NATIONAL RESEARCH UNIVERSITY
HIGHER SCHOOL OF ECONOMICS

Ilya Morozov, Elena Podkolzina

COLLUSION DETECTION IN PROCUREMENT AUCTIONS

BASIC RESEARCH PROGRAM

WORKING PAPERS

SERIES: ECONOMICS
WP BRP 25/EC/2013

Ilya Morozov[1], *Elena Podkolzina*[2]

COLLUSION DETECTION IN PROCUREMENT AUCTIONS[3]

This paper proposes a method of bid-rigging detection, which allows us to reveal cartels in procurement auctions without any prior knowledge of the market structure. We apply it to data on highway construction procurements in one of the Russian regions and show that five suppliers demonstrated passive bidding behavior, which is consistent with the so called 'rotating bidding' scheme of collusion. The suggested methodology can be potentially used by both researchers and anti-trust agencies for cartel disclosure in various markets.

JEL Classification: H57, L41, L92.
Keywords: Bid-rigging, Tacit collusion, Public procurement, Cartel, Open auction.

[1] Research Assistant, International Laboratory for Institutional Analysis of Economic Reforms, morozov.hse@gmail.com

[2] Senior Researcher, International Laboratory for Institutional Analysis of Economic Reforms, epodk@hse.ru

[3] The study was implemented in the framework of the Basic Research Program of the Higher School of Economics in 2011-2012. We are grateful to the participants of Workshop "Institutions viewed by Economists and Sociologists", XIII April international "Conference on Economic and Social Development", and participants of Workshop "Public Procurement: Current Research Trends" for their helpful suggestions. We are also thankful to Maria Yudkevich, Mikhail Drugov, Russell Pittman, Maarten Janssen and Ricardo Perez Truglia for priceless comments.

"People of the same trade seldom meet together, even for merriment and diversion, but the conversation ends in a conspiracy against the public, or in some contrivance to raise prices."

(Adam Smith. The Wealth of Nations)

1. Introduction

How to detect collusion? This question is urgent not only for researchers, but also for governments and taxpayers. In the private sector owners pay much attention to designing procedures in a way that breaks the possible collusive behavior of agents. However in the state sector purchasers have no incentives to encourage healthy competition – they do not take full responsibility for their actions and do not spend their own money. They therefore have few incentives for minimizing prices and controlling the quality of the goods and services supplied. Moreover, purchasers may be corrupt and may serve as cartel protectors, not as the defenders of fair competition. As a result, the burden of market regulation may lie with anti-trust agencies. If the latter fail to make the game fair, it is the taxpayers who will have to pay higher prices for the goods and services they receive.

Between January 2010 and December 2011 the Russian Federal Antimonopoly Service (FAS) filed more than 2000 cases of collusion, including nearly 300 cases of bid rigging in procurement auctions[1]. Most of the firms which colluded in government procurements were accused of so called 'passive behavior' – a bidding pattern often used to create the illusion of competition. FAS marks out three variations on this scheme. In the first, cartel members meet prior to the auction and decide who is going to be the only applicant. In the second, all or most of collusive firms apply to an auction, but only one participant shows up at the day the auction is carried out. In the third scheme, passive behavior may appear is when all conspiracy members show up, but only one of them is a serious bidder struggling with non-cartel firms, if any. In all three forms, a winner defined prior to the auction wins the contract at nearly the maximum price, the only difference is the way other cartel members are involved. Passive bidding of these three types, also known as "bid-rigging", was revealed in auctions for the delivery of gasoline and drugs, the construction of public buildings, bridge

[1] RG, 7 June 2011 (http://www.rg.ru/2011/07/07/kartel.html).

repair, road construction and maintenance, and lumber supplies[1]. In all cases the government budget, and therefore taxpayers, suffered substantial losses.

This paper suggests an econometric procedure that can be used to detect collusion based on passive bidding. We analyze data on highway construction procurement auctions and conduct the analysis in two steps. We start with the assumption that if bid-rigging is present, it is likely to give rise to relatively high prices, which are normally concentrated near the estimated contract value. In the first step, all auctions are divided into two groups using relative price (winner's bid divided by the estimated price of the contract). To choose the boundary of the division, we assume that in all-inclusive cartels firms rarely bring down price lower than by 5-10% of the initial level (Ishii, 2009). We place all auctions with winning bid-to-reserve ratio higher than 90% in the first group, and the rest in the second. Note that the division is conventional and should ideally be based on some general notion about the normal price level in the local market. Below we offer some proof in favor of using a 90%-boundary, but we also conduct a test for robustness by repeating the analysis using an 80%-boundary and by conducting analysis within the upper and the lower quintiles.

The second step is to find different behavior patterns between the groups. To illustrate the idea, we conduct a regression analysis in the spirit of Porter and Zona (1993, 1999) and show that in the low-price group of auctions price variation may be explained by competitive mechanisms. Relative price depends strongly on the number of participants, and on firm-specific characteristics like their capacity and experience. This result is consistent with competitive equilibrium characterized by diminishing returns to scale and the learning-by-doing process. By contrast, in the high-price group the same laws no longer work. Firms do not alter bids when the competition they face changes substantially. Moreover, regardless of the abilities to fulfill the project, suppliers are reluctant to bid aggressively or merely do not submit any bids in the auction. This discrepancy between bidding strategies in the two groups can be a sign of competitive and collusive equilibria, presented correspondingly in low- and high-ratio auctions.

[1] One can find bright examples in Ria Novosti, 21 October 2010 (http://www.realty.rian.ru/news/20101021/97470.html), Karelia FAS website, 9 June 2011 (http://karelia.fas.gov.ru/news/4796),
Ural Stroiportal, 28 April 2010 (http://www.uralstroyportal.ru/news/print5174.html),
Ural Vedomosti, 25 January 2012 (http://u17955.netangels.ru/main/20001/page/7),
Bank Fax, 19 June 2009 (http://www.bankfax.ru/page.php?pg=61296), and
NEP-08, 24 April 2012 (http://www.nep08.ru/law/news/2012/04/24/shtraf).

Although the idea of estimating bidding patterns within various samples is not innovative, our approach is different in two respects. First, it employs an extended list of explanatory variables to conduct a detailed analysis of the data. Such broadened specifications allow us to control for crucial characteristics of the constructors, weakening the potential problem of endogeneity. Second, it aims to detect a conspiracy without any prior knowledge of the market structure. The latter is extremely difficult to achieve; however it is obviously more useful. The proposed method of collusion detection can be potentially used by both researchers and anti-trust agency to reveal cartels in various markets.

The current paper also considers one case revealed with the proposed two-step method. We provide some evidence that five firms behaved in a way which is consistent with rotating scheme of collusion. During 2010 the firms under consideration earned 12 contracts and received more than 360 million rubles, which is 8,5% of all road construction contracts awarded in the region for that year. They routinely applied for auctions and either did not come, or showed up but did not submit bids. We show that no matter how many applications were sent by these firms, the price decrease never exceeded 1% of the estimated price, which is a clear sign of collusive behavior. Although it is not clear whether some other suppliers were involved in bid rotating, 'friendly' relations between the five firms in these cases are widely known in the region and discussed in the local media. It is also notable that the investigation of this case was started in 2011 by the regional FAS department, but no evidence of suppliers' guilt has been presented so far.

Section 2 explains various methods of passive bidding detection suggested in the literature. Section 3 describes the general approach of collusion detection we propose. Section 4 discusses specific features of the road construction market. Section 5 describes some peculiarities of the Russian government procurement system, and section 6 provides the information on the data sample used. Section 7 shows the main results of the data analysis. Section 8 presents one case of bid-rigging revealed with the use of the proposed method. Finally, Section 9 contains two policy recommendations drawn from the results obtained and provides some open questions for discussion. Section 10 ends with concluding remarks.

2. Literature review

In general, no unique method can be developed to detect cartels. As Hendricks and Porter (1989) put it, *"collusion in auctions can take many forms, and it is important to tailor empirical work to specific cases".* Our paper concentrates on a concrete scheme referred to as ‘rotating bidding’ in auctions (McAfee and McMillan, 1992; Lee and Hahn, 2002). In this scheme cartel participants usually choose a pre-arranged winner before the auction date, for instance, by conducting an oral auction inside the cartel. The bids at the real auction are then submitted in a way to let designated firm win the contract at the highest possible price. For this reason, suppliers stay inactive or submit intentionally high bids. The last not only maintains the price, but also creates an illusion of healthy competition and blunts the vigilance of the anti-trust authorities. Such behavior typically leads to lower budget savings and the wasting of taxpayers’ money. We limit our analysis to this type of collusive strategy and provide some thoughts in Section 9 on how this approach can potentially be extended.

How can collusive behavior be detected? There is a growing set of papers on the subject of passive bidding detection. All articles can be roughly divided into two groups. The first group of articles, estimate structural models of collusive and competitive behavior. Bajari (2001) develops computational algorithms for the structural estimation of models, which are useful both in collusion detection and in estimating costs due to cartels. Baldwin et al. (1997) analyze data on timber purchase auctions in the Pacific Northwest from 1975-1981 and construct a model using information about all the submitted bids. Their research is based on the idea that in a competitive environment, the winning bid is likely to be the second-lowest statistic of costs distribution, but if collusion appears, this may be no longer the case. Bajari and Ye (2003) identify a number of conditions which are necessary and sufficient for a data sample to be competitive. They refer to them as ‘conditional independence’ and ‘exchangeability’. They find that only a few firms fail to satisfy these conditions, and those who failed were previously sanctioned for collusion in this market. Comparing the performance of collusive and competitive models is suggested in Banerji and Meenakshi (2004). The researchers analyze the data on oral wheat auctions in India to find out whether three large firms colluded. They consider the asymmetric model with independent valuations and assume that a rotating scheme of collusion is employed. The results they show clearly demonstrate that the collusive model outperforms the competitive model on the data set used. Altogether, the testing of structural models provides a useful instrument for revealing cartels. However, it is demanding as it requires full information about the bid distribution. Detailed data might be unavailable for a researcher since many procurement systems hide information to prevent collusion[1].

[1] For example, in Russian regional sites of government procurements only the lowest (or, in some cases, the first and the second lowest) bid is published.

The second group of papers includes those which use regression analysis to distinguish collusive and competitive bidding behavior. Porter and Zona (1999) provide evidence from Ohio school milk auctions and concentrate on cost analysis. Since milk is very expensive to ship, the distance from the supplier's warehouse to the school should have a significant influence on a firm's bids. Porter and Zona find that some suppliers submitted bids in distant districts well beyond bids in their local sites, which is consistent with collusion presence. The authors note that these firms were previously accused of collusion in this market. A similar approach but using other methods is employed in Hendricks and Porter (1988) to analyze offshore gas and oil drainage auctions. They reveal that in auctions where incumbents appear the level of the winning bid does not depend on the number of bidders. Moreover the mean value of the bids is likely to be a decreasing function of the competition intensity. This can be treated as a sign of the phony bidding in which only one serious bid is usually submitted and other cartel members submit higher frivolous bids so as to create the appearance of competition.

3. The Model

We start our analysis by splitting the data sample into parts. This step is based on the assumption that passive bidding, if present, results in high relative prices – in our terms in higher values of the winning bid-to-reserve ratio. By contrast competitive bidding normally pushes the relative price down. To capture these different bidding patterns we divide the data sample into two groups, high- and low-ratio groups of auctions. The key issue here is how to choose the boundary. It is reasonable to expect that collusive bidders will not decrease the price more than by 1-5% of the maximum level. This sum is considerable enough to create an illusion of competition as it exceeds the auction step in open auction, but still allows the earning of a nearly monopolistic rent[1]. Also evidence from real cartel cases confirms that conspirators often bid from 0,5 to 5% less than the initial contract price and rarely submit bids lower than this in the absence of competitive players[2]. Thus a 95% boundary of division seems to be the most appropriate for the case of phantom bidding. In our data sample only 15% of observations fall in the group of 95%-and-higher prices. For this reason we use a 90% boundary instead of 95% to allow more variation in the relative price and considered

[1] In fact, the boundary should be determined on an ad hoc basis and should be based on the overall austerity of anti-trust control as well as on institutional issues (for example, legislative restrictions which set auction rules).

[2] See, for example, NEP-08, 24 April 2012 (http://www.nep08.ru/law/news/2012/04/24/shtraf), Bank Fax, 19 June 2009 (http://www.bankfax.ru/page.php?pg=61296), and Ural Vedomosti, 25 January 2012 (http://u17955.netangels.ru/main/20001/page/7).

parameters (Section 7). As a robustness check we then run the same specification regressions with 20% boundary and by lower and upper quintiles. The last quintile analysis is done to make the distinctions between bidding patterns clearer (See Appendix 1).

In the second step, we conduct a regression analysis of the obtained groups. We use winning-bid-to-reserve ratio (RATIO) as a dependent variable, which reflects the auction output. As some authors argue, the use of relative price helps both to normalize data across the sample and to reduce the problem of heteroskedasticity, so OLS estimates are expected to be more effective and credible (Bajari and Summers, 2002; Skrzypacz and Hopenhayn, 2004; Porter and Zona, 1993)[1].

The independent variables we include in the model measure the level of competition and some firm-level characteristics. We include variable NUMFIRMS which stands for the number of bidders who showed up for the particular auction. According to the theoretical findings in a competitive environment the winning bid normally decreases as the number of participants increases (Brannman et al., 1987; Holt, 1979; Harris and Raviv, 1981a; Menezes and Monteiro, 2000). On the contrary, in auctions where passive bidding takes place firms do not decrease their bids significantly, and some of them do not participate in actual bidding process at all. We expect NUMFIRMS to have weaker effect on auction output in the high-price group of auctions if the last is collusive.

Porter and Zona (1993) and Jofre-Bonet and Pesendorfer (2000) show that the bidding behavior of construction firms is strongly affected by capacity constraints. Road construction is a large-scale and costly business, and strategies of construction firms depend strictly on the number of machines and workers as well as on material stocks available at the time. Bidders who have won a certain number of contracts recently have higher costs and are not likely to bid aggressively for near-term auctions. We use variables CAPACITY and CAPSHARE to control for this effect. They take higher values in auctions where the winner has a large volume of ongoing projects. Thus, they are expected to have a positive influence on the relative price.

In addition to this, we also include LOTS, a variable which stands for the number of positions (called 'lots') being auctioned at a time. We suppose that if several auctions are conducted in

[1] Focusing on price ratio also allows us to discuss 'government saving', which is usually calculated as the difference between the winning bid and the reserve price as a percentage of the reserve price. That is important because Russian Federal Law on government procurements implemented in 2005 is aimed to stimulate competition, which "may help to achieve higher budget savings".

a short period of time, it lessens the average volume of free capacities per one auction. Suppliers tend to concentrate on one or two particular contracts and bid less aggressively on the rest of the auctions, which can decrease the overall level of competition (Baldwin, Marshall, and Richard, 1997). Therefore, we expect LOTS to have positive effect of winning-bid-to-reserve ratio. We also expect that in auctions where cartels participate, measures for capacities and number of lots will demonstrate insignificant coefficients, as collusive firms divide contracts on a non-competitive basis.

The winner's experience is also included in the regression model. Variable EXP is the number of contracts the winner fulfilled in the previous 3 years in the same region. This variable controls for any potential decrease in costs, which may occur due to the learning-by-doing process. Other things being equal the incumbent firm, which has already completed several projects in the area has more information about specificity of the cost structure and the current condition of the roads, which may be treated as cost advantage. We assume that higher experience leads to lower costs so EXP is expected to have a negative effect on price and should have no influence in auctions with collusive bidders. To check for the stability of results in the second model we replace EXP by AGE, which is calculated as the period in years since firm was registered by the local tax administration (computed at the day of auction); CAPITAL is the fixed capital of a firm from its balance sheet. The last two variables are anticipated to demonstrate the same behavior as EXP.

The model may be subject to the endogeneity problem. As Gupta (2001) argues, those contracts with potentially higher profit normally attract more bidders and reverse causality appears. In this case the effect of competition on the winning bid-to-reserve ratio turns out to be underestimated. To eliminate this bias Gupta proposes including contract-level information such as the contract value in the regression model. Following this logic, we include 'contract type' dummy variables to correct for the size of the construction work and therefore weaken the endogeneity bias.

4. Market

A number of determinants create a favorable environment for collusion in the highway construction market. First purchasers only hold one-dimensional procedures to award construction contracts: since 2010 purchasers are not allowed to conduct beauty contests in the procurement of road works. The selection of the winner is usually based only on financial bids, which simplifies coordination as firms only need to cooperate in price. Moreover, firms have an opportunity to increase spoils at the expense of quality by making so called 'patchwork repairs' instead of profound road repairs. So there is a huge pie to divide among members of a potential collusion, especially in the regions where quality control is not strict.

Second, the number of auction participants is strictly limited. The fact that cooperation is more easily sustainable in small groups is widely-known and discussed, for instance, in the fundamental papers of Selten (1973), Comanor and Schankerman (1976), Weiss (1989). Traditionally, there are only a few firms in the local construction market which are able to undertake large works. Because of high entry barriers (large capital investments are necessary to start road construction), new firms are unlikely to appear. This facilitates coordination and allows large incumbent constructors to bid less aggressively in the absence of outside competition.

Finally, road work purchasers (usually the Territorial Highway Administrations (THA)) exhibit stably-inelastic demand. Every year the region sets an overall budget for the Territorial Administration to spend on road construction and repairs in the region thus, demand is fixed. Moreover it shows a positive tendency as the regional budgeting of the highway industry has been expanding for the last 10 years and is likely to continue in the short term. This is due to a new program of road construction and renovation which was started in May 2011 and is targeted to double the rate of road building in Russia within the next decade [1]. All this enlarges potential profits and creates favorable conditions for construction firms to organize a cartel (whether explicit or tacit).

These market peculiarities make collusion extremely profitable. A growing number of authors find cartels in highway construction. This includes papers of Feinstein et al. (1985) on collusion in North Carolina; Porter and Zona's (1993) research on Long Island's cartel in New York highway construction; and Gupta (2001) considers collusion in Florida highway auctions. Lee and Hahn (2002) provide some evidence on the existence of 'incumbency' collusion scheme among Korean highway and railroad constructors; Padhi and Mohaparta (2011) find a cartel in the Indian Orissa road construction market. It is notable that due to the results of the survey conducted among constructors in different countries, collusion is often perceived by the firms working in highway construction as the 'order of the day' and

[1] According to an article published in *The Guardian,* then Prime Minister Vladimir Putin announced that Russia will spend $285 bn over the next decade for road construction and maintenance. The decision was made in response to The World Bank's recent report, which stated clearly that "Russia's road infrastructure was restricting economic growth, with only a third of all roads meeting quality standards", Monday 30 May 2011.
(http://www.guardian.co.uk/world/2011/may/30/vladimir-putin-road-building-programme).

surprisingly they do not it to be harmful. See, for instance, articles of Zarkada-Fraser and Skitmore (2000), and Doree (2004) about Australian and Dutch cartel cases respectively.

The road construction is exposed to a high risk of collusion, and the Russian market is far from being an exception. Russian highway construction is traditionally discussed as 'the tastiest morsel' for conspirators, and tens of investigations connected with cartels in road building are launched every year. Some recent cases are Foratek Company in Sverdlovsk (Ural Vedomosti, 25 January 2012), Sverdlovskavtodor in the same region (NEP-08, 24 April 2012), six constructors in Altai (Bank Fax, 19 June 2009) and 18 firms in Stavropol (Ria Novosti, 21 October 2010); these are merely the tip of the iceberg. Highway construction seems to be an ideal place for conspiracy, so it is reasonable to search for collusive schemes in this market.

5. Russian procurement process

The procurement process in Russia is regulated by the Federal Law No. 94 "On Placement of Orders to Supply Goods, Carry out Works and Render Services"[1]. The law obliges procurers of goods and services (if the latter are estimated value more than 100 000 rubles or $3 300) to choose the most efficient suppliers through conducting competitive procedures. The procurer has a choice among open first-price auction (both oral and electronic auctions can be chosen), tenders (sealed-bid first-price auction) and so called 'beauty contest' which is also known as negotiation. No pre-qualification or capacity claims can be laid to potential bidders in auctions, so 'beauty contests' are the only procedure which allows procurers to control for quality. However, nowadays regulators persistently push the idea of procurement transparency and recommend purchasers to conduct open auctions, which break collusion, providing equal chances for all contractors. And Russian practice shows that procurers only rarely employ negotiations in order placement[2].

Since 2005, when the Federal Law was implemented, government procurers were obliged to publish auction documentation on the websites of regional procurements[3]. The procurement placement process normally starts with the announcement of an auction. At this stage, the

[1] Federal Law No. 94-FZ of July 21, 2005 "On Placement of Orders to Supply Goods, Carry out Works and Render Services for Meeting State and Municipal Needs".

[2] Moreover, due to an amendment to the Federal Law, which came into force in July 2010, construction and renovation contracts should be awarded only through open auctions (oral or electronic). Beauty contests are forbidden for this type of contract.

[3] Later, due to the Federal Law N223, entered into force on 1st January 2012, all procurers became bound to reveal information on a single website of federal procurements.

technical details of the purchase, the reserve price, deadlines for application and the date of the auction are published on the web and become publicly available. Then firms start the process of application. This process includes gathering documents which should be attached to an application letters. Firms are also obliged to pay a guarantee fee before sending an application letter in open auctions, so the application process is has both financial and time costs. Note that because of this firms are not likely to apply for an auction and incur these costs, if they have no interest in the government contract. The number of applications sent to the auctioneer can therefore be a good proxy for the level of real competition.

When the application process is complete, it takes from 4 to 7 days for purchaser to approve the applications. Those firms getting authorization for participation are allowed take part in bidding process. Then on the scheduled day representatives of those firms which decided to take part in tender, come and participate in an oral auction. The firm which submits the lowest bid, wins the contract, and information about the identities of all participants, the winner's identity and the price of the contract is published on the website within 1-2 weeks. In the case of sealed-bid auctions, document packages and submitted bids are sent to the auctioneer simultaneously, and then the auctioneer opens envelopes and chooses the lowest bidder among those which sent all the necessary documentation. The contract is awarded to the winner at the price equal to their bid. If the winner of auction refuses to conclude the government contract, the procurer is allowed to award contract to the firm which submitted the second lowest bid. In this case, when there is initially only one participant in the auction, the procurer can award them the contract at the reserve price or at any price below this level (subject to agreement).

The only anti-trust regulator of the procurement process is the Federal Antimonopoly Service (FAS). The FAS monitors the whole procurement process and has the right to attach administrative sanctions to the firms which demonstrate collusive bidding patterns[1]. Also, contractors can appeal to the FAS and complain about unfairness of the conducted procurement procedure or the illegal actions of other firms. Generally however, in government procurements the FAS only reveals cases of collusion which are obvious and transparent. In auctions on highway construction works, which are the focus of this paper, only two cartels were detected in the last 5 years. One of them, a collusion between road constructors backed by the public bodies, was revealed in Sverdlovsk region after six months

[1] Federal Law No. 135-FZ of July 26, 2006 "On protection of competition" allows FAS to attach sanctions even for so called 'tacit collusion', if it provide evidence of simultaneous prices adjustment conducted by suppliers.

of discussion in the regional media[1]. Moreover in certain regions cartels are regularly disclosed but in some others, like in Novosibirsk region, which is our focus, no cartels have been revealed in last five years in any industry. This could be a sign of weakness and inability (or unwillingness) to hunt for the conspirators in the regional FAS. A lack of anti-trust monitoring can strengthen incentives for the firms to collude or at least create a favorable environment for a tacit coordination.

6. Data

The data set is on auctions conducted in Novosibirsk region, one of the Russian regions located in the Siberian Federal District. The full sample which we use for the calculation of firms capacities consists of 172 first-price open auctions for highway construction contracts which are summarily divided into 495 lots. These were all carried out in the region from January 2008 to December 2010. Three levels of data are presented in the sample: federal, regional and municipal procurement auctions. The former is a responsibility of federal ministries and is usually connected with the construction of the so called 'highways of federal importance', while the latter two – regional and municipal orders – are normally placed by Local Administrations and Departments.

Because of bareness of federal- and local-level data, in regression analysis we use a subsample of auctions which include only regional level procedures. These were all conducted by the only purchaser in region, the Novosibirsk Highway Administration (NHA). The total number of lots in the auctions is 296, and 80 of them which ended without any price decrease, are dropped from the sample. This was done to avoid a potential bias that can be caused by jobs receiving only one application to bid. We will turn to the analysis of the excluded observations later (see Section 8, where we provide a case-study of potential conspiracy).

Information on regional orders is obtained from the regional procurement website[2], where procurers are obliged to publish information about current and past auctions and 'beauty contests'. The details comprise the following information for each lot: reserve price (maximum price, estimated by the purchaser) and the winning bid, the identity of all participants and of the winner, the time assigned to complete the project, the date of the auction, the location of road section, the contract type, and the number of lots.

[1] According to the article published in Ural Vedomosti, 25 January 2012 (http://u17955.netangels.ru/main/20001/page/7/).
[2] http://oblzakaz.nso.ru/index.html

The list of variables included in the regressions is the following:

MAXPRICE Starting (maximum, reserve) price in the auction;

WINPRICE Winning bid – the lowest bid of those submitted by auction participants;

RATIO Winning bid-to-reserve ratio, WINPRICE divided by MAXPRICE ;

NUMFIRMS Number of participants who sent applications to participate in auction (and were admitted to the tender by the purchaser);

TYPE_4 (5,6,7) A set of dummy variables, 4 – road construction, 5 – capital repairs, 6 – bridge construction, 7 – current repairs (road maintenance);

LOTS Number of lots in the current auction (number of simultaneous auctions);

CAPACITY Total value of ongoing projects of the winner. Calculated on the assumption that road works are done uniformly during the whole period from the date of contract to the specified deadline. The variable is a proxy for how 'busy' the winner is and therefore for his marginal costs.

LN_CAPACITY Logarithm of CAPACITY;

EXP Experience of winner. The number of contracts won in the same region on all (federal, regional and municipal) levels since 2008.

We now follow the logic described in Section 3. We first divide the data sample into two groups: low- and high-ratio auctions using a 90% cutoff. Descriptive statistics by obtained groups are reported in Tables 1.1 and 1.2.

Table 1.1

Descriptive statistics for low-ratio auctions (RATIO<90%)

Variable	Mean	Std. Dev.	Min	Max
RATIO	0,722	0,142	0,305	0,895
MPRICE (th.rub)	18935,62	17396,6	522,17	99440,29
WPRICE (th.rub)	13900,39	12954,8	265,14	77066,23
NUMFIRMS	3,82	2,04	1,0	13,0
TYPE_4	0,206	0,407	0	1
TYPE_5	0,237	0,428	0	1
TYPE_6	0,206	0,407	0	1
TYPE_7	0,351	0,480	0	1
LOTS	14,3	18,7	1,0	55,0
LN_CAPACITY	12,62	8,545	0,0	22,20
EXP	8,77	14,630	0	55

Number of observations: 126

Table 1.2

Descriptive statistics for high-ratio auctions (RATIO≥90%)

Variable	Mean	Std. Dev.	Min	Max
RATIO	0,973	0,030	0,900	0,996
MPRICE (th.rub)	12319,59	8839,0	371,19	37952,70
WPRICE (th.rub)	12013,23	8733,5	350,77	37573,17
NUMFIRMS	2,91	1,28	2,0	7,0
TYPE_4	0,182	0,392	0	1
TYPE_5	0,303	0,467	0	1
TYPE_6	0,091	0,292	0	1
TYPE_7	0,424	0,502	0	1
LOTS	15,6	16,0	1,0	55,0
LN_CAPACITY	15,16	6,748	0,0	20,65
EXP	8,24	15,496	0	50

Number of observations: 90

The data set contains a wide range of contract sizes, and winning-bid-to-reserve ratio varies substantially from 30% to 99,6%. There were 112 distinct bidders competing for these projects and 70 of them won at least one auction during 2008-2010. Note that only 10 firms competed for ‘big’ contracts with estimated price exceeding 20m rubles (approximately $680,000). Moreover in these 3 years the set of firms who bid for ‘big’ contracts remained stable. In bidding for the larger contracts, incumbent firms did not face any outside competition and therefore had strong incentives to collude.

Transparency of information also plays a crucial role. Since the Novosibirsk region has a web site of regional procurements, where purchasers were publishing information about the history of procurement auctions, firms knew the identity of bidders in auctions conducted previously. Thus it was easy for bidders to learn who the potential bidders would be and predict competition they would face even before the procedure. The ‘transparency policy’, and simplified cooperation, boosted incentives for the participants to coordinate their bids. In addition to this, the fact that only open auctions were run in 2010 raises the question of whether undercutting was physically feasible. As an open auction is usually conducted by gathering firms’ representatives in one room and allowing them to submit bids by raising their hands, all talk about possible deviation from cartel strategy seem ridiculous – retaliation for any one-shot deviation always will follow immediately[1]. In this case, the current procedure design contains the ideal mechanism for conspiracy enforcement – the temptation to get immediate monopolistic profit does not undermine cooperation.

Also large contract bidders had grounds to communicate with each other. During the period from 2006 through 2011 the local giants of highway construction made a number of deals of garage and machinery purchase. As reported by the FAS, making 'big deals' with machinery, equipment and other assets is a common instrument of side-payments widely adopted by cartels as it is legal and hard to trace. In any case, suppliers seem to be well-acquainted and have strong connections with each other. Note also that most of these firms describe each other (and sometimes the purchaser – NHA) as 'business partners' on their web sites. In short certain peculiarities of the Novosibirsk highway construction market make it very likely to be collusive.

Below we apply our two-stage procedure of collusion detection to the data and discuss the results as well as making policy recommendations.

7. Results and interpretation

We apply two models of regressions to the subsample of 216 open auctions. In both models RATIO – relative price – is a dependent variable. The difference is that in the first model we use the variable LN_CAPACITY to capture the influence of rising marginal costs on price; meanwhile in the second model we replace it by SHARE to control for the size of the firm. The results of GLS estimation of the first specification are given in Table 2.

Generally, all coefficients in the low-ratio group of auctions have expected signs. Number of applications has significantly negative influence on the relative price. Additional participant, ceteris paribus, pushes down price by 2-3% of the maximum level. Surprisingly, this relationship is insignificant in the high-ration group of procedures – whatever number of bidders participates in the auction, it makes no difference for the price level. This can be a clear sign of most of firms bidding passively (not as aggressive as they are expected to bid in competitive environment) or not submitting bids at all.

[1] Assuming that the designated winner in the cartel is the most efficient one (in terms of particular contract), there will always be at least one participant in each auction, which is able to overbid a deviator. Thus, there exists a credible threat of immediate retaliation, which limits deviations making them unprofitable and counterproductive.

Table 2

The first specification. Dependent variable – winning bid-to-reserve ratio.

	90% - boundary		**80% - boundary**		**<70% and >94%**	
	Low-group	**High-group**	**Low-group**	**High-group**	**Low-group**	**High-group**
NUMFIRMS	-0,031***	-0,007	-0,029***	-0,006	-0,017**	-0,007
	(0,007)	(0,006)	(0,008)	(0,007)	(0,008)	(0,006)
TYPE_4	0,109***	0,030	0,063	-0,043	0,078	0,030
	(0,040)	(0,023)	(0,041)	(0,036)	(0,053)	(0,023)
TYPE_5	0,087**	-0,009	-0,042	-0,033	-0,039	-0,009
	(0,040)	(0,019)	(0,049)	(0,031)	(0,060)	(0,019)
TYPE_6	0,032	-0,005	-0,016	-0,066*	-0,061	-0,005
	(0,041)	(0,023)	(0,042)	(0,034)	(0,062)	(0,023)
LOTS	**0,003*** **	**-0,000**	**0,002***	**-0,001**	**0,007***	**-0,000**
	(0,001)	(0,001)	(0,001)	(0,001)	(0,005)	(0,001)
LN_CAPACITY	**0,003****	**-0,001**	**0,007*****	**0,001**	**0,004****	**-0,001**
	(0,002)	(0,001)	(0,002)	(0,001)	(0,003)	(0,001)
EXP	**-0,003*****	**0,000**	**-0,002****	**0,001**	**-0,001****	**0,000**
	(0,001)	(0,000)	(0,001)	(0,001)	(0,001)	(0,000)
(Constant)	0,732***	1,004***	0,611***	0,953***	0,468***	1,004***
	(0,040)	(0,027)	(0,044)	(0,038)	(0,056)	(0,027)
Number of obs.	126	90	105	111	54	54
R^2	0,366	0,216	0,437	0,129	0,486	0,216
Adjusted R^2	0,316	0,003	0,365	0,026	0,342	0,003

The t-statistics are displayed in parentheses, significance level is marked by asterisk (***-1%, **-5%, *-10%). White robust estimates of variances are used to correct for possible heteroskedasticity.

Other estimated coefficients in the first column of Table 2 also have intuitive signs. The number of lots in the current auction has significant positive influence on the competitive group. This result can be explained by the effect of several simultaneous auctions conducted on one day. The higher the firm's interest in one of the contracts, the less aggressively it is going to bid in auctions for other parallel projects. The presence of such special areas of interest can decrease substantially the overall level of competition and push prices up. In our case, 10 lots instead of one auctioned on one day increases the price by approximately 3%. However we see that it is not the case for the firms bidding in the auctions of the passive group. In these procurements suppliers' strategies are not affected when the purchaser conducts a number of simultaneous auctions.

The same effect appears with the winner's occupied capacities and his experience. If capacity of the supplier (machinery, workers) is limited by other contracts, they are more likely to submit higher bids because of increased marginal costs. We can observe clearly that in competitive auctions a large number of ongoing projects has a significant effect on bidding patterns. Other things equal, the increase in the value of the current projects (LN_CAPACITY) by 10% leads to 3% increase of winning-bid-to-reserve ratio. In the 'passive group' the same coefficient is insignificant on 10% level and has negative sign. Reformulating the results, both busy and free firms have equal chances of winning the auction at a price close to the maximum (estimated) level, which is counterintuitive. Moreover, the winner's experience measured by EXP seems to be a source of serious cost advantage. Every additional year in the local market brings down the price by 0,3%, which can point to the specific skills and knowledge the firm learns from completed projects. Once again, in the second group of observations there is no significant effect of experience on prices at all.

The results are robust to specification changes. In Appendix 1 we show that moving the boundary to 80% or splitting the sample into the upper and lower quintiles does not change the signs of key coefficients. Replacing some of regressors with relevant substitutes also has no influence on the general conclusions.

Why are suppliers in the second group indifferent to their costs? One possible explanation is that firms collude, and the winner is 'rotated' among cartel members. That is, if the abilities to use side-payments for rent redistribution are limited, the only way to approximate the prearranged share of the market is for firms to win one by one. If so, the probability of winning should be uncorrelated with firm-specific characteristics. An alternative explanation may be that reserve prices are incorrectly estimated. If the purchaser underestimates the current level of construction costs, firms may be reluctant to decrease the price substantially. Moreover, suppliers can come to the auction but not bid in order to signal their high costs (Feinstein et al., 1985). However, we have doubts as to whether this is really the case. As is widely reported by industry experts (especially by former CEOs), contract prices are systematically overestimated, often by up to 70%. Moreover, the purchasers often gather information about costs from the participants of the market. In this case costs are very unlikely to exceed the maximum price.

The main issue is, however, if collusion really exists, is it tacit or explicit? ‘Coordination without communication’ can arise when suppliers have some specific information about the interests of other firms. If, for instance, it is widely known, that construction firm A builds and repairs roads in region X, other firms may avoid bidding for the projects in this region. In response, firm A may bid less aggressively in other regions or not bid at all. This can make the prices in all regions converge to their estimated levels. Such a situation is usually referred to as tacit collusion – a form of cooperation when firms do not have to communicate directly to achieve cooperative equilibrium.

Unfortunately, this case is practically impossible to distinguish from explicit illegal agreement. As well as a firm optimizes its own profit, cartels maximize total spoils, and this can be achieved by choosing the most efficient firm as auction winner. In this case, cartel members will win contracts which are in their primary interest, and behave passively in other auctions in order to create an illusion of competition. From an outside observer’s point of view, Firm A will still win contracts in the area X and lose in others, precisely as it would do in ‘tacit collusion’.

This example, however, raises a question about the results above. We concluded that capacities, size, and experience of the supplier do not affect prices. Does it mean that the cartel, if present, is inefficient and does not maximize profit? This question is puzzling. On the one hand, potential cartel members may be constrained by their inability to transfer money to each other – in this case they will rotate to get their stakes, which can make all bid determinants insignificant. On the other hand, even if the cartel is efficient in terms of assigning the most reasonable candidate as a winner, we could miss some crucial variables they are aware of, for instance, the place of construction, the distance to the nearest gravel and crushed stone producer, or the guarantee period. They could even be guided by certain unobservable characteristics such as specific skills which are not captured by our measures for the experience.

In addition, as more than 100 participants took part in bidding for road contracts in 2008-2010, the cartel could be non-inclusive. That is, not all observations from high-price group are collusive auctions. If so, the insignificance of estimates may arise from the difference in the degree of competition. For instance if cartel participant A is experienced in doing jobs in collusive areas, but has no experience (and thus has higher costs) in competitive auctions, intensive bidding in the second could equalize levels of the relative price in two areas. The argument is in the vein of Porter and Zona (1999), who show that in the Ohio school milk market more distant firms bid lower. This is because markets near certain firms' headquarters are fully collusive, while more distant markets are highly competitive and cartel members are forced to submit lower bids there. Of course, there is no unique solution to this puzzle. In fact, real collusion cannot be distinguished clearly from 'accidental' forms of cooperation or even from competitive equilibrium until we conduct an inquest and catch the conspirators in the act.

The results of the regression analysis clearly demonstrate the presence of passive bidding, whether it is caused by tacit or explicit collusion. Although they do not enable us to draw definite conclusions, the proposed approach can still be used to narrow the field of investigation. Further research, therefore, should be based on a thorough and detailed analysis of the concrete cases from the group of auctions we found suspicious. To demonstrate this strategy, in the next section we present some evidence of illegal conspiracy found in the high-ratio cluster.

8. Detected passive behavior

We now turn back to the full data sample, which includes auctions with no price decrease (these were excluded to avoid a bias of GLS-estimates), and present the case from our data where firms behaved passively and demonstrated a rotating winning pattern. Five firms were found to meet frequently in the auctions – these firms behaved in a way which is consistent with a rotating collusion scheme (we name these firms as Firm A, Firm B, … , Firm E). The scheme employed by these suppliers was the following. From two to five members of the group usually applied for an auction, but only one construction firm submitted bids in the auction. As a result, the only auction participant who submitted a bid (or even the only firm, who showed up for the procedure) obtained project at the price close to maximum level. Rotating the role of auction winner, auction by auction, suppliers divided government contracts among them in certain proportions. The history of cartel meetings is presented in Table 3.

Table 3

The history of cartel meetings.

Auct №	Reserve price, th. rub.	Winner	Applied		Showed up		Ratio
			Collusive	Non-collusive	Collusive	Non-collusive	
1	146 907,2	**Firm A**	3	0	1	0	**1,000**
2	77 950,0	**Firm B**	2	0	1	0	**1,000**
3	46 250,3	**Firm E**	2	0	1	0	**1,000**
4	21 998,3	**Firm A**	4	0	1	0	**1,000**
5	16 835,0	**Firm C**	3	1	3	1	**0,820**
6	15 650,1	**Firm A**	5	0	4	0	**0,995**
7	11 045,7	**Firm A**	2	0	2	0	**0,995**
8	10 364,8	**Firm C**	5	0	5	0	**1,000**
9	9 714,7	**Firm B**	4	0	1	0	**1,000**
10	6 959,9	**Firm D**	3	2	3	2	**0,545**
11	2 198,3	**Firm D**	4	0	4	0	**0,995**
12	464,0	**Firm B**	4	1	4	1	**0,870**

During 2010 the five suppliers distributed 12 contracts and got a total of 366 million rubles (about $11,7 million) which is approximately 8,5% of all road works procured this year. We single out three different groups of auctions. In the first group, which consists of auctions № 1-4, 8-9 firms used the scheme of ‘fake applications’. A few cartel members first sent applications, but then – all except one – didn’t show up for the auction. As there was no price decrease, in these procedures ratio is 1,00 and the ‘budget saving’ is zero. The second group, which includes auctions № 6, 7 and 11, present cases of a small decrease by the auction step. The difference from the first scheme is that all applied firms showed up for an auction, but only one contractor submitted a bid, which is only 0,5% lower than the auction’s maximum price (thus, only one firm was a serious bidder). In this way cartel members brought prices down by the smallest possible sum, so as to maximize their rent and create an illusion of competition. Similarly, such behavior led to lower ‘budget saving’, as construction firms won contracts at prices close to auction reserve level. The third group, with auctions № 5, 10, 12, consists of ‘non-inclusive’ agreement cases, where one or more outsiders come to participate in an auction. It can be seen, that outsider participation breaks cartel’s passive strategy and forces cartel members to struggle with non-cartel contractors. The participation of an non-cartel bidder led to 13–18% price reduction, and participation of two non-cartel bidders reduced maximum prices by almost 50%.

Four of twelve considered contracts were awarded to Firm A – the biggest construction firm in the region. Its share exceeds 50%, the second biggest share of 24% belongs to Firm B, and three remaining contractors got 12.6, 7.4 and 2.5% correspondingly. According to cartel theory, collusion is the most sustainable, when spoils are divided proportionally to firms' costs, which can be achieved in a long series of auctions using a rotating scheme. However, we cannot claim that the calculated shares reflect the real costs of the distribution of collusive firms. Although this possibility could be limited, Firm A could use transfers to redistribute spoils from a large indivisible project. During 2010 the firm closed some deals selling machinery, and some years earlier the same firm sold 2 of its subsidiaries (with the whole production base) to the Firms D and E. Thus, shares of each of five firms cannot serve as reasonable reflection of cartel's inner structure.

Not surprisingly, the contractors and their participation in auctions with practically no decrease are widely discussed in regional media. Investigations against some of them started in 2011; however, no proof of illegal collusion has been presented so far. It is not clear, whether the regional FAS is too weak to pursue the suspected collusion. In other regions such uncompetitive auctions in road construction procurement which end with decrease coefficient about 0,990 – 0,995, is a widespread reason to accuse firms of criminal conspiracy[1] and penalize them with a certain share of their annual revenue. Such suspicious schemes are normally the focus of FAS attention not only in road construction, but also in other industries, such as pharmaceutical delivery, building construction and maintenance, and gasoline procurement. The same happens with 'fake application' schemes, the FAS regularly accuses construction firms of "coordinated actions", when only one firm shows up and 'hits the jackpot'[2]. The probable weakness of the regional FAS and its inability to expose cartels can create even more favorable conditions for collusion members to limit competition and share monopolistic profit.

9. Discussion

Since 2005 the Russian procurement system was based on the law which prohibits any kind of pre-qualification. The only exclusion connected with qualification requirements which

[1] See, for instance, recent FAS investigation, reported on *Karelia FAS website* on 9 June 2011 (http://karelia.fas.gov.ru/news/4796), or high-profile case of collusion detection in Sverdlovsk region, where family members of the regional governor's were found to be involved in conspiracy schemes, Ural Vedomosti, 25 January 2012 (http://u17955.netangels.ru/main/20001/page/7/).

[2] Some evidence can be found in articles in *Ria Novosti*, 21 October 2010(http://www.realty.rian.ru/news/20101021/97470.html) and in *Bank Fax,* 19 June 2009 (http://www.bankfax.ru/page.php?pg=61296).

could be set in so called ‘beauty contests’ was eliminated in July 2010. This was done in order to remove corruption from application committees and to limit the abilities of purchasers to manipulate the structure of the competition. However, the results obtained in the current paper show that this prohibition can simplify collusion. As no specific requirements need to be met to enter the auction, cartel members may easily show up and submit phony bids to hide collusion. Some mechanisms of pre-qualification, for example a check for sufficiency of capacities or appropriate experience – should be probably implemented to hinder such practice.

Another important question is information transparency. In 2011 the system of government orders started moving towards a fully-transparent unique web-site that was created to aggregate information over all procurement auctions in all regions. This has a number of advantages including a potential increase of competition, an ordering of auction documentation and a higher level of public control. However such transparency can also serve as a mechanism facilitating coordination between suppliers. Even in the system of e-auctions, which public regulators are going to adopt in the near future, firms still have full information about past auctions and can easily collude with potential participants. Thus, increasing the level of informational transparency may turn out to be counterproductive.

One more question is about the use of the proposed approach in practice. If we announce the start of this approach to collusion detection, how will firms react? Clever cartels can obviously adopt more sophisticated schemes of bidding to pass the test for collusion, for example, they can put submitted phony bids ‘in the right order’. If the test is based on the sufficiency of free capacities, constructors with more capacity will be assigned as designated winners, and those, who have lower but still sufficient abilities to fulfill contract, will simply submit higher phantom bids. Although such a scenario sounds realistic, the adoption of the proposed method of cartel detection can still be useful. At least, it could force firms to collude more carefully, which requires better coordination mechanisms. Along with lower informational transparency, this practice may put certain restrictions on the abilities to collude and make it more demanding (and therefore, less probable).

Finally, in the papers on collusion detection the authors usually concentrate on one of many possible collusion schemes. In our case different schemes of conspiracy including phantom bidding and passive rotating seem to coexist in one market. Is it because the local FAS pays more attention to one auction, but not to others? That is, for example, in areas with traditionally low competition the regulator does not expect fierce competition, therefore there is no need to create any ‘illusion’ of it. By contrast, in auctions, where the number of bidders was always substantial, a cartel may need to employ phony bids to meet the expectations of the FAS. It would be useful to investigate the theoretical model of cases where different mechanisms of market division are adopted by cartels. An important question here is not only ‘why’ they can coexist, but also how it can affect behavior of non-collusive suppliers.

10. Conclusion

In the current paper we present a method which can be used for collusion detection in procurement auctions. We create a model of competition and then estimate it separately in two groups of observations: high- and low-price auctions. We find that in the low-price procedures the data fits the competitive theory well, while in the other group it fails to do so. In particular, we show that the behavior of suppliers in the high-price subsample does not depend on several key determinants such as a share of occupied capacity and cost advantages that come with experience. Regardless of how much a contractor is ready to fulfill the contract, he does not bid aggressively or does not submit any bids at all. This may be treated as a sign of coordination among local suppliers. The results turned out to be robust to both changes in the ‘boundary’ level and in model specification.

Although the general approach constructed is similar to that of the papers of Hendricks and Porter (1988) and Porter and Zona (1993, 1999), it differs from the latter in two dimensions. First, it uses extended firm-specific characteristics in regression analysis, which allows us to control for a number of key firm characteristics and weakens the endogeneity effect. And second, it aims to detect collusion without any prior knowledge of the market, which is of high practical importance. The proposed method can be potentially used by both researchers and anti-trust agencies to reveal cartels in various markets.

The results also raise certain questions about policy implications. If firms which are uninterested in winning, can participate merely to create an illusion of healthy competition, we may need a mechanism of pre-qualification to filter out such noisy bidders. For instance, the auctioneer can demand a confirmation that the firm has sufficient capacities to do the work on time, or that he has a suitable partner to offer a subcontract to. That both insures the purchaser against risks of missing deadlines and prevents the appearance of phantom bidders in auctions. Similarly, information transparency can also serve as a market feature that facilitates collusion. With a unique documentation-aggregating website, firms can easily use the full history of auctions to define potential cooperators. It raises the question of whether the current policy of the ‘super-transparent’ procurement system is a suitable instrument to make markets more competitive.

References

Bajari, P. (2001). Comparing competition and collusion: a numerical approach. *Economic Theory*, 18, 187-205.

Bajari, P., Summers, G. (2002). Detection of collusion in procurement auctions. *Antitrust Law Journal*, 70 (1), 143-170.

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

Baldwin, L.H., Marshall, R.C., Richard, J.F. (1997). Bidder collusion at forest service timber sales. *Journal of Political Economy*, 105 (4), 657–699.

Banerji A., Meenakshi J.V. (2004). Buyer Collusion and Efficiency of Government Intervention in Wheat Markets in Northern India: An Asymmetric Structural Auctions Analysis. *American journal of agricultural economics*, vol. 86(1), pp. 236-253.

Brannman, L., Klien, D., Leonard W. (1987). The Price Effects of Increased Competition in Auction Markets. *The Review of Economics and Statistics*, 69(1), February, pp. 24-32.

Comanor, W.S., Schankerman, M.A. (1976). Identical Bids and Cartel Behavior. *Bell Journal of Economics*, Spring, 7, pp. 281-296.

Dorée, A.G. (2004). Collusion in the Dutch construction industry: an industrial organization perspective, *Building Research and Information*, Volume 32, Number 2, March-April, pp. 146-156.

Feinstein, J.S., Block, M.K., Nold, F.C. (1985). Asymmetric Information and Collusive Behavior in Auction Markets. *American Economic Review, American Economic Association*, vol. 75(3), pages 441-60, June.

Gupta S. (2001). The Effect of Bid Rigging on Prices: A Study of the Highway Construction Industry. *Review of Industrial Organization*, vol. 19(4), 451-465.

Harris, M., Raviv, A. (1981,a). Allocation Mechanisms and the Design of Auctions. *Econometrica*, Nov. 1981a, 49(6), pp. 1477-99.

Hendricks, K., Porter, R. (1988). An Empirical Study of An Auction with Asymmetric Information. *American Economic Review*, 78: 865-883.

Holt, C.A., Jr. (1979). Uncertainty and the Bidding for Incentive Contracts. *American Economic Review,* September, 69(4), pp. 697-705.

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

Jofre-Bonet, M., Pesendorfer, M. (2000). Bidding behavior in a repeated procurement auction: A summary, *European Economic Review*, Volume 44, Issues 4–6, May, 1006-1020.

Lee I., Hahn K. (2002). Bid-Rigging in Auctions for Korean Public-Works Contracts and Potential Damage, *Review of Industrial Organization*, Springer, vol. 21(1), pages 73-88, August.

McAfee, R.P., McMillan, J. (1992). Bidding rings. *American economic review*, 82(3), 579-599.

Menezes, F., Monteiro, P. (2000). Auctions with endogenous participation. *Review of Economic Design*, 5(1), pp. 71-89.

Padhi, S.S., Mohaparta, P.K.J. (2011). Detection of collusion in government procurement auctions. *Journal of Purchasing and Supply Management,* doi:10.1016/j.pursup.2011.03.001.

Porter, R.H., Zona J.D. (1993). Detecting of bid rigging in procurement auctions. *Journal of Political Economy*, 101 (3), 518-538.

Porter, R.H., Zona J.D. (1999). Ohio School Milk Markets: An Analysis of Bidding. *Journal of Economics*, The RAND Corporation, vol. 30(2), pages 263-288, Summer.

Selten, R. (1973). A Simple Model of Imperfect Competition Where Four are Few and Six are Many. *International Journal of Game Theory,* 2, 1973, pp.141 -201.

Skrzypacz, A., Hopenhayn, H. (2004). Tacit collusion in repeated auctions. *Journal of Economic Theory*, 114, 153–169.

Weiss, L.W. (1989). Concentration and Price, Cambridge, Mass, and London: MIT Press.

Zarkada-Fraser, A., Skitmore, M. (2000). Decision without moral content: collusion. *Construction Management and Economics,* 18, 101-111.

Appendix 1

To check the results for robustness, we move the demarcation line from 90% to 80%, and run the same regressions with the new groups. Corresponding descriptive statistics are given in Tables 4.1-4.2. We also use the division by 25% and 75% of observations, which stands for relative prices 0,7 and 0,94 correspondingly. Summary statistics on these groups can be found in Tables 5.1-5.2. In the latter case, the competitive group consists of auctions with price decrease lower than 6%, the passive group, higher than 30%. The results, which are given in columns 3-6 of Table 2, show that the coefficients and their significance are robust to the changes of a clustering boundary.

We also estimate other specifications. In the second model (see Table 7) we use variable SHARE instead of LN_CAPACITY to control for the size of the winner (for a description of how all variables were calculated see the table below). In the third and the fourth specifications (Tables 8-9) variable EXP is replaced by AGE – the variable which stands for the time passed since the registration of the firm in the local market, and the logarithm of fixed capital (LN_CAPITAL) is used to control for the firm's size. In these models the coefficient at SHARE preserves the same positive sign as LN_CAPACITY in the very first model. Variable AGE loses significance in some specifications, but still has negative coefficients, so experience in road works still brings a competitive advantage. The large size of the winner's fixed capital decreases the relative price in the competitive group, which can be treated similarly as the effect of age or experience. Note that all these variables are again insignificant in the high-ratio group of auctions, which can be a sign of suppliers' coordination, whether explicit or tacit.

Full list of variables included different specifications:

MAXPRICE	Starting (maximum, reserve) price in the auction;
WINPRICE	Winning bid – the lowest bid of those submitted by auction participants;
RATIO	Winning bid-to-reserve ratio, WINPRICE divided by MAXPRICE ;
NUMFIRMS	Number of participants who sent applications to participate in auction (and were admitted to the auction by a purchaser);
TYPE_4 (5,6,7)	A set of dummy variables, 4 – road construction, 5 – capital repairs, 6 – bridge construction, 7 – current repairs (road maintenance);

LOTS	Number of lots in the current auction (number of simultaneous auctions);
CAPACITY	Total value of ongoing projects of the winner. Calculated on the assumption that road works are done uniformly during the whole period from the date of the contract to the specified deadline. The variable is a proxy for how busy the winner is, and therefore for his marginal costs.
LN_CAPACITY	Logarithm of CAPACITY;
SHARE	Share of occupied capacities – CAPACITY divided by maximum value of ongoing projects for the whole period of 2008-2010. The latter is indirect measure of general winner's capacity including both own machinery and workers and the possibility of subcontracting.
EXP	Experience of winner. Number of contracts won in the same region on all (federal, regional and municipal) levels since 2008;
AGE	Age of winner. Years passed since winning company was registered. The dates of registration are taken from the FIRA rating agency (http://www.fira.ru/);
CAPITAL	Fixed-capital obtained from winner's balance sheet. This date is taken from the FIRA rating agency as well.

Table 4.1

Descriptive statistics for high-ratio auctions (RATIO≥90%)

Variable	Mean	Std. Dev.	Min	Max
RATIO	0,973	0,03	0,9	0,996
MPRICE(th.rub)	12319,59	8839	371,2	37952,7
WPRICE(th.rub)	12013,23	8733,5	350,8	37573,17
NUMFIRMS	2,91	1,28	2	7
TYPE_4	0,182	0,392	0	1
TYPE_5	0,303	0,467	0	1
TYPE_6	0,091	0,292	0	1
TYPE_7	0,424	0,502	0	1
LOTS	15,6	16	1	55
LN_CAPACITY	15,16	6,75	0	20,65
SHARE	0,505	0,328	0,004	1
EXP	8,24	15,50	0	50
AGE	6,67	5,21	0,04	15,5
LN_CAPITAL	10,44	2,59	5,38	13,32

Number of Observations: 90

Table 4.2

Descriptive statistics for low-ratio auctions (RATIO<90%)

Variable	Mean	Std. Dev.	Min	Max
RATIO	0,722	0,142	0,305	0,895
MPRICE(th.rub)	18935,6	17396,6	522,2	99440,3
WPRICE(th.rub)	13900,4	12954,8	265,1	77066,2
NUMFIRMS	3,82	2,04	1	13
TYPE_4	0,206	0,407	0	1
TYPE_5	0,237	0,428	0	1
TYPE_6	0,206	0,407	0	1
TYPE_7	0,351	0,48	0	1
LOTS	14,3	18,7	1	55
LN_CAPACITY	12,62	8,55	0	22,2
SHARE	0,564	0,33	0	1
EXP	8,77	14,63	0	55
AGE	7,52	5,21	0,14	16,65
LN_CAPITAL	10,73	2,74	3,83	13,32

Number of Observations: 126

Table 5.1

Descriptive statistics for high-ratio auctions (RATIO≥80%)

Variable	Mean	Std. Dev.	Min	Max
RATIO	0,911	0,069	0,805	0,996
MPRICE(th.rub)	15536,4	13303,7	371,2	79556,2
WPRICE(th.rub)	13966,4	11728,1	350,8	71202,8
NUMFIRMS	3,47	1,45	2	7
TYPE_4	0,197	0,401	0	1
TYPE_5	0,288	0,456	0	1
TYPE_6	0,152	0,361	0	1
TYPE_7	0,348	0,480	0	1
LOTS	15,9	18,4	1	55
LN_CAPACITY	18,01	1,87	12,82	22,20
SHARE	0,545	0,318	0,002	1
EXP	7,11	12,61	0	50
AGE	7,31	4,89	0,04	15,50
LN_CAPITAL	10,79	2,40	5,38	13,32

Number of Observations: 111

Table 5.2

Descriptive statistics for low-ratio auctions (RATIO<80%)

Variable	Mean	Std. Dev.	Min	Max
RATIO	0,661	0,130	0,305	0,795
MPRICE(th.rub)	19908,3	18604,4	688,7	99440,3
WPRICE(th.rub)	13434,2	12709,6	265,1	77066,2
NUMFIRMS	4,42	2,14	2	11
TYPE_4	0,203	0,406	0	1
TYPE_5	0,203	0,406	0	1
TYPE_6	0,186	0,393	0	1
TYPE_7	0,407	0,495	0	1
LOTS	13,8	18,2	1	55
LN_CAPACITY	17,82	1,86	13,94	20,30
SHARE	0,600	0,313	0,019	1
EXP	11,08	17,13	0	55
AGE	7,93	5,48	0,14	16,65
LN_CAPITAL	11,02	2,40	5,38	13,32

Number of Observations: 105

Table 6.1

Descriptive statistics for high-ratio auctions (Upper quintile, RATIO≥94%)

Variable	Mean	Std. Dev.	Min	Max
RATIO	0,987	0,014	0,945	0,996
MPRICE(th.rub)	12695,0	9784,5	371,2	37952,7
WPRICE(th.rub)	12547,2	9665,4	350,8	37573,2
NUMFIRMS	3,27	1,46	2	7
TYPE_4	0,231	0,430	0	1
TYPE_5	0,346	0,485	0	1
TYPE_6	0,077	0,272	0	1
TYPE_7	0,346	0,485	0	1
LOTS	13,3	13,6	1	55
LN_CAPACITY	17,78	1,99	12,82	20,65
SHARE	0,527	0,351	0,035	1
EXP	9,46	16,76	0	50
AGE	6,79	5,46	0,04	15,50
LN_CAPITAL	10,72	2,49	5,38	13,32

Number of Observations: 54

Table 6.2

Descriptive statistics for low-ratio auctions (Lower quintile, RATIO<70%)

Variable	Mean	Std. Dev.	Min	Max
RATIO	0,560	0,116	0,305	0,7
MPRICE(th.rub)	16719,7	17811,1	688,7	86545,4
WPRICE(th.rub)	9216,8	8532,3	265,1	38080,0
NUMFIRMS	5,34	2,61	2	11
TYPE_4	0,241	0,435	0	1
TYPE_5	0,345	0,484	0	1
TYPE_6	0,103	0,310	0	1
TYPE_7	0,310	0,471	0	1
LOTS	7,1	5,5	1	18
LN_CAPACITY	17,16	1,82	13,94	20,26
SHARE	0,569	0,346	0,019	1
EXP	11,93	20,08	0	55
AGE	7,60	5,88	0,42	16,65
LN_CAPITAL	10,89	2,17	7,48	13,32

Number of Observations: 54

Table 7

The second specification. Dependent variable – winning bid-to-reserve ratio.

	90% - boundary		**80% - boundary**		**<70% and >94%**	
	Low-group	**High-group**	**Low-group**	**High-group**	**Low-group**	**High-group**
NUMFIRMS	-0,033***	-0,006	-0,024*	-0,007	-0,019*	-0,006
	(0,007)	(0,006)	(0,009)	(0,007)	(0,008)	(0,006)
TYPE_4	0,120***	0,032	0,086*	-0,044	0,102**	0,032
	(0,041)	(0,023)	(0,045)	(0,037)	(0,048)	(0,023)
TYPE_5	0,101**	-0,005	-0,007	-0,038	-0,018	-0,005
	(0,041)	(0,018)	(0,054)	(0,031)	(0,055)	(0,018)
TYPE_6	0,057	-0,006	0,023	-0,061*	-0,035	-0,006
	(0,040)	(0,023)	(0,045)	(0,035)	(0,059)	(0,023)
LOTS	**0,004*** **	**-0,000**	**0,003*** **	**-0,001**	**0,010*** **	**-0,000**
	(0,001)	(0,001)	(0,001)	(0,001)	(0,003)	(0,001)
SHARE	**0,010***	**-0,008**	**0,052** **	**-0,006**	**0,081** **	**-0,008**
	(0,039)	(0,017)	(0,048)	(0,028)	(0,051)	(0,017)
EXP	-0,003***	0,000	-0,001	0,001	0,000	0,000
	(0,001)	(0,000)	(0,001)	(0,001)	(0,001)	(0,000)
(Constant)	0,755***	0,996***	0,642***	0,974***	0,400***	0,996***
	(0,045)	(0,022)	(0,055)	(0,034)	(0,069)	(0,022)
Number of observations	126	90	105	111	54	54
R^2	0,334	0,209	0,322	0,117	0,488	0,209
Adjusted R^2	0,281	0,013	0,236	0,012	0,345	0,013

The t-statistics are displayed in parentheses, significance level is marked by asterisk (***-1%, **-5%, *-10%). White robust estimates of variances are used to correct for possible heteroskedasticity.

Table 8

The third specification. Dependent variable – winning bid-to-reserve ratio.

	90% - boundary		**80% - boundary**		**<70% and >94%**	
	Low-group	**High-group**	**Low-group**	**High-group**	**Low-group**	**High-group**
NUMFIRMS	-0,031***	-0,005	-0,004	0,006	0,002	-0,005
	(0,009)	(0,007)	(0,010)	(0,011)	(0,016)	(0,007)
TYPE_4	0,127***	0,040	0,056	-0,060	0,072	0,040
	(0,057)	(0,030)	(0,047)	(0,051)	(0,091)	(0,030)
TYPE_5	0,133**	0,015	0,010	-0,042	0,002	0,015
	(0,058)	(0,025)	(0,062)	(0,043)	(0,117)	(0,025)
TYPE_6	0,103	-0,005	0,079	-0,113	0,014	-0,005*
	(0,058)	(0,038)	(0,047)	(0,053)	(0,127)	(0,038)
LOTS	**0,004*** **	**-0,000**	**0,002***	**-0,002**	**0,003***	**-0,000**
	(0,001)	(0,001)	(0,001)	(0,001)	(0,009)	(0,001)
LN_CAPACITY	**0,008** **	**0,001**	**0,012** **	**0,004**	**0,009*** **	**0,001**
	(0,003)	(0,002)	(0,003)	(0,003)	(0,006)	(0,002)
AGE	**0,007**	**-0,002**	**-0,015*** **	**0,002**	**-0,018** **	**-0,002**
	(0,006)	(0,004)	(0,005)	(0,005)	(0,008)	(0,004)
LN_CAPITAL	**-0,028*** **	**0,001*** **	**-0,038*** **	**0,005*** **	**-0,037*** **	**0,001*** **
	(0,011)	(0,007)	(0,010)	(0,010)	(0,015)	(0,007)
(Constant)	1	1	1	1	1	1
	0,091	0,067	0,094	0,085	0,147	0,067
Number of observations	104	76	42	45	87	93
R^2	0,490	0,275	0,710	0,159	0,751	0,275
Adjusted R^2	0,412	0,011	0,635	0,028	0,569	0,011

The t-statistics are displayed in parentheses, significance level is marked by asterisk (***-1%, **-5%, *-10%). White robust estimates of variances are used to correct for possible heteroskedasticity.

Table 9

The fourth specification. Dependent variable – winning bid-to-reserve ratio.

	90% - boundary		**80% - boundary**		**<70% and >94%**	
	Low-group	**High-group**	**Low-group**	**High-group**	**Low-group**	**High-group**
NUMFIRMS	-0,035***	-0,005	-0,016	0,010	-0,015	-0,005
	(0,009)	(0,007)	(0,012)	(0,011)	(0,014)	(0,007)
TYPE_4	0,179***	0,047	0,127	-0,053	0,228	0,047
	(0,055)	(0,029)	(0,053)	(0,052)	(0,083)	(0,029)
TYPE_5	0,179**	0,020	0,094	-0,035	0,143	0,020
	(0,058)	(0,024)	(0,071)	(0,044)	(0,095)	(0,024)
TYPE_6	0,155	0,016	0,137	-0,087	0,209	0,016*
	(0,058)	(0,038)	(0,058)	(0,055)	(0,140)	(0,038)
LOTS	**0,005*** **	**0,000**	**0,004***	**-0,001**	**0,017***	**0,000**
	(0,001)	(0,001)	(0,001)	(0,001)	(0,005)	(0,001)
SHARE	**0,075*** *	**-0,040**	**0,118*** *	**-0,012**	**0,121*** **	**-0,040**
	(0,067)	(0,028)	(0,077)	(0,049)	(0,158)	(0,028)
AGE	**-0,005**	**-0,001**	**-0,015*** **	**0,001**	**-0,012*** *	**-0,001**
	(0,006)	(0,003)	(0,007)	(0,005)	(0,009)	(0,003)
LN_CAPITAL	**-0,022*** **	**0,004*** **	**-0,035*** **	**0,000*** **	**-0,020*** **	**0,004*** **
	(0,011)	(0,007)	(0,013)	(0,009)	(0,018)	(0,007)
(Constant)	1	1	1	1	1	1
	0,095	0,063	0,112	0,088	0,155	0,063
Number of observations	104	76	42	45	87	93
R^2	0,438	0,344	0,564	0,125	0,716	0,344
Adjusted R^2	0,352	0,006	0,452	0,069	0,510	0,006

The t-statistics are displayed in parentheses, significance level is marked by asterisk (***-1%, **-5%, *-10%). White robust estimates of variances are used to correct for possible heteroskedasticity.

Authors

Ilya Morozov - Research Assistant, International Laboratory for Institutional Analysis of Economic Reforms, morozov.hse@gmail.com

Elena Podkolzina - Senior Researcher, International Laboratory for Institutional Analysis of Economic Reforms, epodk@hse.ru