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David Imhof, Yavuz Karagok, Samuel Rutz

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CRESE
30, avenue de l'Observatoire
25009 Besançon
France
http://crese.univ-fcomte.fr/

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Screening for Bid-rigging – Does it Work?

DAVID IMHOF*, YAVUZ KARAGÖK**, SAMUEL RUTZ***

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Abstract: This paper proposes a method to detect bid-rigging by applying mutually reinforcing screens to a road construction procurement data set from Switzerland in which no prior information about collusion was available. The screening method is particularly suited to deal with the problem of partial collusion, i.e. collusion which does not involve all firms and/or all contracts in a specific data set, implying that many of the classical markers discussed in the corresponding literature will fail to identify bid-rigging. In addition to presenting new screens for collusion, it is shown how benchmarks and the combination of different screens may be used to identify subsets of suspicious contracts and firms. The discussed screening method succeeds in isolating a group of "suspicious" firms exhibiting the characteristics of a local bid-rigging cartel with cover bids and a – more or less pronounced – bid rotation scheme. Based on these findings the Swiss Competition Commission (COMCO) opened an investigation and sanctioned the identified "suspicious" firms for bid-rigging in 2016.

Keywords: bid-rigging, screening method, variance screen, cover bidding screen, bid rotation test, partial collusion

JEL-Classification: C00, C40, D22, D40, K40, L40, L41

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* Economist, Secretariat of the Swiss Competition Commission. Email: david.imhof@weko.admin.ch. Affiliated to the University of Fribourg (Switzerland), the University of Franche-Comté (France) and Unidistance (Formation universitaire à distance, Switzerland).

**Senior Economist, Secretariat of the Swiss Competition Commission. Email: yavuz.karagoek@weko.admin.ch. Corresponding author.

*** Project Manager, Swiss Economics and Adjunct Fellow, Avenir Suisse. Email: samuel.rutz@avenir-suisse.ch.

1 Introduction

Bid-rigging involves groups of firms conspiring to raise prices or lower the quality of goods or services offered in public tenders. Although illegal, this anti-competitive practice costs governments and taxpayers vast sums of money every year.[1] It is therefore not surprising that the fight against bid-rigging is currently a top priority in many countries and also a much-debated issue internationally.[2] In Switzerland, it was acknowledged a few years ago that the fight against bid-rigging in the procurement sector should be a priority, not least because the Swiss Competition Commission (COMCO) uncovered several bid-rigging cartels in the recent past.[3]

To detect bid-rigging (and other competition law infringements) national competition authorities heavily rely on leniency programs (OECD 2014). Switzerland is no exception: whistle-blowers or leniency applicants are the common denominator of recently prosecuted cases, and they contributed significantly to the uncovering of bid-rigging cartels. To mitigate the dependency on these external sources and actively reinforce the fight against bid-rigging, COMCO decided to initiate a long-term project in 2008. One of the goals of this project was to develop a statistical screening tool with the following properties:

1. *Modest data requirements*: Screening exercises will often have to rely on limited available public data, e.g. data collected by a procurement agency or a statistical office. Gathering detailed information from private firms will hardly ever be an option since this would immediately raise suspicion of potential cartel members and lead to the destruction of any proof of collusion.

2. *Simplicity:* For a competition authority to conduct screening exercises on a regular basis, the applied method should be as simple as possible. In other words, it is rather unlikely that methods based on complex, econometric models are suited for broad-

[1] On average, procurement amounts to 29% of the government expenditure in OECD countries and to 13% of GDP. For Switzerland, procurement accounts for 23% of the government expenditure and represents 8% of the Swiss GDP (see OCED, 2013).
[2] In 2009, the OECD adopted the *Guidelines for Fighting Bid-rigging in Public Procurement*. These guidelines were followed by the adoption of a *Recommendation on Fighting Bid-rigging in Public Procurement* in 2012, which calls for governments to assess their public procurement laws and practices at all levels of government in order to promote more effective procurement and reduce the risk of bid-rigging in public tenders. The two documents mentioned and many other documents related to bid-rigging are available at the OECD homepage (http://www.oecd.org/daf/competition/fightingbidrigginginpublicprocurement.htm).
[3] See Strassenbeläge Tessin (LPC 2008/1, pp. 85-112), *Elektroinstallationsbetriebe Bern* (LPC 2009/2, pp. 196-222), *Wettbewerbsabreden im Strassen- und Tiefbau im Kanton Aargau* (LPC 2012/2, pp. 270-425), *Wettbewerbsabreden im Strassen- und Tiefbau im Kanton Zürich* (LPC 2013/4, pp. 524-652) and *Tunnelreinigung* (LPC 2015/2, pp. 193-245). Furthermore, COMCO regularly institutes proceedings concerning bid-rigging cases (in the beginning of 2017 several proceedings were still being investigated by COMCO).

base screening activities. Such models are often data-intensive and time-consuming to implement.

3. *Flexibility*: Of course it cannot be expected, that there is a "one-size-fits-all" approach to detect bid-rigging cartels. The screening method should be therefore simple to adapt to different situations, e.g. to specific circumstances of the screened industry or to the available data.

4. *Reliable results*: In general, a screening method will not produce hard evidence for the existence of a cartel. This – explicitly – is not the goal of an *ex ante* screening exercise. In principle, screening methods can only help to identify possible deviations from competitive procurement processes. In this sense, we do not expect our screening method to produce proofs of collusion but evidence sufficiently reliable to convince a competition authority to open an investigation.

We choose the following procedure to build a detection method meeting these four requirements: Starting from the existing screening literature, we apply two screens – also called markers – to a procurement data set in which no prior information about (potential) collusion was available. Both of these screens assume that collusive behavior, e.g. in the form of explicit coordination or an exchange of information, modifies the distribution of the bids. Both screens, however, did not produce unambiguous evidence as to whether collusion is likely to exist or not in our sample. A possible reason for this result is that the statistical methods suggested in the literature are not particularly well suited to detect partial collusion, i.e. collusion that does not involve all firms and/or all contracts in a data set. Therefore, we designed an approach that allows testing for partial collusion. In general, our approach amounts to a collection of mutually reinforcing tests to identify potential collusion between subsets of firms. With the help of these tests, it was possible to isolate a group of "suspicious" firms in our sample that exhibits the characteristics of a local bid-rigging cartel, operating with cover bids and a – more or less pronounced – bid rotation scheme. Based on these results COMCO opened in 2013 an investigation at the end of which eight firms were sanctioned for bid-rigging.[4]

In this article, we present our detection method in detail. It is organized as follows: Section 2 presents the literature on screening methods. Section 3 then explains the setup of our data set

[4] See press release of the 4th October 2016 on COMCO's website: https://www.weko.admin.ch/weko/de/home/aktuell/medieninformationen/nsb-news.msg-id-64011.html. COMCO's decision is, however, currently pending before the appeals court.

and provides some descriptive statistics. In section 4 we apply two simple screens to our data set. Given the ambiguous results in section 4, section 5 combines these two screens and shows how this may help to detect partial collusion. Furthermore, several tests serving to reinforce suspicions of partial collusion are discussed in section 5. Another test, the bid rotation test, is then discussed separately in section 6. Section 7 concludes.

2 Screening methods

There is a growing literature on cartel detection which can roughly be divided into two strands: Some literature discusses *structural methods* for the empirical identification of markets prone to collusion. Such structural methods try to analyze the market structure in different industries, aiming at the identification of factors which are known to enhance respectively sustain collusion.[5] In general, this approach uses relatively aggregated data on an industry level, and can therefore only indicate whether collusion is more or less likely to occur in certain industries. In contrast, the so-called *behavioral methods* analyze the concrete behavior of firms in specific markets. To this purpose a multitude of more or less complex statistical tests may be employed.

Harrington (2008) summarizes the literature on behavioral methods and discusses a number of *statistical markers* that may help to distinguish competitive from collusive behavior. Some of these markers rely on theoretical considerations from literature on collusion, while others are based on empirical observations from uncovered cartels (see also Harrington, 2007 or OECD, 2014). In general, *price*- and *quantity-related markers* may be distinguished. Conceptually, in the case of tenders, the price-related markers use the information contained in the structure of the winning and losing bids to identify suspect bidding behavior. In contrast, the quantity-related markers attempt to identify collusive behavior from developments in the market shares that are *prima vista* not compatible with competitive markets.

The most comprehensively tested price-related marker is the so-called *variance screen*: Several empirical papers provide evidence for the fact that in case of collusion prices are often less responsive to effective costs than in a competitive environment, i.e., price variability is lower in a collusive environment. Feinstein and Brock (1985) apply the variance screen to highway construction cartels in North Carolina and find that the coefficient of variation is lower when bidders collude. They also find that collusion is characterized by frequent and

[5] See Grout and Sonderegger (2005) for an empirical discussion on the structural approach.

repeated interaction of the same group of bidders. More recently, Abrantes-Metz et al. (2006) examine a US bid-rigging cartel for frozen fish. They show that prices for frozen perch fell – on average – by 16% after the collapse of the cartel and the standard deviation of bids increased by more than 250%. Esposito and Ferrero (2006) show that the use of the variance screen would have been successful in detecting two cartels – one in the fuel market and another one in the market for baby food products sold in pharmacies – investigated by the Italian Competition Authority (AGCM).

Bolotova et al. (2008) provide mixed evidence for the lysine and the citric acid cartels: In the lysine cartel, the standard deviation of bids was indeed significantly lower during the cartel period. However, these results could not be confirmed for the citric acid cartel. Abrantes-Metz et al. (2012) use – *inter alia* – a variance screen to show that daily bank quotes for the Dollar Libor behaved abnormally compared to other short-term borrowing rates. Jimenez und Perdiguero (2012) provide another application of the variance screen: They use the screen to examine price variability in the fuel market in the Spanish Canary Islands. Although they do not find (clear) evidence for collusion, they confirm that lower competition in markets tends to lower price variability and to increase the level of prices.

The variance screen has also been applied by competition authorities. Ragazzo (2012), for example, describes a method developed by the Brazilian Competition Policy System (BCPS) to screen regional gasoline markets for collusive behavior. Also, the Mexican competition agency used price screens to identify bid-rigging for different types of drugs: Mena-Labarthe (2012) as well as Estrada and Vazquez (2013) report the typical pattern of low price variance during collusive periods and a significant increase of price variance after the cartel collapsed.

So far, economic theory has not provided a wholly convincing explanation for the link between collusion and price variability. There are two theoretical contributions in the literature attempting to explain why price variability may be lower in a collusive environment. Athey et al. (2004) consider an infinitely repeated Bertrand game in which each firm's cost is private information and varies over time. In each period messages concerning the firm's costs are exchanged and then prices are chosen. The basic problem colluding firms face is to induce truthful revelation of costs. Assuming an inelastic demand, Athey et al. (2004) show that – if firms are sufficiently patient – optimal collusion is characterized by price rigidity. Harrington and Chen (2006) choose a different approach: They start out from the idea that cartels try to avoid detection by buyers, who become suspicious whenever they perceive anomalous changes in the history of prices. Assuming that a cartel is aware of how its price choice affects the beliefs of buyers, Harrington and Chen show that prices are less responsive to cost shocks than in a non-collusive environment, i.e., there is a certain degree of price rigidity.

While price- and quantity-related markers, such as the discussed variance screen, are relatively simple to apply and may be implemented with a limited amount of information, there is also some literature dealing with more complex, econometric detection methods for bid-rigging cartels. However, such methods often require firm-specific data, e.g. cost estimates for concrete contracts, information about cost structure and capacity utilization of respective firms, or the distance between the location of a firm and the project site. Additionally, these methods usually require the modeling of a (competitive) auction process serving as counterfactual for a situation without collusion. The contributions by Porter and Zona (1993, 1999), Pesendorfer (2000), Bajari and Ye (2003) or Ishii (2009) can be cited as examples of such detection methods. Typically, these authors use data from bid-rigging cartels uncovered earlier and condemned by a competition authority. They then model counterfactuals fitting the specific circumstances of the examined cartels. Such methods may be very useful for a competition authority in order to show the anti-competitive effects of a specific bid-rigging cartel within a particular investigation. Furthermore, one may learn important lessons concerning the behavior of collusive firms. Yet, it is questionable whether complex, econometric methods are indeed suited for a wider, preventive screening activity. The sparsely documented attempts to use such methods for *ex ante* screening are – so far – not very encouraging (see Aryal and Gabrielli 2013).

3 Sample Construction and Descriptive Statistics

The starting point for the construction of our sample were the annual submission statistics of a Swiss canton[6], listing all awarded contracts, grouped by the categories *services*, *deliveries* and *construction*. These statistics contain the name of the winner of each tender, details on the price granted, and a very short description of the contract. There is, however, no information on the losing bids. It was decided to focus on the category *construction* for two reasons: Firstly, in this sector several bid-rigging cartels have been uncovered and investigated by COMCO in the recent past. Thus, it seems to be a sector prone to collusion. Secondly, due to the relatively high number of annual contracts in this sector, the setup of a meaningful sample seemed realistic. All contracts not relating to "classical" construction work were eliminated from the sample. These were e.g. contracts for road surveillance equipment or protection

[6] With respect to population size and surface area, this canton can be characterized as an average Swiss canton.

equipment against rock fall. Furthermore, contracts for tunnel construction were eliminated since such contracts are only executed by a handful of specialized firms. After this process of elimination, roughly 400 contracts connected to road construction remained.

Information concerning the losing bids was gathered from the official records of the tender opening, which contain the name of the bidders and their final bids. For 282 of the 400 contracts in the road construction sector, the procurement body was able to provide the official records of the tender opening. They cover the time period from 2004 to 2010. Table 1 summarizes some key data of the contracts in our sample. All in all, 138 firms submitted roughly 1’500 bids for the 282 contracts. Consortiums submitted 228 bids and won the contract in 78 cases. Consequently, 204 contracts were won by an individual firm.[7] Overall, the total value of the 282 contracts – measured by the sum of all winning bids – amounts to roughly CHF 216 million.

Table 1: Overview of the Sample (2004-2010)

Number of tenders	282
Number of bids submitted	1’491
Number of firms involved	138
Number of bids from consortiums[8]	228
Number of winning bids from individual firms	204
Number of winning bids from consortiums	78
Total value of all 282 projects (in CHF million)	216

Furthermore, Table 2 shows the distribution of the contracts over the time period considered and the corresponding annual total value of the contracts. The annual number and the total value of the conducted contracts are quite evenly distributed over the years.[9] Note, however, that the year 2005 is an exception since an especially large contract of CHF 25 million was tendered. The value of the majority of the contracts in the sample is between CHF 100’000 and CHF 600’000. The median value of the contracts amounts to roughly CHF 400’000 and

[7] This does not exclude the possibility that in some of these cases other firms were involved as sub-contractors.
[8] A consortium is a business combination in which two or more firms submit a common bid for a specific contract.
[9] Although the sample includes only ca. 60% of the initially identified 400 contracts, these 282 contracts reflect – on a value basis – roughly 95% of all the contracts in the road construction sector. Thus, the sample does not include all contracts but *prima vista* all the important ones.

the average contract value is around CHF 770’000. The considerable difference between the average and the median indicates a skewed distribution. This asymmetry is due to a few very large contracts in the sample. The average number of bids per tender amounts to 7 while the median (6) is only marginally lower.

The tenders differ furthermore with regard to the tender procedure (invitation vs. open procedure). In an invitation procedure, the procurement agency invites firms directly to submit a bid, i.e., there is no public tender and the number of submitters is limited. In general, public procurement agencies are legally obliged to solicit at least three bids. The invitation procedure may be used for contracts with a value of up to CHF 500’000. For contracts with a value of more than CHF 500’000, public procurement agencies in Switzerland must institute an open procedure, in which, all interested firms – without any constraints – may submit a bid. Thus, the contract is publicly tendered.

Table 2: Number and Value of Annual Tenders

Year	Number of Submissions	Total value (CHF million)
2004	35	26
2005	40	55
2006	44	23
2007	37	30
2008	40	22
2009	46	28
2010	40	32

Our sample contains 135 contracts which were tendered publicly (open procedure) and 147 contracts which were tendered by an invitation procedure. The average and the median of the contract values largely coincide (ca. CHF 250’000) in the invitation procedures. In contrast, there is a notable difference between the average (ca. CHF 1.3 million) and the median (ca. CHF 816’00) for the open procedures which can be explained by the existence of a certain number of very large contracts in the sample. The value of the 135 contracts tendered publicly amounts to roughly CHF 185 million, i.e., roughly 85% of the total value of all contracts in the sample. There is also a significant difference between the invitation and the open procedures with respect to the number of submitted bids: While procurement bodies usually invite 4 or 5 firms to submit a bid in an invitation procedure, more than 20 firms bid for certain large contracts in the open procedure.

4 Two Simple Statistical Markers

Our data set is not well-suited to test for all the statistical markers suggested in the literature. The quantity-related markers[10] are in particular not likely to produce meaningful results for two reasons: Firstly, the contracts in our sample most likely only represent a part of the firms' construction activities, i.e., the firms in our sample may also be active in sectors other than road construction (e.g. construction of buildings). Furthermore, the sample is restricted to road construction contracts, tendered by the procurement body, and does not account for tenders by local procurement bodies or private stakeholders. Consequently, there is no reliable information concerning firm-specific market shares in our sample. Secondly, annual demand for road construction (i.e. the number and the size of the tendered contracts) may fluctuate. This notion is supported by strongly fluctuating market shares (measured by the annual total value of realized contracts) of the firms in our sample. It is thus rather unlikely that an agreement on market shares can be realized short term. Yet, a focus on long-term market shares largely eliminates the intertemporal structure in the data imposed by possible collusion.

Therefore, we decided primarily to focus on price-related markers. Again, due to different reasons, it was not possible to test for all price-related markers suggested in the literature. For example, to test whether there is a high degree of uniformity across firms in dimensions such as prices for ancillary services, one needs information not available in the records of the tender opening. Given the information available in our data set, it seemed most promising to focus on markers analyzing the structure among firms' bids. In what follows, we apply two such markers to our data set.

4.1 Variance Screen

As discussed in section 2, the variance screen is the most comprehensively tested statistical marker to detect collusion. Therefore, it seems natural to start the analysis with this particular marker. In the context of bid-rigging, the coefficient of variation is normally used to

[10] Harrington (2008) suggests three quantity-related markers: (1) highly stable market shares over time, (2) subsets of firms for which each firm's share of total supply is highly stable over time and (3) firms market shares negatively correlating with each other in time.

implement the variance screen since the measure is scale-invariant and thus allows for the comparison of bidding behavior for contracts with significantly differing values.[11] In general, the coefficient of variation (CV_j) is defined as the standard deviation (σ_j) divided by the arithmetic mean (μ_j) of all bids submitted for contract j:

$$CV_j = \frac{\sigma_j}{\mu_j}$$

The empirical literature assumes that low values of the coefficient of variation indicate price rigidity, i.e., suspicious bidding behavior. More precisely, significant non-temporary decreases in the coefficient of variation are taken as indication for periods of collusion and *vice versa*.

Figure 1: Variance Screen

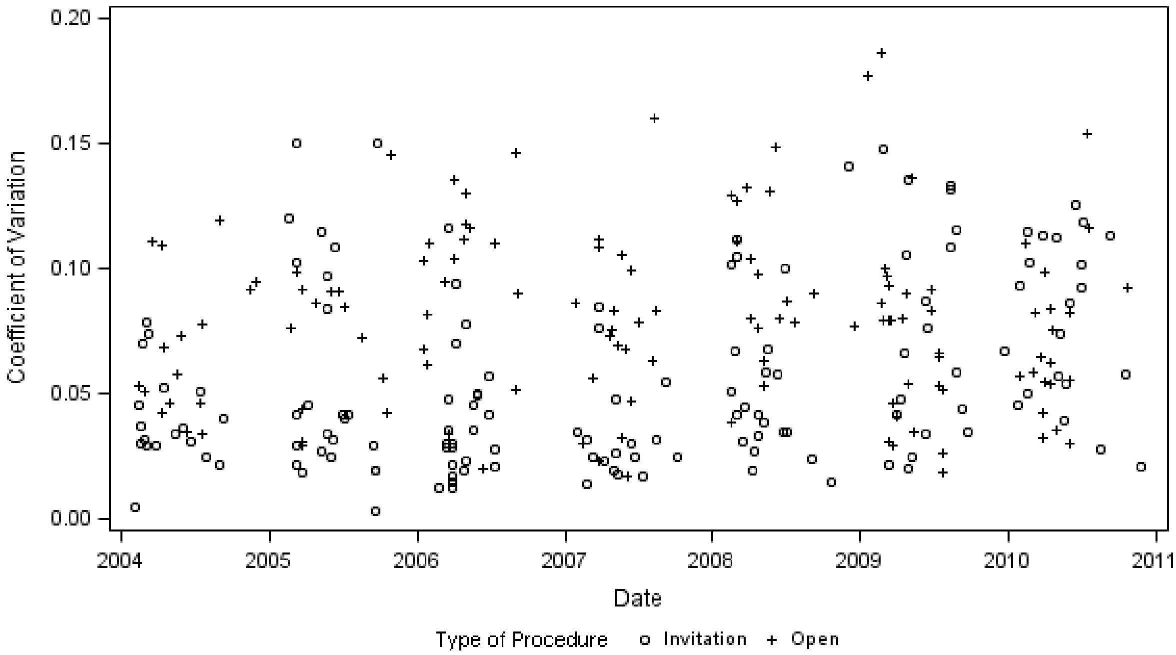


Figure 1 shows the coefficient of variation of the bids submitted in both types of procedures for the – chronologically organized – 282 contracts. As can be observed, there is no peculiar evolution of the coefficient of variation over time, i.e., there are *prima vista* no time periods, where the coefficient of variation systematically differs from other time periods. There is, however, a notable difference between invitation and open procedures: On average, the

[11] See e.g. Feinstein and Brock (1985), Abrantes-Metz et al. (2012), Jiminez and Perdriguo (2012) or Ragazzo (2012).

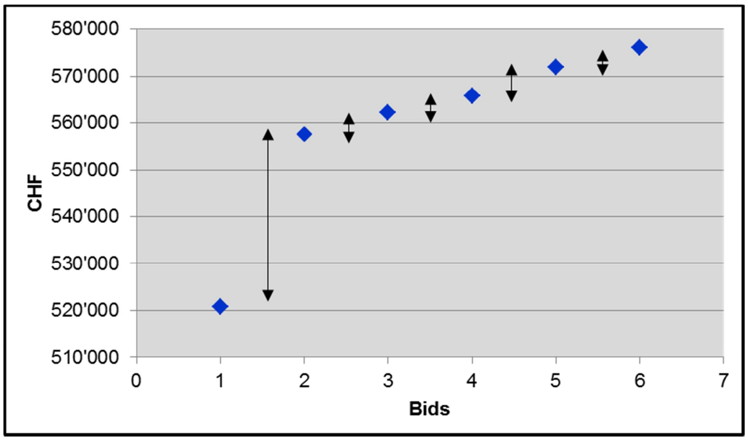
coefficient of variation of the open procedures amounts to 0.081 while the corresponding value for the invitation procedures amounts to 0.058. Statistical tests confirm that the difference between the two types of tender procedures is significant.[12] This finding may be interpreted as a (weak) indication that invitation procedures are more prone to bid-rigging than open procedures.

4.2 Cover Bidding Screen

In the past few years, COMCO has uncovered several bid-rigging cartels in Switzerland.[13] In many of these bid-rigging cases, it was striking that the difference between the loosing bids was systematically smaller than the difference between the winning bid and the second-best bid. Figure 2 illustrates this finding.

Figure 2: Typical Bidding Behavior in Rigged Tenders[14]

Bids (in ascending order, CHF)		Difference X_n-X_{n+1}
X_1	520’816	Δ_1 = 36’800
X_2	557’616	Δ_2 = 4’648
X_3	562’264	Δ_3 = 3’561
X_4	565’825	Δ_4 = 6’141
X_5	571’966	Δ_5 = 4’151
X_6	576’117	



Intuitively, such bidding behavior may be explained by the presence of cover bidding: Bidders not intending to win a contract offer distinctly higher prices than the agreed winner. This practice ensures that the designated winner gets the contract and that the winning bid appears to be competitive. There are three reasons why such bidding behavior is realistic in

[12] Note that the coefficient of variation in our sample is not distributed normally: The Kolmogorov-Smirnov test for normality rejects the null hypothesis at the 5% significance level. Other normality diagnostic tests –Shapiro-Wilk, Cramer-Von Mises and Anderson-Darling – also reject the null hypothesis (at the 1% significance level). The difference between the two types of tender procedures is confirmed by the Mann-Whitney test, which rejects the null hypothesis of no difference between the two distributions with a z-statistic of 5.58 (p-value: < 0.0001). Also, the Kolmogorov-Smirnov test rejects the null-hypothesis of no difference between the distribution of the coefficient of variation for both procedures with an asymptotic Kolmogorov-Smirnov statistic of 3.27 (p-value: < 0.0001).

[13] See footnote 3.

[14] The example in Figure 2 is taken from the case *Strassenbeläge Tessin* (LPC 2008/1, pp. 85-112).

practice: Firstly, in many contracts the price is not the only criterion procurement authorities take into consideration. Other criteria, such as the offered technical solution, quality or environmental aspects, may be taken into account when deciding on the winner of a contract. Such non-monetary criteria may influence the award of a contract and undermine intended bid-rigging especially when bids are close to each other. Secondly, witnesses in bid-rigging cases have reported that members of bid-rigging cartels usually make sure that the designated winning bid is 3-5% lower than the second-best bid.[15] Thirdly, losing bids may be close to each other because no bidder wants to risk being perceived as overly expensive in the eyes of the procurement agency.

Based on the described bidding behavior, it is possible to construct an alternative price-related marker by considering the difference between loosing bids and the difference between the two best bids for a specific contract.[16] To test whether cover bidding might be present, we calculate the ratio between the difference of the two lowest bids ($\Delta_{j,1}$) and the standard deviation of the loosing bids ($\sigma_{j,lb}$). This yields the following formula for the measure of relative distance (RD_j):

$$RD_j = \frac{\Delta_{j,l}}{\sigma_{j,lb}}$$

Note that the standard deviation should only be calculated for the loosing bids since the difference between the two best bids is anomalously high when collusion is present.[17] Without this correction, the standard deviation would be distorted upward.[18] The relative distance measure has to be interpreted as follows: A *RD* of approximately 1 indicates that there is no difference in the bidding behavior of the winner and the rest of the bidders (see the reference line in Figure 3), i.e. there is no suspicious bidding behavior. A *RD* (much) larger than 1 indicates, however, that cover bidding may have taken place. Figure 3 depicts the relative distance measure for all contracts in chronological order and by procedures.

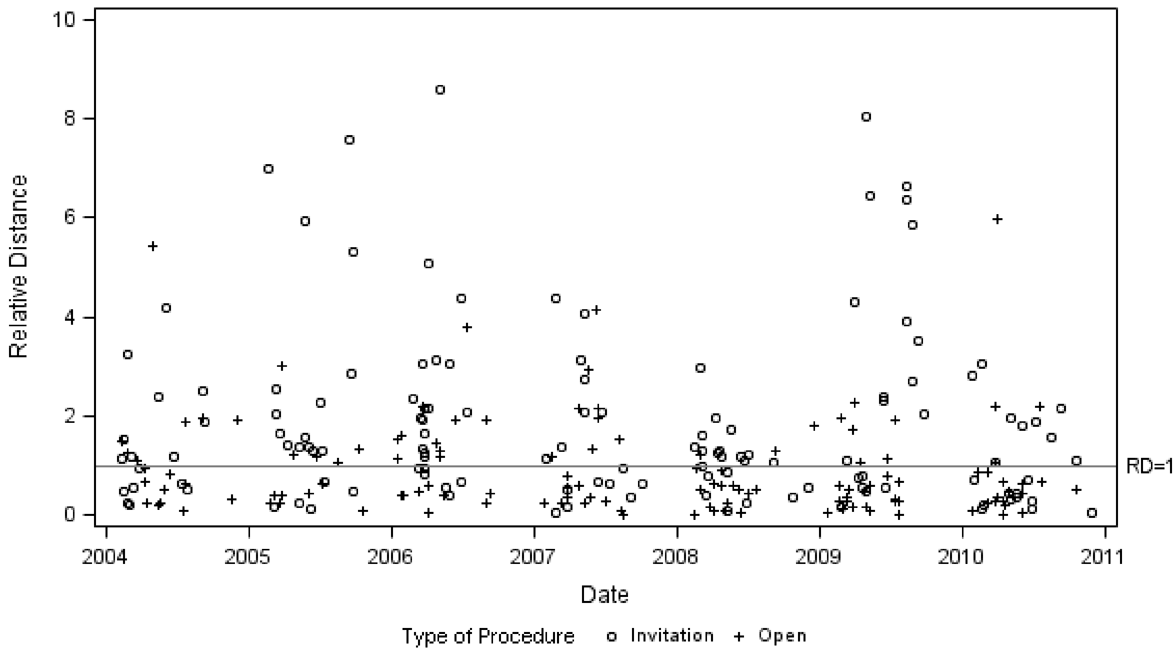
[15] See e.g. *Strassenbeläge Tessin* (LPC 2008/1, pp. 85-112, in particular recital 60) or *Wettbewerbsabreden im Strassen- und Tiefbau im Kanton Zürich* (LPC 2013/4, pp. 524-652, in particular p. 561, recital 182 and p. 573, recital 309 and 314).

[16] The general idea to consider the differences between winning and losing bids to identify bid-rigging was already proposed in the seventies (see OECD 1976). Yet, a concrete statistical marker has – to the best of our knowledge – not yet been suggested in the literature.

[17] Note also that we can calculate the *RD* only for contracts with three bids or more.

[18] It is of course possible to define the measure for relative distance differently. For instance, one may calculate the difference between the two best bids and divide it by the mean of the differences between losing bids instead of the standard deviation. We also performed the cover bidding test in this alternative way: results qualitatively remain, however, the same.

Figure 3: Cover Bidding Screen



From Figure 3 conclusions similar to the case of the variance screen can be drawn. On the one hand, there are no peculiar developments of the *RD* observable over time, i.e., time periods where the *RD* systematically differ from other time periods cannot be identified. On the other hand, with an average of 1.92 the cover bidding test again suggests that collusion is more likely to be present in invitation procedures. In contrast, the average of the relative distance measure for open procedures only amounts to 1.2.[19]

5 Screening for Partial Collusion

Our analysis so far indicates that firms in our sample do not seem to be involved in a systematic market-embracing collusive scheme. Furthermore, the two applied markers suggest that collusion – if present at all – is more likely to occur in invitation procedures. Both of these results are not surprising. COMCO's investigations concerning bid-rigging have revealed that cartels in construction markets often are partial, i.e., they only involve a subset

[19] As in the case of the coefficient of variation, the Kolmogorov-Smirnov test (at the 5% significance level) – as well as the Shapiro-Wilk, Cramer-Von Mises and Anderson-Darling tests (at the 1% significance level) – rejects the normality hypothesis. The Mann-Whitney test confirms that there is a significant difference between the two types of tender procedures (z-statistic: 5.58; p-value: < 0.0001), a result also corroborated by the Kolmogorov-Smirnov test (asymptotic Kolmogorov-Smirnov statistic: 3.27; p-value: < 0.0001).

of colluding firms and/or collusion is targeted at specific contracts. Thus, excluding the presence of bid-rigging from the results derived above would be premature. In the remainder of this section we will show how partial collusion may be detected.

5.1 Multistep Procedure to Detect Partial Collusion

A crucial prerequisite to detect partial collusion with a statistical marker is a sufficient degree of regular interaction between stable groups or sub-groups of firms. Irregular and selective bid-rigging agreements between firms loosely connected (e.g. for special types of projects) are, however, extremely hard – if not impossible – to identify with a screen. Our approach amounts to a collection of mutually reinforcing tests, which allow conclusions as to whether collusion is likely to exist between subgroups of firms. All of the suggested tests may be extended, refined and adapted to the specific features of other cases in which bid-rigging is suspected.

Our procedure consists of four steps. In the *first step*, we isolate contracts and firms exhibiting a specific (suspicious) bidding pattern from our data set. To this purpose, we combine the variance and the cover bidding test, and screen for contracts which simultaneously exhibit a low coefficient of variation and a high relative distance measure. The reason for combining the two screens is simply that we want to produce a conservative sample of suspicious contracts and firms. Given that results pointing to the existence of bid-rigging may in practice trigger the opening of an antitrust investigation – most likely accompanied by drastic investigative measures such as house searches –, it seems to be a reasonable strategy to minimize the probability of *type I errors* right from the start.[20]

Since a certain degree of repeated interaction is a basic ingredient of most bid-rigging cartels (see e.g. Feinstein and Brock 1985), we analyze in a *second step* whether there are groups of firms regularly submitting bids for the same conspicuous contracts. There is no obvious “automatic” process which could be used to identify possible groups of colluding firms. Statistical methods potentially suited for such a purpose, e.g. cluster analysis, are explorative processes. In other words, there is no given algorithm which could be applied to our sample – rather, the goal is to find an appropriate algorithm. Based on a simple iterative process we

[20] Statistically, a *type I error* occurs when the null hypothesis is incorrectly rejected. In our case, a *type I error* would imply a contract is wrongly labeled as collusive. By combining the screens, we attempt to reduce the risk of erroneously flagging a contract as collusive since two different criteria must be satisfied simultaneously.

identify conspicuous groups of firms and analyze the interaction between firms within such groups.

In a *third step*, we analyze geographical bidding behavior. More precisely, we want to know whether the identified conspicuous groups of firms are active in the entire territory of the canton or whether possible collusion is restricted to certain regions. Delineating the area where a potential bid-rigging cartel is active then allows to analyze local competitive forces, i.e., how many firms regularly submit bids in a certain region, whether these are mainly "suspect" firms or if there are other firms active in this region etc. Overall, such an analysis provides important conclusions as to whether (suspected) collusion is likely to be stable. Furthermore, an affirmative result reinforces and substantiates the group formation process.

In the absence of side payments, bid-rigging agreements usually involve a rotation element to sustain collusion (see e.g. Pesendorfer 2000). In other words, a rational firm will only renounce to submit a truly competitive bid for a contract if other cartel members reward it for this behavior in the future. Typically, the reward for such cover bidding or bid suppression is the assignment of future contracts. In a *fourth step* – presented separately in section 6 – we develop a graphical method designed to visualize bid rotation within a group of firms.

5.2 Empirical Implementation of the Multistep Procedure

5.2.1 Identification of Conspicuous Contracts and Firms

In the first step of the multistep procedure, we want to isolate conspicuous contracts and firms from our sample by simultaneously applying the variance and the cover bidding screen. Two issues need to be discussed in this context: First, although the variance and the cover bidding screen capture conceptually different aspects of the price setting behavior of colluding firms, it cannot be excluded that the results of the two tests correlate in practice. In this case, combining the two screens would be of limited value. The correlation between the *CV* and the *RD* amounts to -0.15 (*p-value*: 0.0811) for open procedures and -0.16 (*p-value*: 0.0623) for invitation procedures.[21] In other words, for both types of procedures, there is no significant correlation between the two markers.

[21] We use the Spearman correlation test because the *CV* and the *RD* are not normally distributed (see section 4). In section 4, we highlighted a significant difference between the two types of tender procedures: the coefficient of variation is lower and the relative distance measure larger for the invitation procedure as compared to the open procedure. Given these differences, it seems appropriate to apply the correlation test separately to each procedure type.

The second issue to discuss is the following: To separate conspicuous from inconspicuous tenders, a threshold for the *CV* and the *RD* has to be defined. In the case of the *RD* this is relatively straightforward: A *RD* larger than 1 points to a conspicuous contract (see section 4.2). However, the determination of a reasonable threshold for the *CV* is less obvious – there is no theoretical argument for a specific level of the *CV* separating conspicuous from inconspicuous contracts. Yet, practical experience with bid-rigging cartels in the road construction sector may be a viable way to determine a threshold for the *CV*. Calculations made by COMCO have, for example, revealed that in the case of the road construction cartel in the canton of Ticino the *CV* amounted to 0.03 on average during the cartel phase. Additionally, there were almost no rigged tenders with *CV* values higher than 0.05. After the breakdown of the cartel, the *CV* – on average – increased to 0.098.[22] Given that this cartel was very well organized (the members of the cartel e.g. held weekly cartel meetings) and basically involved all firms located in the canton of Ticino, a *CV*'s value of 0.03 may be interpreted as a conservative benchmark for rigged contracts. In contrast, the road construction cartel in the canton of Aargau may serve as an example of a much more loosely organized cartel.[23] The cartel was characterized by partial collusion between 17 construction firms and collusion was not targeted at all road construction contracts in the canton. The average *CV* for the roughly 100 rigged contracts that were investigated by COMCO amounted to 0.06. Thus, for an initial screen, one may arrive at the hypothesis that tenders with a *CV* above 0.06 and a *RD* below 1 are inconspicuous and *vice versa*.

Applying this initial screen to our data set (scenario 1 in Table 3) results in the identification of 80 conspicuous contracts, i.e., in this scenario, bid-rigging cannot be excluded for more than 25% of all contracts in our sample. Given our results in section 4, it is also not surprising to find that the majority of these contracts (approx. 80%) were tendered by invitation procedure. Still, a non-negligible fraction of the contracts identified in scenario 1 is tendered by open procedure. Scenario 1 is a relatively rigorous screen. We therefore tested two more conservative scenarios (scenario 2 and 3 in Table 3). Even in the most conservative scenario ($CV \leq 0.03$ and $RD > 1.30$) we identify 38 contracts deemed conspicuous.

Having isolated different sets of conspicuous contracts, we proceed by identifying all firms bidding for the corresponding contracts. More precisely, we identify the firms which have submitted a bid for at least 10% of all conspicuous contracts for each scenario in Table 3 (e.g.,

[22] See *Strassenbeläge Tessin* (LPC 2008/1, pp. 85-112), especially p. 103.
[23] See *Wettbewerbsabreden im Strassen- und Tiefbau im Kanton Zürich* (LPC 2013/4, pp. 524-652).

for scenario 1, we consider only firms which submitted a bid for at least eight conspicuous contracts). The purpose of this threshold is to eliminate "fringe bidders", i.e. firms which do not regularly submit bids for conspicuous contracts. Such firms are unlikely to be part of a stable collusive scheme.

Table 3: Identification of Conspicuous Contracts – 3 Scenarios

Scenario	*CV*	*RD*	Number of Contracts	% of Total Sample	Invitation Procedure	Open Procedure
1	≤ 0.06	> 1.00	80	28.4%	63	17
2	≤ 0.05	> 1.15	65	23.1%	53	12
3	≤ 0.03	> 1.30	38	13.5%	30	8

Interestingly, the list of firms turns out to be independent of the chosen thresholds: in all three scenarios the same 17 firms submitted a bid for at least 10% of the conspicuous contracts. The only difference between the scenarios is the ranking of the firms as pertaining to the absolute number of bids submitted for conspicuous contracts. Thus, the observed suspect bidding behavior can be exclusively attributed to 17 firms. Accounting for the fact that overall 138 firms have at least once submitted a bid in our sample, this result suggests that, if bid-rigging occurred in our sample, these 17 firms were most likely involved.[24]

5.2.2 Validation of the Results

Yet, as noted above, roughly 80% of the identified conspicuous contracts in each of the three scenarios were tendered by invitation procedure which – by definition – limits bidder participation. Given our finding in section 4 that the *CV* (*RD*) is significantly lower (higher) for the invitation procedure, this result is not surprising. It raises the question whether the limited number of bidders or any other specific characteristics of the invitation procedure affects the results reported in Table 3. In order to validate our results, we first consider the correlation between the number of bids and our two markers. In a second step, we examine whether varying characteristics of the tender procedures influence the identification process of conspicuous contracts.

[24] Of course, this does not permit the reverse conclusion that all other firms in our sample were not involved in collusion. One can only draw the conclusion that these firms do not exhibit a bidding behavior that the applied screen identifies as conspicuous.

For the entire sample the correlation between the *CV* and the number of bids amounts to 0.27 (*p-value*: <0.0001), while the corresponding value for the *RD* is -0.28 (*p-value*: <0.0001).[25] Consequently, there is a weak but significant correlation between the number of bids and our two markers. However, it is interesting to note that the observed correlation vanishes when excluding the 80 conspicuous contracts from the entire sample. For the reduced sample, the correlation between the *CV* and the number of bids amounts to 0.02 (*p-value*: 0.7884), while the corresponding value for the *RD* is -0.04 (*p-value*: 0.61). This suggests that the observed correlation in the entire sample is due to the subset of conspicuous contracts. In other words, there is no general correlation between the number of bidders and our two markers: the observed correlation is a specific feature of the subset of conspicuous contracts.

We next examine whether – besides the number of bidders – there are other systematic differences between the tender procedures that may influence our results. Put differently, we want to exclude the possibility that the *CV* (*RD)* is generally lower (higher) for the invitation procedure, i.e. for reasons not connected to collusive behavior of the involved firms. For that purpose, we use again the reduced sample and we test if there is a significant difference between invitation procedures and open procedures for our two screens. For the *CV*, results are unambiguous: We find no significant difference for invitation and open procedures.[26] Yet, results for the *RD* are mixed. While the Kolmogorov-Smirnov test indicates that there is no significant difference, the Mann-Whitney test suggests the contrary.[27] To resolve this contradiction, we resort to an analysis of the concrete differences of the mean and the median of the *RD* for the distinct types of contract. Table 4 reports the mean and the median of the *RD* for the conspicuous contracts and the contracts in the reduced sample. The latter values are furthermore reported separately for the invitation and open procedure.

[25] We use the Spearman correlation test because the *CV* and the *RD* are not normally distributed (see section 4).

[26] The Mann-Whitney test does not reject the null hypothesis of no difference between the invitation and the open procedure for the inconspicuous sample with a z-statistic of -0.89 (*p-value*: 0.3751). Also, the Kolmogorov-Smirnov test do not reject the null-hypothesis of no difference between the invitation and the open procedure for the inconspicuous sample with an asymptotic Kolmogorov-Smirnov statistic of 1.20 *(p-value*: 0.1112).

[27] The Kolmogorov-Smirnov test do not reject the null hypothesis of no difference between the invitation and the open procedure for the inconspicuous sample with an asymptotic Kolmogorov-Smirnov statistic of 1.18 (*p-value*: 0.1222). However, the Mann-Whitney test rejects the null hypothesis of no difference with a z-statistic of 2.36 (*p-value*: 0.0194).

Table 4: Comparative Values of the *RD*

	Mean of the *RD*	**Median of the *RD***
Conspicuous contracts	5.22	2.06
Reduced sample: all contracts	1.22	0.56
Reduced sample: contracts tendered by invitation procedure	1.59	0.67
Reduced sample: contracts tendered by open procedure	0.99	0.50

The difference between the mean of the conspicuous contracts and the contracts in the reduced sample amounts to 4, while the corresponding value for the difference between contracts tendered by invitation and open procedures in the reduced sample is 6.67 times smaller (0.6). This suggests that the procedure type explains a maximum of 15% of the difference between conspicuous and the contracts in the reduced sample. Considering the values for the median leads to similar results: The difference between the mean of the conspicuous contracts and the contracts in the reduced sample amounts to 1.5, while the corresponding value for the difference between contracts tendered by invitation and open procedures in the reduced sample is 8.8 times smaller (0.17). Thus, also the analysis of the medians from the different samples suggests that the procedure type only explains a minor part (11%) of the difference between conspicuous and inconspicuous contracts.

To sum up, although the Mann-Whitney test seems to suggest that the procedure type influences the *RD*, our analysis of the concrete differences of the mean and the median of the *RD* for the distinct types of contract shows that this influence is weak. In any case, the above presented results are not called into question: If bid-rigging occurred in our sample, it is most likely that the 17 identified firms were involved and the results of the first step remain valid.

5.2.3 Analysis of Firm Interaction

To analyze the interaction between the 17 suspect firms, we started with a simple matrix quantifying how many times a firm had participated in a conspicuous tender at the same time as another firm. In order to arrive at the most comprehensive result possible, we decided to continue the analysis with the 80 conspicuous contracts identified in scenario 1. Our results show that some firms often and regularly submitted bids for the same conspicuous contracts while others either never interacted with other suspect firms or only on a very limited basis. Since it is natural to assume that a bid-rigging cartel involves a certain degree of (regular) interaction between firms this finding is indicative of the non-existence of a collusive agreement between all 17 firms. Based on this argument, the matrix was reduced to sub-matrices of firms that interacted (more or less) regularly with each other. By iterating the process, two potentially interesting groups of firms were condensed. For illustrative purposes we will only focus on one of these groups in what follows.[28]

As can be observed from Table 5, firms *2*, *4*, *5* and *6* seem to interact often and regularly. Consider firm *2*, for example: Overall, firm *2* submitted 17 bids for conspicuous projects. For 16 of these projects (94%) firm *4* also submitted a bid. Furthermore, for 9 (53%), respectively 15 (88%) of these 17 projects firms *5* and *6* likewise submitted a bid. A similar pattern can be found when analyzing the bidding behavior of firms *4*, *5* and *6*. Additionally, all these firms submitted a comparable number of bids for conspicuous projects. Thus, the high degree and symmetry of interaction between these firms may serve as an indication for a group of colluding firms.

Table 5: Interaction between Firms in Conspicuous Contracts

Firm	**1**	**2**	**3**	**4**	**5**	**6**
1	15	2	8	5	1	4
2	--	17	14	16	9	15
3	--	--	45	18	11	17
4	--	--	--	23	12	19
5	--	--	--	--	14	12
6	--	--	--	--	--	20

Consider next that firm *3* is a much larger construction company than the other four firms (*2*, *4*, *5* and *6*). This is reflected in the fact that this firm submitted altogether 45 bids for conspicuous contracts. Besides this fact, the bidding behavior of firm *3* is more or less

[28] All analyses discussed in the following were also conducted for the group of firms identified in the second sub-matrix. Overall, results for this second group of firms are somewhat less indicative. In particular, the degree of interaction between these firms is lower and bidding behavior for conspicuous contracts is less symmetric. In other words, in case there is collusion between the firms in this second group it is not as pronounced as the suspected collusion in the first group.

comparable to the other four firms, which suggests that firm *3* may also be a member of the identified group of possibly colluding firms. Lastly, the somewhat special case of firm *1* needs to be discussed. Firm *1* is a relatively large construction company, too, which, – following a merger – exited the market in 2006. This explains the lower interaction between firm *1* and the rest of the firms in Table 5. Still, until 2006, firm *1* seems to have interacted regularly with the other firms. Therefore, it is not unlikely that firm *1* has also been a member of a collusive group of firms until 2006.

5.2.4 Geographical Analysis

The analysis of the bidding interaction conducted above results in the identification of a group of six firms which were possibly involved in a collusive scheme. By means of the official records of the tender opening, it is further possible to allocate each contract to a specific region. Table 6 shows the number of submitted bids for conspicuous contracts for the six suspect firms, sorted by the eight regions. The numbers in the brackets refer to the number of contracts actually won by the respective firm.

As can easily be observed from Table 6, it is in particular region *A* and *E* where the suspect firms are jointly active. These are in fact neighboring regions. Participation in conspicuous contracts in region *E* is, however, substantially lower than in region *A* and – with the exception of firm *3* – no firm ever won a conspicuous contract in this region. In fact, firms *2*, *4*, *5* and *6* only won conspicuous contracts in region *A*, which suggests that the analysis should focus on this region. Overall, 21 conspicuous contracts are identified in region *A* whereby firms *2*, *4*, *5* and *6* won 19 of these tenders, either alone or as members of a consortium.[29] Only two conspicuous contracts were not won by a member of the suspect group of firms. It is further interesting to note that (with the exception of firm *1* which exited the market in 2006) all firms submitted bids for at least 13 conspicuous contracts and won between three and five contracts.

As mentioned above, firm *3* is much larger than the other firms, which is also confirmed by its wider geographic activity. Although firm *3* submitted the highest number of bids for conspicuous contracts in region *A*, it cannot be excluded that this firm is involved in other (regional) collusive schemes, e.g. in regions *B* and *G*. Keeping in mind that firm *1* is also a large construction company and exited the market in 2006, the same can be said for this firm:

[29] Note that the numbers in the brackets for the contracts won in region *A* sum up to 22 and not to 19. This is due to the fact that a consortium of two firms won a contract in three cases.

in absolute numbers, firm *1* submitted the majority of its bids for conspicuous contracts in region *A*. However, it also won conspicuous contracts in regions *C* and *H* and could therefore have been involved in bid-rigging activities in these regions.

Table 6: Regional Bidding for Conspicuous Contracts

Firm	Region: A	B	C	D	E	F	G	H
1	5 (1)	1 (0)	2 (1)	1 (0)	--	--	4 (0)	3 (2)
2	13 (3)	--	--	--	4 (0)	--	--	--
3	17 (3)	8 (3)	4 (0)	--	6 (2)	2 (0)	10 (4)	3 (1)
4	18 (5)	--	--	--	5 (0)	--	--	--
5	13 (5)	1 (0)	--	--	2 (0)	--	--	--
6	16 (5)	--	--	--	4 (0)	--	--	--

To sum up, the geographical analysis largely validates the results of the group formation process and raises suspicions concerning a local bid-rigging cartel operating in region *A*.[30] In this context, it is further interesting to note that the potential for competition from non-members of the identified suspicious group of firms in region *A* is limited: According to the 2008 firm census of the Swiss Federal Statistical Office, there are only 6 construction firms located in region *A* which identified road construction as their principal business activity. Moreover, region *A* is to a certain extent isolated by a range of hills from other regions of the canton under consideration. This implies a certain distance protection due to transportation costs which play an important role in the construction sector. In addition, region *A* borders several other cantons and such political frontiers may limit market access for potential competitors. Thus, the geographical characteristics of region *A* certainly may create an environment where collusion could potentially be sustained and stabilized.

Still, one has to account for the possibility that the observed bidding pattern may not be attributable to collusion but to specific characteristics of the tendered construction contracts in region *A*. Given the information in our data set, we can control for two important factors: the number of bids and the size of the contracts. To test whether the number of bidders and the size of the contracts differs significantly between region *A* and the other regions, we use again a Mann-Whitney and a Kolmogorov-Smirnov test. For both factors we do not find significant

[30] Our observations are also supported by a Chi test: There is a statistical significant relationship between regions and conspicuous contracts in our sample.

differences between region *A* and other regions.[31] Hence, it can be excluded that these two factors explain the identified conspicuous bidding pattern in region *A*.

6 Screening for Bid Rotation

In a final step, we focus on the practice of bid rotation in order to further substantiate the group formation process and to produce a better understanding of the organization and operation of a possible bid-rigging cartel.

6.1 The Connection between Bid Rotation and Cover Bids

The practice of bid rotation typically involves submitting cover bids for contracts. Bid rotation is likely to produce a distinct bidding pattern: whenever the designated winner submits a "low" bid, all other firms will submit a deliberately "high" bid. To test whether the members of the potential bid-rigging cartel systematically behave in a way consistent with bid rotation, we start by normalizing bids. This is necessary since the value of the contracts in our sample varies considerably, i.e. it is not possible to directly compare individual bids from different contracts. A well-known standard transformation to normalize bids in a contract *j* is the following:

$$b_{j,i}^{norm} = \frac{b_{j,i} - b_{j,\min}}{b_{j,\max} - b_{j,\min}} \in [0,1]$$

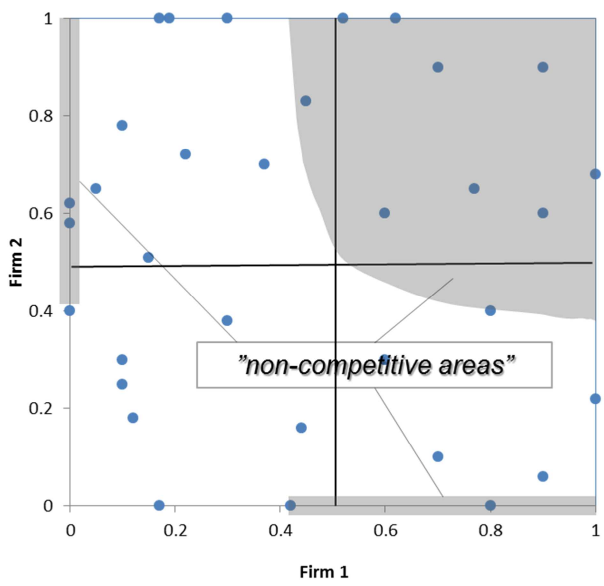
where $b_{j,i}$ denotes the bid of firm *i* and $b_{j,\min}$ ($b_{j,\max}$) the lowest (highest) bid in tender *j*. This transformation assigns a value between 0 and 1 to every bid in our sample and therefore allows for a comparison of different-valued bids. Note that value 0 is always assigned to the lowest bid, while the highest bid gets assigned value 1.

With the help of these normalized bids, it is now possible to analyze the bidding behavior of the suspect firms pairwise. The basic idea of this analysis is illustrated in Figure 4: For all

[31] The Mann-Whitney test does not reject the null hypothesis of no difference for the number of bidders per tender between the region *A* and the others regions, with a z-statistic of 0.45 (*p-value*: < 0.65). In addition, the Kolmogorov-Smirnov test does not reject the null hypothesis of no difference with an asymptotic Kolmogorov-Smirnov statistic of 0.99 (*p-value*: < 0.33). We find the same qualitative results for the size of contract with a z-statistic of 0.99 (*p-value*: < 0.33) and an asymptotic Kolmogorov-Smirnov statistic of 1.09 (*p-value*: < 0.18).

conspicuous contracts, in which two suspect firms simultaneously submitted a bid, the corresponding normalized values are shown in the x/y-space. A point on the ordinate or the abscissa implies that one of the two firms actually won the contract, i.e. submitted the lowest bid in a distinctive contract.[32] For all other points, none of the two firms considered in the diagram were assigned the contract.

Figure 4: Competitive vs. Non-Competitive Bids



In a competitive environment – i.e., when firms calculate bids independently – one would expect the combinations of bids to be distributed (more or less) randomly in the x/y-space.[33] The most competitive combinations of bids are to be found in the bottom left quadrant close to the origin. Furthermore, combinations of bids where only one firm bids aggressively are to be found close to the ordinate respectively the abscissa. In general, when firms bid independently (i.e., in a situation without collusion) one would expect to find a certain mass of points in the bottom left, the top left and the bottom right quadrant of Figure 4.

In contrast, if bids are systematically calculated to ensure that a designated firm wins a tender – i.e., cover bidding is present – one would expect to find the following graphical pattern: First, there should be a tendency to find cover bids submitted for the other considered firm either on the ordinate in the top left quadrant or on the abscissa in the bottom right quadrant. Second, if the considered firms jointly and repeatedly cover other cartel firms, this will lead to

[32] All of the 21 conspicuous contracts analyzed in section 5 and 6 were awarded to the lowest bidder.
[33] This intuition is confirmed by an analysis of the bidding behavior of non-suspicious firms and contracts in our sample: bids are not accumulated in particular regions of the x/y-space, i.e., they are – more or less – evenly distributed all over the x/y-space.

a certain mass of points in the top right quadrant. The shaded areas of Figure 4 show where cover bids are likely to be found.[34]

6.2 Empirical Implementation

Figure 5 shows the pairwise bidding behavior of the six suspect firms for the conspicuous contracts in region *A*.[35] Each contract is assigned a number indicating the firm which actually won the respective contract. Note that there is one contract not won by the group of the six suspect firms. This contract is marked with a zero. Furthermore, when a consortium wins the tender, the number of both firms is indicated. As can easily be observed, the individual diagrams do not point in the direction of much competitive interaction between the suspect firms. Rather, the depicted bidding behavior seems compatible with cover bidding: there are hardly any points in the area where competitive bids would be expected. The bottom left quadrant is in all cases empty or near empty. Furthermore, there are no loosing bids notably lower than 0.4, which suggests that there are substantial price differences between the winning and the losing bids in all respective contracts.

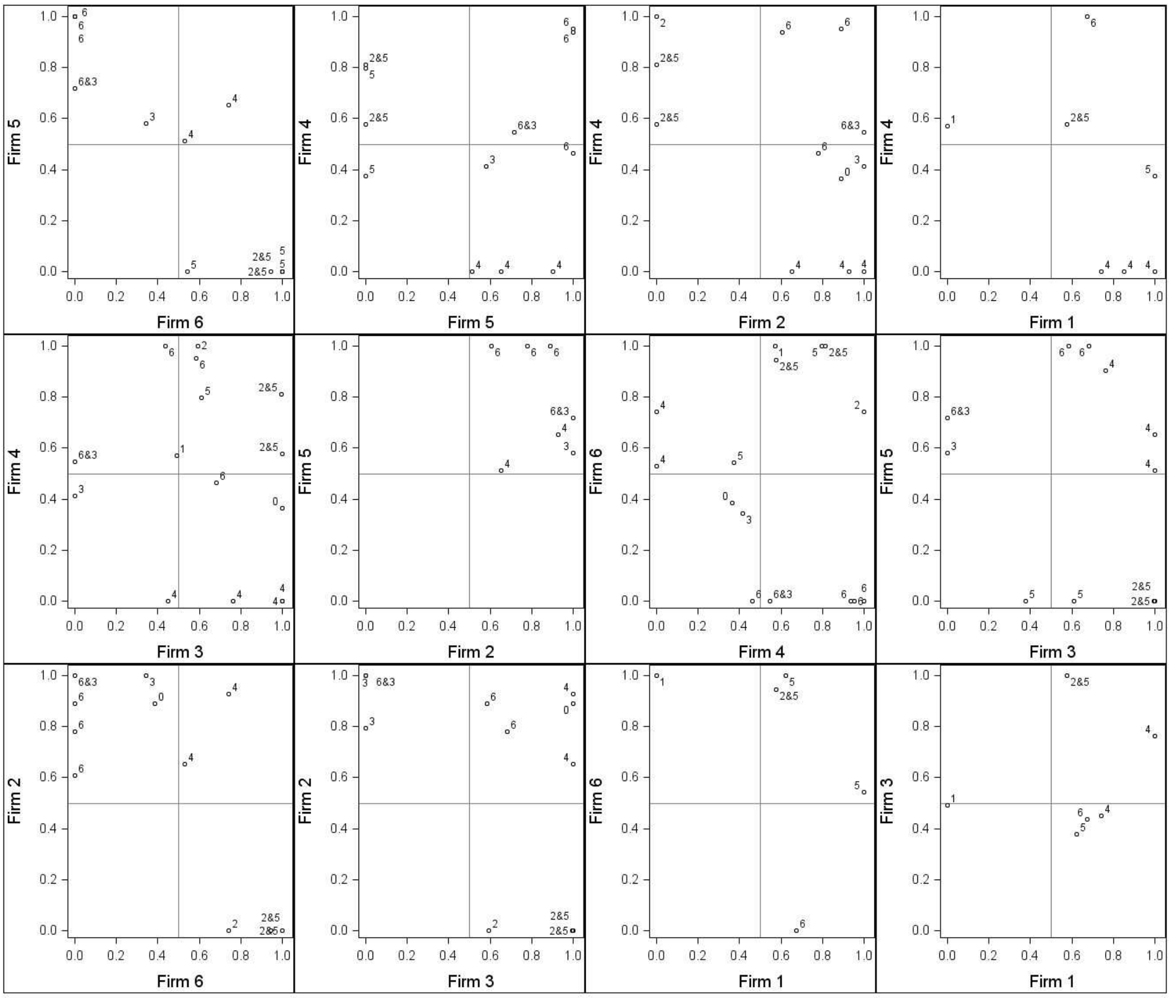
This first result does not come as a complete surprise since all considered contracts showed a certain conspicuousness as pertaining to the cover bidding test, i.e., these contracts are *inter alia* characterized by the fact that the difference between loosing bids is systematically smaller than between the winning and the second-best bid. The diagrams contain, however, much more information. In particular, they visualize the connection between cover bids and bid rotation: From Figure 5, we observe that all suspect firms submit bids for conspicuous contracts with pronounced regularity.[36] Each of the suspect firms has on average and simultaneously with another suspect firm submitted bids for roughly 10 conspicuous contracts. An additional analysis shows that suspect firms exclusively submitted bids for 14 contracts, and that 91% of all submitted bids came from the suspect group of firms. These results and figures point in the direction of a high degree of entanglement between the suspect firms.

[34] Note that it is not possible to precisely determine the boundaries of the areas where cover bids are likely to be found. The boundaries of the shaded areas in Figure 4 should be regarded as indicative.

[35] We renounce to show three graphs in Figure 5 since they are characterized by very few interactions between the two bidders and are therefore not illustrative. All three suppressed graphs involve firm 1 which exited the market in 2006.

[36] It should not be assumed that all suspect firms submit a bid for every rigged tender. Factors, such as the specialization of firms, distance to the construction site, capacity utilization etc., decide which firms of a cartel will submit a bid for a distinct contract. Furthermore, the possibility of bid suppression has to be kept in mind.

Figure 5: Pairwise Bidding Behavior for Suspect Firms in Region A



There is another interesting observation derived from Figure 5. Considering the winning bids on the ordinates and abscissas, we observe a certain symmetry: The number of winning and (possible) cover bids between the individual firms is largely equal.[37] This may be taken as an indication for the fact that "scores" between the firms exist and get settled. In summary, the identified group-internal bidding behavior may well be compatible with a bid-rigging cartel operating with cover bids and a – more or less pronounced – rotation scheme.

[37] Since the distinct contracts vary with respect to contract values, there is no reason to belief that the number of winning and (possible) cover bids between two firms must necessarily be equal. A cover bid for a large contract may e.g. be worth two cover bids for smaller contracts.

7 Conclusions

A successful fight against bid-rigging today still largely depends on whistle-blowers or leniency applicants. Screening tools may therefore constitute important instruments to mitigate the dependency on these external sources and actively reinforce the fight against bid-rigging. Besides the benefit of identifying concrete bid-rigging cartels, the successful implementation of cartel detection instruments is furthermore likely to have a strong deterrence effect. In this paper, we presented – based on simple collusive markers – a detection method characterized by the following four properties: Its data requirement is relatively modest, it is simple and flexible to apply, and it has produced sufficient evidence to open an antitrust investigation. In our view, all of these properties are crucial for preventive screening activities of a competition or procurement authority.

Our approach to detect bid-rigging contributes to the screening literature in several ways. First, we present a new statistical marker to detect cover bidding. Second, we call attention to the possibility of partial collusion, which implies that the classical markers discussed in the literature will fail, and propose a way to deal with this problem. In particular, we show how benchmarks and the combination of (uncorrelated) screens may be used to identify subsets of conspicuous contracts and firms. To substantiate and validate suspicions of collusive behavior, we further discuss a collection of mutually reinforcing tests providing conclusions as to whether a bid-rigging cartel is likely to exist.

Applying our method to a road construction procurement data set in which no prior information about collusion was available, we succeeded in isolating a group of "suspicious" firms exhibiting the characteristics of a local bid-rigging cartel operating with cover bids and a – more or less pronounced – bid rotation scheme. Based on these results COMCO opened an investigation in 2013. The conducted house searches produced proofs of collusion and led to a conviction and sanctioning of the involved firms in 2016 by COMCO as court of first instance.

Although our method delivers coherent results applied to uncovered bid-rigging cases in Switzerland, it remains to a certain degree, as all other methods discussed in the literature, case-specific and data driven. Depending on the specific features of the industry, in which bid-rigging is suspected, some of the suggested tests may be inapplicable. Others may have to be extended, refined and adapted. Given that collusion may take a multitude of forms in the real world and data availability may differ from case to case, the flexibility of our "toolbox-approach" seems to be more of an advantage than a disadvantage.

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