *Revue économique*, 53(1):29–41.

Chong, E., Staropoli, C., and Yvrande-Billon, A. (2009). Auction versus negotiation in public procurement: Looking for new empirical evidence. *Working paper*.

Clarke, R. N. (1983). Collusion and the incentives for information sharing. *The Bell Journal of Economics*, 14(2):383–394.

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

De Silva, D. G., Dunne, T., and Kosmopoulou, G. (2003). An empirical analysis of entrant and incumbent bidding in road construction auctions. *The Journal of Industrial Economics*, 51(3):295–316.

Fehl, U. and Guth, W. (1987). Internal and external stability of bidder cartels in auctions and public tenders: A comparison of pricing rules. *International Journal of Industrial Organization*, 5(3):303–313.

Güth, W. (1986). Auctions, public tenders, and fair division games: An axiomatic approach. *Mathematical Social Sciences*, 11(3):283–294.

Hendricks, K. and Porter, R. H. (1989). Collusion in auctions. *Annales d'Economie et de Statistique*, (15/16):217–230.

Ingraham, A. T. (2005). A test for collusion between a bidder and an auctioneer in sealed-bid auctions. *Contributions in Economic Analysis & Policy*, 4(1):1–34.

Ishii, R. (2009). Favor exchange in collusion: Empirical study of repeated procurement auctions in Japan. *International Journal of Industrial Organization*, 27(2):137–144.

Lambert-Mogiliansky, A. (2011). Corruption and collusion: Strategic complements in procurement. *The International Handbook on the Economics of Corruption, Volume Two*, pages 108–140.

Lambert-Mogiliansky, A. and Kosenok, G. (2009). Fine-tailored for the cartel-favoritism in procurement. *Review of Industrial Organization*, 35(1):95–121.

Lee, I. and Hahn, K. (2002). Bid-rigging in auctions for Korean public-works contracts and potential damage. *Review of Industrial Organization*, 21(1):73–88.

Lundberg, S. (2005). Bidder behaviour in Swedish simultaneous procurement auctions. *Working paper*.

Marshall, R. and Marx, L. (2007). Bidder collusion. *Journal of Economic Theory*, 133(1):374–402.

Marshall, R., Meurer, M., Richard, J., and Stromquist, W. (1994). Numerical analysis of asymmetric first-price auctions. *Games and Economic Behavior*, 7(2):193–220.

Maskin, E. and Riley, J. (2000). Asymmetric auctions. *Review of Economic Studies*, 67(3):413–438.

Pesendorfer, M. (2000). A study of collusion in first-price auctions. *Review of Economic Studies*, 67(3):381–411.

Porter, R. and Zona, J. D. (1993). Detection of bid rigging in procurement auctions. *Journal of Political Economy*, 101(3):518–538.

Porter, R. and Zona, J. D. (1999). Ohio school milk markets: An analysis of bidding. *RAND Journal of Economics*, 30(2):263–88.

Price, M. K. (2008). Using the spatial distribution of bidders to detect collusion in the marketplace: Evidence from timber auctions. *Journal of Regional Science*, 48(2):399–417.

Staiger, D. and Stock, J. (1997). Instrumental variables regression with weak instruments. *Econometrica*, 65(3):557–586.

Vellez, M. (2011). Auctions versus negotiations: Evidence from public procurement in the Italian healthcare sector. *Working paper*.

Annexes

Table 1: **Definition of Variables and Main Statistics**

Variable	Definition	Nb. Obs.	Min	Max	Mean	St Dev
Cartel_Win	Dummy variable that equals one when the cartel was awarded the contract	114	0	1	.8070	.3964
Estimate	Log of engineer's estimation	114	9.135	17.91	13.35	1.868
Cartel_Bid	Low cartel bid divided by the engineer's estimation	114	.5424	1.844	1.005	.1910
Outside_Bid	Low outside bid divided by the engineer's estimation	99	.6600	1.683	1.043	.1532
Nb_Colluders	Number of bidders from the cartel	114	2	12	4.316	2.247
Nb_Outsiders	Number of outside bidders	114	1	13	3.640	2.406
Local	Dummy equals to one if the public buyer is a local public buyer and 0 if not local	114	0	1	.3802	.4874
Instr_Out	Log of the mean number of outside firms that other cartels face in the same sector yet in different geographical zones	114	2.15	4.711	3.667	1.018

Table 2: **Goodness of fit tests for Benford's Law**

First Significant Digit of Lowest Bids

Test	**P-Value for Cartels**	**P-Value for Outsiders**
Pearson's $\chi 2$	0.0035	0.5914
Log Likelihood Ratio	0.0015	0.5693

Second Significant Digit of Lowest Bids

Test	**P-Value for Cartels**	**P-Value for Outsiders**
Pearson's $\chi 2$	0.2004	0.3681
Log Likelihood Ratio	0.1996	0.3822

Figure 1: **Low Cartel Bids and Benford's Law**

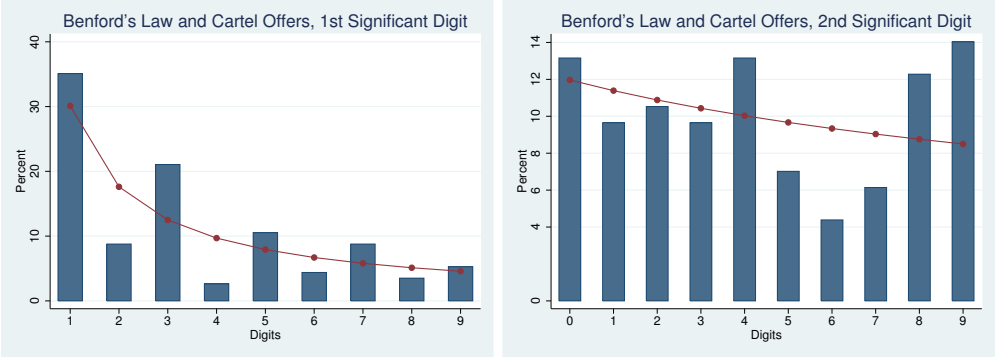

Figure 2: **Low Outside Bids and Benford's Law**

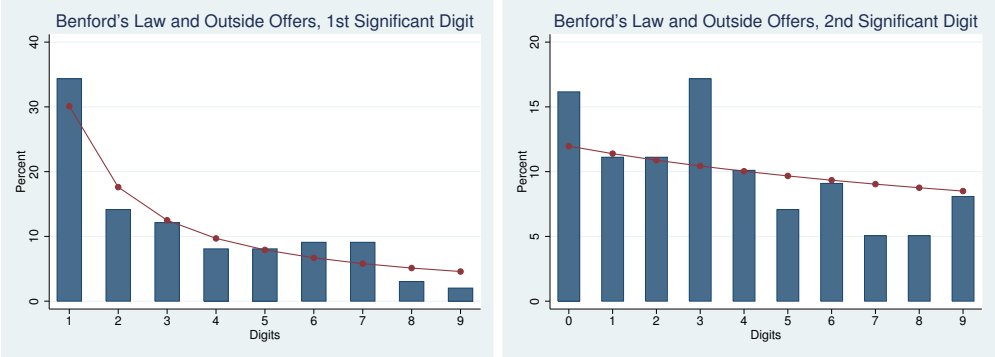

Table 3: **Regressions of the Cartel Bids**

	Model 1 OLS *Cartel_Bid*	Model 2 OLS *Cartel_Bid*	Model 3 OLS *Cartel_Bid*	Model 4 OLS *Cartel_Bid*	Model 5 1st Stage *Nb_Outsiders*	Model 6 2SLS *Cartel_Bid*	Model 7 1st Stage *Nb_Outsiders*	Model 8 2SLS *Cartel_Bid*
Estimate	-0.009	-0.009	-0.031	-0.033	-0.133	-0.023*	-0.136	-0.023*
	(0.007)	(0.007)	(0.023)	(0.024)	(0.100)	(0.013)	(0.102)	(0.013)
Local	0.060*	0.054+	0.011	-0.024	0.040	0.090*	0.060	0.086+
	(0.036)	(0.036)	(0.051)	(0.054)	(0.497)	(0.052)	(0.509)	(0.054)
Nb_Outsiders	-0.006	-0.006	-0.015*	-0.015*		-0.069**		-0.071**
	(0.007)	(0.007)	(0.009)	(0.009)		(0.034)		(0.035)
Nb_Colluders		-0.005		-0.013			0.031	-0.005
		(0.006)		(0.010)			(0.096)	(0.010)
Instr_Out					2.104***		2.135***	
					(0.539)		(0.567)	
Constant	1.132***	1.148***	-	-	2.662*	1.535***	2.525+	1.565***
	(0.098)	(0.107)	-	-	(1.484)	(0.265)	(1.553)	(0.284)
FE by Cartel	NO	NO	YES	YES	NO	NO	NO	NO
Nb. Obs.	114	114	101	101	114	114	114	114
R^2	0.029	0.032	0.053	0.077	0.090	-0.573	0.091	-0.612
F-Stat	-	-	-	-	10.98	-	10.36	-

Note: Standard errors in parentheses. + $p < 0.15$, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. In our FE specifications, singleton observations of cartels were dropped.

Table 4: **Regressions of Cartel Wins**

	Model 9 Probit *Cartel_Win*	Model 10 Probit *Cartel_Win*	Model 11 LPM *Cartel_Win*	Model 12 LPM *Cartel_Win*	Model 13 1st Stage *Nb_Outsiders*	Model 14 2SLS *Cartel_Win*	Model 15 1st Stage *Nb_Outsiders*	Model 16 2SLS *Cartel_Win*
Estimate	0.029	0.007	0.001	0.003	-0.133	0.017	-0.136	0.016
	(0.071)	(0.073)	(0.054)	(0.055)	(0.100)	(0.029)	(0.102)	(0.029)
Local	-0.133	0.087	-0.388+	-0.363	0.040	-0.056	0.060	-0.025
	(0.284)	(0.308)	(0.257)	(0.272)	(0.497)	(0.087)	(0.509)	(0.088)
Nb_Outsiders	0.058	0.060	0.018	0.018		0.055		0.070
	(0.051)	(0.052)	(0.015)	(0.015)		(0.070)		(0.069)
Nb_Colluders		0.175**		0.010			0.031	0.035***
		(0.069)		(0.014)			(0.096)	(0.014)
Instr_Out					2.104***		2.135***	
					(0.539)		(0.567)	
Constant	0.325	-0.163			2.662*	0.406	2.525+	0.197
	(0.987)	(1.074)			(1.484)	(0.591)	(1.553)	(0.599)
FE by Cartel	NO	NO	YES	YES	NO	NO	NO	NO
Nb. Obs.	114	114	101	101	114	114	114	114
R^2	0.032	0.033	0.043	0.063	0.138	-0.299	0.140	-0.303
F-Stat	-	-	-	-	10.98	-	10.36	-

Note: Standard errors in parentheses. + $p < 0.15$, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. In our FE specifications, singleton observations of cartels were dropped.

Table 5: **Regressions of the Cartel Bids (using the log number of outsiders)**

	Model 1 OLS *Cartel_Bid*	Model 2 OLS *Cartel_Bid*	Model 3 OLS *Cartel_Bid*	Model 4 OLS *Cartel_Bid*	Model 5 1st Stage *Nb_Outsiders*	Model 6 2SLS *Cartel_Bid*	Model 7 1st Stage *Nb_Outsiders*	Model 8 2SLS *Cartel_Bid*
Estimate	-0.010+	-0.010+	-0.031	-0.033	-0.048+	-0.023*	-0.049+	-0.023*
	(0.007)	(0.007)	(0.023)	(0.024)	(0.031)	(0.012)	(0.031)	(0.012)
Local	0.058+	0.055+	0.012	-0.023	-0.079	0.069+	-0.066	0.065+
	(0.036)	(0.036)	(0.056)	(0.067)	(0.127)	(0.043)	(0.135)	(0.044)
Log_Nb_Outsiders	-0.028	-0.028	-0.044	-0.040		-0.198**		-0.199**
	(0.026)	(0.027)	(0.033)	(0.033)		(0.093)		(0.093)
Log_Nb_Colluders		-0.012		-0.063			0.053	-0.012
		(0.026)		(0.047)			(0.128)	(0.038)
Instr_Out					0.747***		0.751***	
					(0.172)		(0.175)	
Constant	1.150***	1.164***			0.782*	1.501***	0.713	1.517***
	(0.101)	(0.117)			(0.463)	(0.236)	(0.506)	(0.256)
FE by Cartel	NO	NO	YES	YES	NO	NO	NO	NO
Nb. Obs.	114	114	101	101	114	114	114	114
R^2	0.029	0.032	0.053	0.077	0.090	-0.573	0.091	-0.612
F-Stat	-	-	-	-	13.63	-	13.31	-

Standard errors in parentheses. + $p < 0.15$, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. In our FE specifications, singleton observations of cartels were dropped.

Table 6: **Regressions of Cartel Wins (using the log number of outsiders)**

	Model 9 Probit *Cartel_Win*	Model 10 Probit *Cartel_Win*	Model 11 LPM *Cartel_Win*	Model 12 LPM *Cartel_Win*	Model 13 1st Stage *Nb_Outsiders*	Model 14 2SLS *Cartel_Win*	Model 15 1st Stage *Nb_Outsiders*	Model 16 2SLS *Cartel_Win*
Estimate	0.021	0.004	0.000	0.001	-0.048+	0.016	-0.049+	0.015
	(0.073)	(0.072)	(0.054)	(0.055)	(0.031)	(0.029)	(0.031)	(0.028)
Local	-0.112	0.083	-0.374	-0.370	-0.079	-0.039	-0.066	0.006
	(0.280)	(0.298)	(0.301)	(0.310)	(0.127)	(0.080)	(0.135)	(0.079)
Log_Nb_Outsiders	0.063	0.066	0.025	0.025		0.159		0.173
	(0.193)	(0.200)	(0.052)	(0.052)		(0.200)		(0.197)
Log_Nb_Colluders		0.594**		0.007			0.053	0.147**
		(0.262)		(0.084)			(0.128)	(0.067)
Instr_Out					0.747***		0.751***	
					(0.172)		(0.175)	
Constant	0.564	-0.043			0.782*	0.433	0.713	0.227
	(1.046)	(1.125)			(0.463)	(0.564)	(0.506)	(0.575)
FE by Cartel	NO	NO	YES	YES	NO	NO	NO	NO
Nb. Obs.	114	114	101	101	114	114	114	114
R^2			0.021	0.021	0.138	-0.052	0.140	-0.031
F-Stat	-	-	-	-	13.63	-	13.31	-

Standard errors in parentheses. + $p < 0.15$, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. In our FE specifications, singleton observations of cartels were dropped.

Table 7: **Weighted Regressions of Cartel Wins**

	Model 9 LPM *Cartel_Win*	Model 10 LPM *Cartel_Win*	Model 11 LPM *Cartel_Win*	Model 12 LPM *Cartel_Win*	Model 13 1st Stage *Nb_Outsiders*	Model 14 2SLS *Cartel_Win*	Model 15 1st Stage *Nb_Outsiders*	Model 16 2SLS *Cartel_Win*
Estimate	0.051**	0.045**	-0.012	-0.011	-0.320	-0.039	-0.318+	-0.026
	(0.020)	(0.021)	(0.040)	(0.040)	(0.238)	(0.084)	(0.205)	(0.071)
Local	-0.135	-0.119	-0.206	-0.215	-1.638***	-0.263	-1.727***	-0.210
	(0.101)	(0.094)	(0.144)	(0.154)	(0.453)	(0.183)	(0.450)	(0.164)
Nb_Outsiders	-0.003	-0.004	0.015	0.016		-0.157		-0.122
	(0.012)	(0.014)	(0.015)	(0.017)		(0.114)		(0.101)
Nb_Colluders		0.010		-0.002			0.110	0.014
		(0.008)		(0.006)			(0.161)	(0.017)
Instr_Out					2.203***		2.853**	
					(0.733)		(1.422)	
Constant	0.111	0.152			6.065	2.018	4.810	1.630
	(0.356)	(0.372)			(4.257)	(1.679)	(5.076)	(1.457)
FE by Cartel	NO	NO	YES	YES	NO	NO	NO	NO
Nb. Obs.	114	114	101	101	114	114	114	114
R^2	0.137	0.144	0.010	0.010	0.191	-0.534	0.216	-0.251
F-Stat	-	-	-	-	7.04	-	3.48	-

Standard errors in parentheses. + $p < 0.15$, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. In our FE specifications, singleton observations of cartels were dropped. Regressions are weighted by the value of the contract.