Supplemental Appendix

Collusion by Exclusion in Public Procurement

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B.1 Cartel Conviction by the Antimonopoly Office of the Slovak Republic

While the lion's share of cases of cartel behavior originate in public procurement, only recently was a cartel convicted for bid-rigging in public procurement auctions on the EKS. On June 6, 2017, a case was opened against 6 firms suspected of coordinating bids from January 2015 to April 2017 on the EKS platform in public procurement auctions involving delivery of furniture, medical equipment, clothes and textile. In December 2019, the AMO SR imposed a fine of EUR 1,181,441 for this collusive behavior, but as the verdict was not yet legally binding, the details of the case remained scant, and the identities of bidders were unknown. Finally, in May 2021, the case was concluded with a confirmation of the verdict, and the authorities released the firms' names and auctions affected.

Out of the 276 auctions analyzed by the antitrust authority, we can locate 274 in our dataset. Table B.1 summarizes these auctions and splits them into those conducted before and after the reform. As in our previous, more general analysis, a shift in the decomposition of savings generated in the preselection stage in comparison to that in the main auction can be observed. However, the number of postreform auctions investigated is very low, so any comparison should be made with caution. Interestingly, in all postreform investigated auctions, a cartel member won the contract, and the number of cartel members participating substantially decreased.

Finally, we will focus on auctions that took place before the reform. Due to the investigation, we know which companies are cartel members. This gives us more confidence in decomposing the collusive auctions into cases where the cartel faces competition versus cases where it does not. Table B.2 shows that while the number of cartel bidders in auctions where rivals participated (Columns 2–4) is similar to the number where they did not (Column 1) , there is a stark difference in the average savings. The difference in savings is conducive to the conclusion that bidding in the main auction is much more aggressive, supported by the much larger numbers of bids and bidders. However, this is not the whole story, as the savings based on the preselection stage are already substantially higher. This suggests that cartels must also anticipate larger interest in an auction and therefore start with a more aggressive opening bid. The fact that the re-

Table B.1: Investigated auctions

	(1) All		(2) Before the reform		(3) After the reform	
	Mean	SD	Mean	SD	Mean	SD
Savings	0.14	0.15	0.14	0.15	0.10	0.12
Preselection Savings	0.11	0.13	0.12	0.14	0.02	0.05
Reserve price (k EUR)	10.60	16.63	10.41	16.80	12.60	14.75
Winning bid (k EUR)	10.31	16.27	10.12	16.42	12.41	14.68
Preselection bidders	4.46	2.49	4.57	2.50	3.17	1.99
Main auction bidders	0.85	1.19	0.75	1.08	2.00	1.68
Main auction bids	11.24	32.98	9.58	29.07	29.39	59.32
Cartel bidders in preselection	2.35	0.88	2.46	0.84	1.17	0.39
Cartel winner	0.81	0.39	0.80	0.40	1.00	0.00
Observations	274		251		23	

Notes: The table summarizes auction-level variables for the 274 auctions in our dataset that were investigated by the antimonopoly authority.

serve price for these auctions is substantially higher corroborates this conclusion.

Table B.2 also sheds light on how outcomes change when the cartel is successful at excluding rivals. Clearly, when fewer than 3 cartel bidders participate, they are not able exclude any rivals, which is summarized in Column 4. Columns 2 and 3 both summarize cases where the cartel is large enough to exclude rivals, but it is only successful in Column 2. Most strikingly, when a cartel successfully excludes rivals, none of the three cartel members submit any further bids in the main auction. Moreover, the cartel seems more likely to be successful when the contract value is rather high.

Table B.2: Success and failure of exclusion

	(1) no rivals present		(2) rivals excluded		(3) rivals not excluded		(4) rivals present	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Savings	0.03	0.04	0.12	0.12	0.28	0.13	0.20	0.18
Preselection Savings	0.03	0.04	0.12	0.12	0.24	0.14	0.14	0.15
Reserve price (k EUR)	7.53	6.66	12.14	22.35	10.24	15.44	11.92	18.36
Winning bid (k EUR)	7.32	6.61	11.90	22.24	9.83	14.59	11.55	17.58
Preselection bidders	2.53	0.77	5.67	2.32	6.02	2.50	4.66	2.54
Main auction bidders	0.19	0.54	0.05	0.37	1.57	1.15	1.66	1.06
Main auction bids	0.32	1.13	0.05	0.37	16.39	26.12	27.15	49.69
Cartel bidders in preselection	2.53	0.77	3.01	0.12	3.02	0.15	1.31	0.47
Cartel winner	1.00	0.00	1.00	0.00	0.23	0.42	0.72	0.45
Observations	73		73		44		61	

Notes: The table summarizes auction-level variables for the 251 investigated auctions run in the prereform period.

Shortly after the reform abolishing the preselection rule, the Antimonopoly Office of the Slovak Republic initiated investigations into a supposed cartel composed of six companies: ARTRA, ČECHOVO, JANOLI, JASTA Slovakia, Ing. Jaroslav Marinica – MARINI and PMB Slovakia. The allegation concerned coordination of bids in a way that exploited the preselection rule. The evidence was based on a detailed investigation of 276 electronic auctions.[65] The bid-rigging affected various procurement categories, namely, furniture, medical equipment, clothing, footwear and textile products.

An interesting observation is that the cartel members were highly asymmetric in size, with ARTRA being the largest in revenue terms by far. However, this did not reflect the involvement in cartel activity. In our dataset, we can track 274 out of the 276 auctions investigated. In all of them, at least one cartel member participated. ARTRA participated in only 14 and won only a single auction. On the other hand, the strong core of the cartel appears to have been JANOLI, ČECHOVO and MARINI. JANOLI participated in 181 auctions, 98 of which it won; ČECHOVO participated in 218, 94 of which it won. While both JANOLI and ČECHOVO have received their fair share of wins, MARINI mostly lost: It participated in 170 auctions but won only 17. This suggests that it was largely helping the others, while being compensated through side payments instead of a rotation scheme. JASTA played a similar role but participated less frequently (in 53 auctions), and PMB played only a minor role.[66]

Since the fines imposed by the antimonopoly authority were designed to be proportional to annual revenues, they stood in stark contrast to the gains from bid-rigging, at least when we focus on the 250 contracts in our dataset. While ARTRA won contracts with a total value of only EUR 6,194, its fine amounted to EUR 900'069. In contrast, the two most active members, JANOLI and ČECHOVO, won contracts worth EUR 1,055,131 and EUR 674,957 in those collusive auctions but were fined EUR 162,247 and EUR 8,621, respectively.[67]

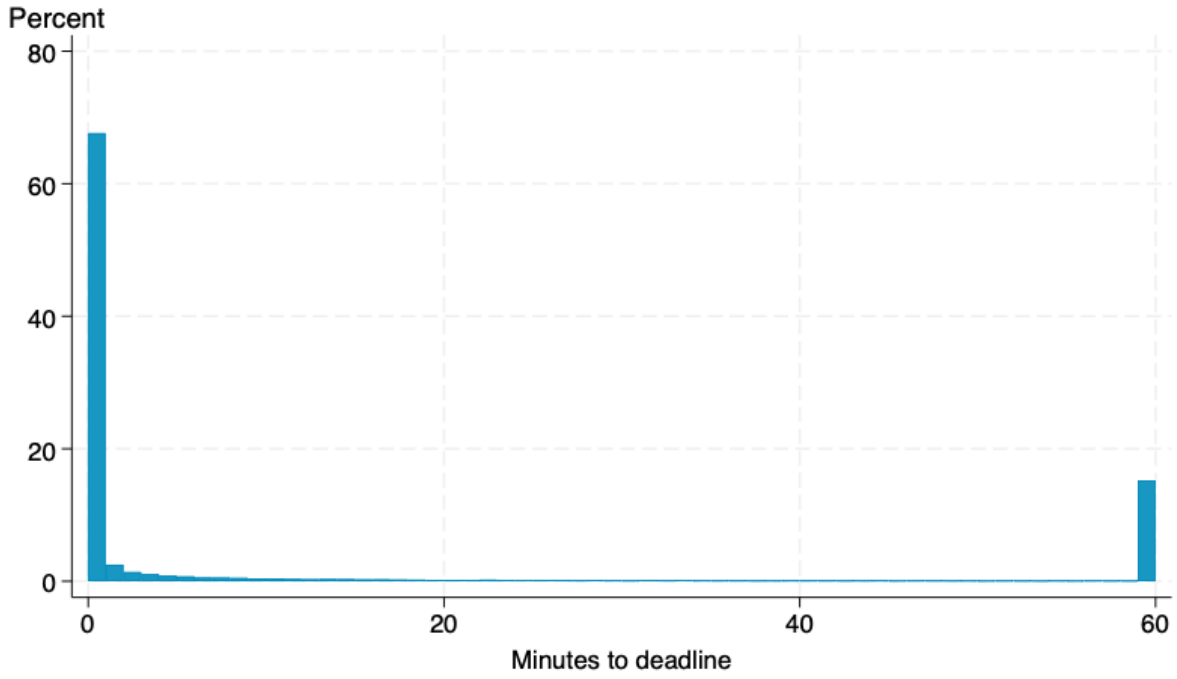
[65] For further details, see https://www.antimon.gov.sk/data/att/e1d/2171.64e3dd.pdf?csrt=3756949773301016497 on the first decision and https://www.antimon.gov.sk/data/att/691/2170.cc3422.pdf?csrt=3756949773301016497 on the final decision.

[66] Among the 26 contracts not in our data, we could find 20 on the EKS website. All 20 were won by either ČECHOVO or JANOLI, even though 7 faced competition from noncartel rivals in the main auction. Unfortunately, we cannot observe all firms that participated in the preselection stage since they appear in the documentation only if they proceeded to the main auction.

[67] In the 274 auctions contained in our data and investigated by the antimonopoly authority, the contract values for the remaining cartel members were as follows: Marini EUR 470,042; JASTA, EUR 111,770; and PMB EUR 37,100. In contrast, their fines, in the same order, amounted to EUR 12,455, EUR 10,807 and EUR 50,236.

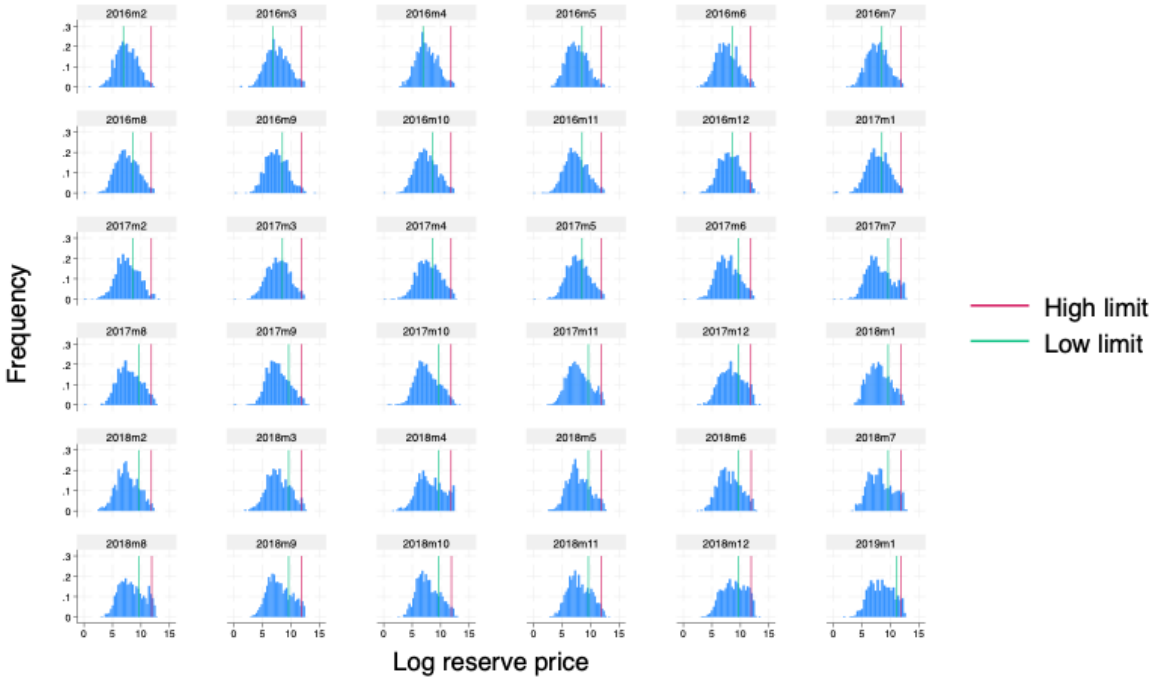
B.2 Supplementary Figures and Tables

Figure B.1: Time of opening bids relative to the deadline of the preselection stage



Notes: The histogram is winsorized at 60, grouping all bids prior one hour to the deadline into the last bin.

Figure B.2: Distributions of the reserve prices and the corresponding legal thresholds, by month



Notes: High limit corresponds to the definition of under-the-threshold contracts for which the use of EKS auctions was mandatory. Low limit corresponds to the definition of low value contracts, for which the use of EKS was optional.

Figure B.3: Average reserve price and winning bid over time

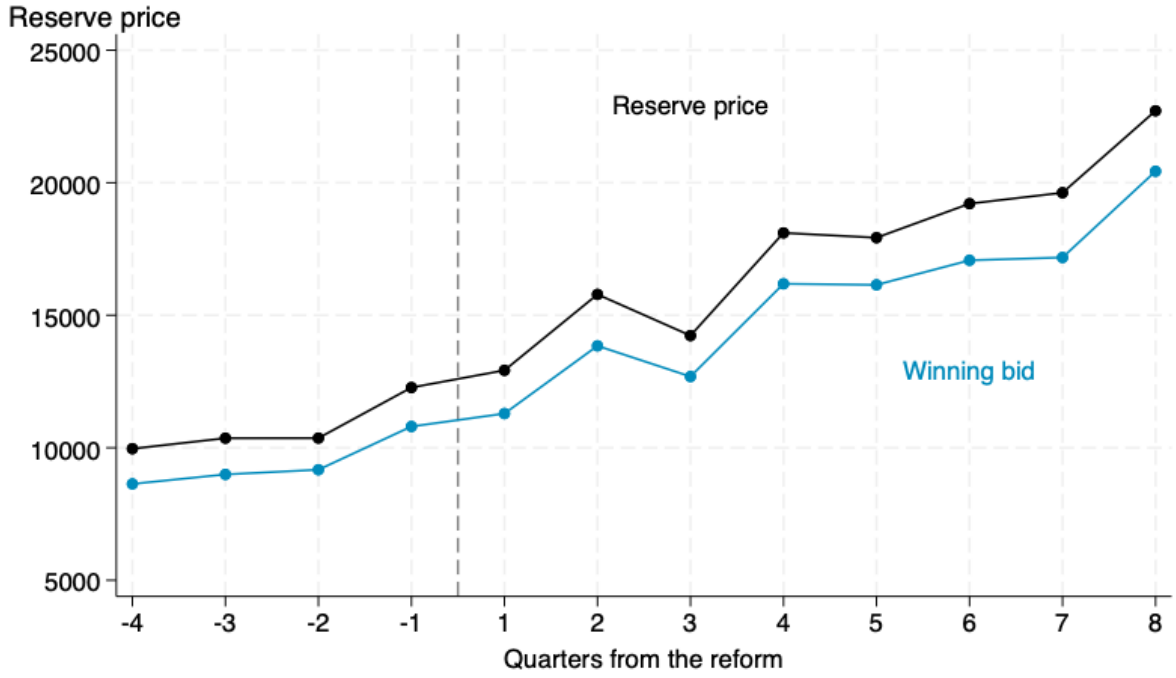
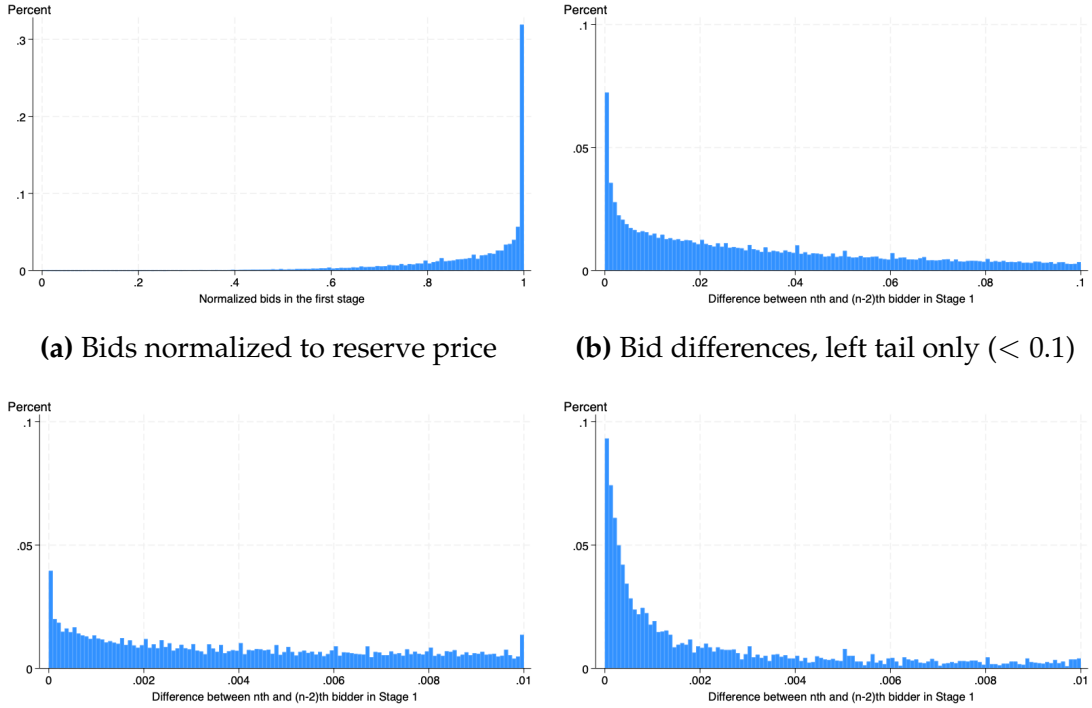


Figure B.4: Distribution of bids in the pre-selection stage



(a) Bids normalized to reserve price

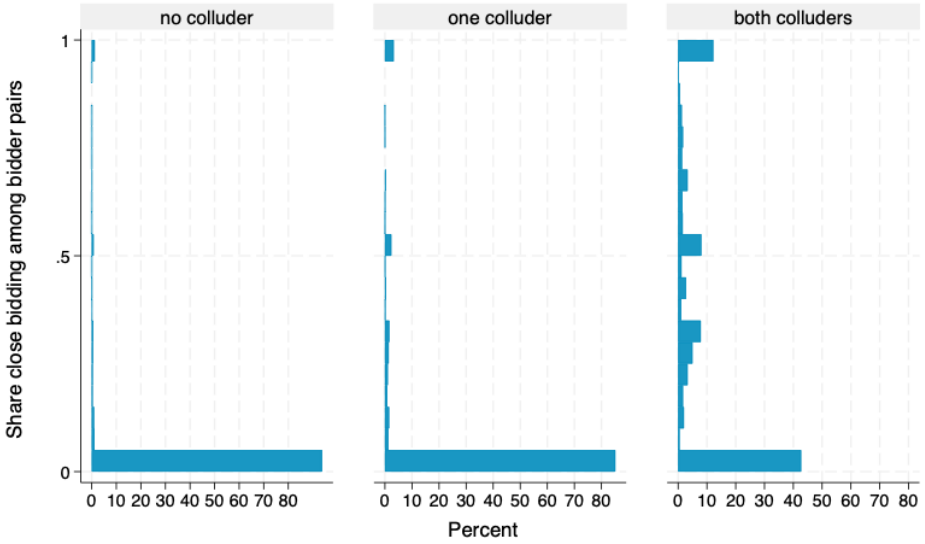
(b) Bid differences, left tail only (< 0.1)

(c) Bid differences in competitive auctions, left tail only (< 0.01)

(d) Bid differences in collusive auctions, left tail only (< 0.01)

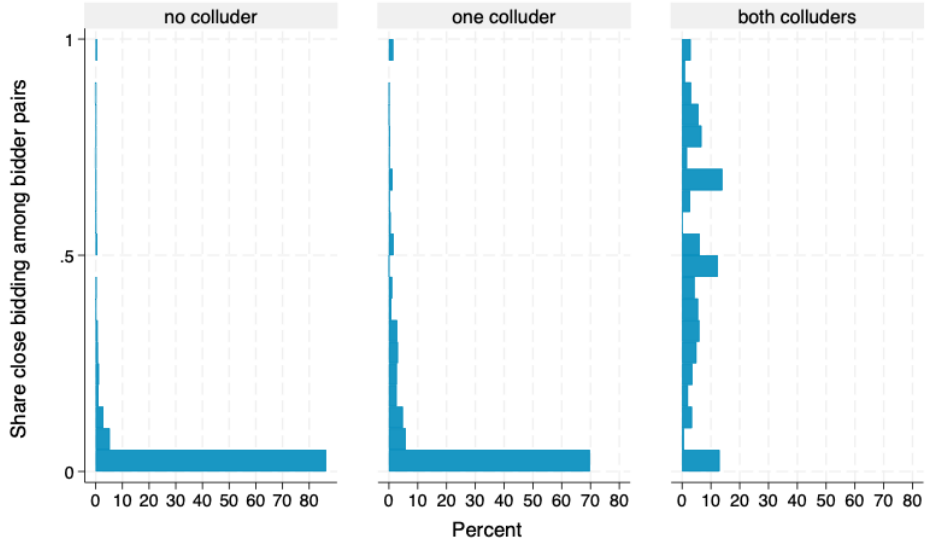
Notes: In panel (a) we plot the histogram of bids in the first stage, normalized by the reserve value. In panel (b), we plot the histogram of differences between nth and $(n+2)$th normalized bids, focusing only on the left tail of the distribution (differences less than 10% of the reserve value). In panels (c) and (d) we look at even narrower left tail (1% of the reserve price) and we further distinguish between auctions without potential colluders and with potential colluders, respectively.

Figure B.5: Distribution of the share of close bidding among bidder pairs (unweighted)



Notes: Close bidding is defined as the occurrence of three opening bids within a value range of 0.1% of each other relative to the reserve price. We consider the share of close bidding among prereform auctions in which a bidder pair participated.

Figure B.6: Distribution of the share of close bidding among bidder pairs (weighted) in subsample not used for marker construction



Notes: Close bidding is defined as the occurrence of three opening bids within a value range of 0.1% of each other relative to the reserve price. We consider the share of close bidding among prereform auctions in which a bidder pair participated.

Table B.3: Bidding in the main auction with preselection (fully-interacted)

	Competition in the Main Auction Stage:		
	Bidders	Bids	Add. savings
1 bidder x 1 coll. bidder	0.05	1.32	0.01*
	(0.03)	(1.27)	(0.00)
2 bidders	1.11***	16.96***	0.06***
	(0.02)	(0.68)	(0.00)
2 bidders x 1 coll. bidder	-0.23***	-7.65***	-0.02***
	(0.07)	(1.85)	(0.01)
2 bidders x 2 coll. bidder	0.06	-4.70	-0.03***
	(0.09)	(3.01)	(0.00)
3 bidders	1.80***	27.77***	0.08***
	(0.02)	(1.02)	(0.00)
3 bidders x 1 coll. bidder	-0.39***	-7.04*	-0.02**
	(0.07)	(2.94)	(0.01)
3 bidders x 2 coll. bidder	-0.27*	-11.86***	-0.03*
	(0.12)	(3.54)	(0.01)
3 bidders x 3+ coll. bidder	-0.15	4.92	-0.06***
	(0.08)	(3.45)	(0.00)
4+ bidders	1.87***	29.12***	0.07***
	(0.02)	(0.91)	(0.00)
4+ bidders x 1 coll. bidder	-0.26***	-5.23**	-0.02***
	(0.04)	(1.99)	(0.00)
4+ bidders x 2 coll. bidder	-0.44***	-8.40***	-0.02***
	(0.05)	(2.20)	(0.00)
4+ bidders x 3+ coll. bidder	-0.33***	-7.18***	-0.03***
	(0.05)	(1.83)	(0.00)
4+ bidders x 3+ coll. bidder x rival excl.	-1.06***	-16.39***	-0.02***
	(0.07)	(1.82)	(0.00)
Constant	0.04	1.27	-0.01**
	(0.03)	(1.62)	(0.00)
Month FE	yes	yes	yes
Year FE	yes	yes	yes
Procurer FE	yes	yes	yes
CPV Category FE	yes	yes	yes
Adj. R2	0.40	0.12	0.14
Avg. Outcome	1.19	17.80	0.04
N	18554	18554	18554

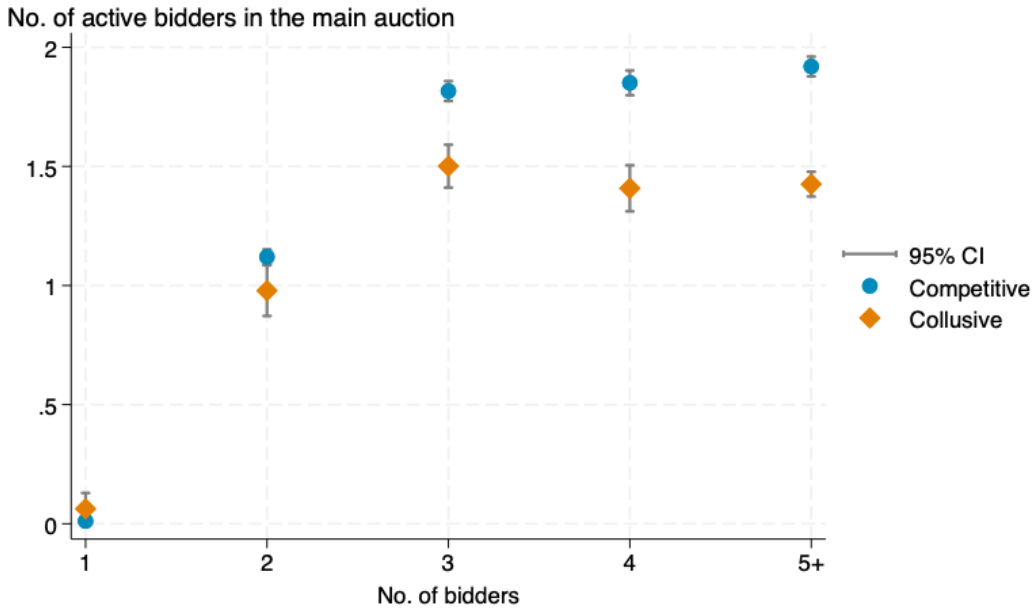
Notes: All specifications are estimated by OLS and include fixed effects indicated at the bottom of the table. Bidder covariates refer to bidders in the preselection stage. Outcome variables are the number of active bidders (#Bidders), number of bids (#Bids) and additional savings (Savings) generated in the main auction stage. Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.4: Bidding in the main auction with preselection (Poisson)

	Competition in the Main Auction Stage:	
	Bidders	Bids
≥1 colluders	-0.19***	-0.28***
	(0.02)	(0.06)
≥3 colluders	0.02	0.13
	(0.03)	(0.08)
Rivals excluded	-1.21***	-2.12***
	(0.10)	(0.25)
≥2 bidders	3.32***	5.94***
	(0.07)	(0.08)
≥3 bidders	0.47***	0.52***
	(0.02)	(0.05)
≥4 bidders	0.03	0.06
	(0.02)	(0.05)
≥5 bidders	0.03	-0.01
	(0.02)	(0.05)
Constant	-3.15***	-2.85***
	(0.08)	(0.10)
Month FE	yes	yes
Year FE	yes	yes
Procurer FE	yes	yes
CPV Category FE	yes	yes
Avg. Outcome	1.19	17.80
N	18364	18364

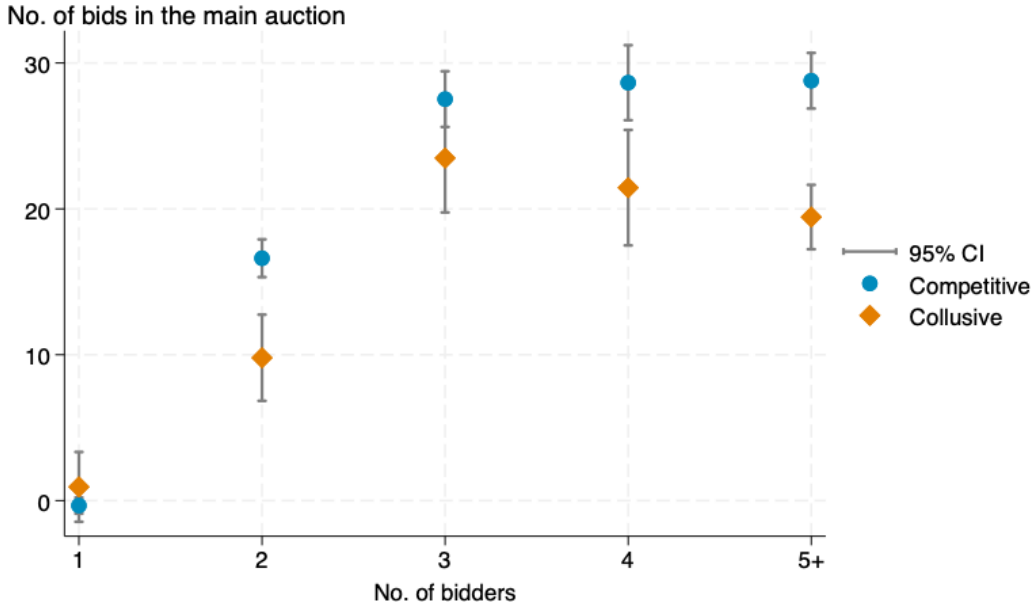
Notes: Both models are estimated using Poisson Pseudo-Maximum Likelihood and include fixed effects indicated at the bottom of the table. Bidder covariates refer to bidders in the preselection stage. Outcome variables are the number of active bidders (#Bidders) and the number of bids (#Bids). Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Figure B.7: Heterogeneity of the collusion effect: Number of bidders



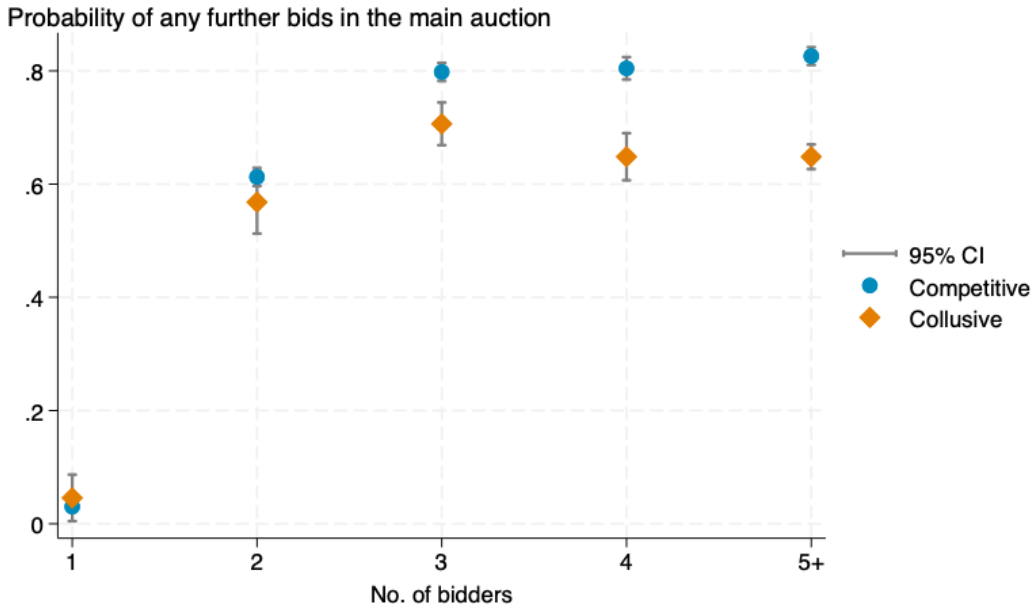
Notes: The graph plots estimates of number of active bidders in the main auction from a regression with full interactions between the number of bidders and an indicator for a potentially collusive auction, while controlling for a set of CPV-category, procurer, year–month fixed effects. The value 5+ on the x-axis captures auctions with 5 or more bidders.

Figure B.8: Heterogeneity in the collusion effect: Number of bids



Notes: The graph plots estimates of number of bids in the main auction from a regression with full interactions between the number of bidders and an indicator for a potentially collusive auction and a set of CPV category, procurer, and year–month fixed effects. The value 5+ on the x-axis captures auctions with 5 or more bidders.

Figure B.9: Heterogeneity in the collusion effect: Any bids



Notes: The graph plots estimates of the probability of no further bids in the main auction from a regression with full interactions between the number of bidders and an indicator for a potentially collusive auction and a set of CPV category, procurer, and year–month fixed effects. The value 5+ on the x-axis captures auctions with 5 or more bidders.

Table B.5: Bidding in the main auction with preselection

	Competition in the Main Auction Stage:		
	Bidders	Bids	Add. savings
Close Bids in Stage 1	-0.33***	-4.44***	-0.03***
	(0.03)	(1.29)	(0.00)
≥2 bidders	1.10***	16.37***	0.06***
	(0.02)	(0.64)	(0.00)
≥3 bidders	0.68***	11.14***	0.02***
	(0.02)	(1.10)	(0.00)
≥4 bidders	-0.01	0.32	-0.01
	(0.03)	(1.43)	(0.00)
≥5 bidders	-0.00	-1.62	-0.02***
	(0.03)	(1.36)	(0.00)
Constant	0.04	1.33	-0.01**
	(0.03)	(1.62)	(0.00)
Month FE	yes	yes	yes
Year FE	yes	yes	yes
Procurer FE	yes	yes	yes
CPV Category FE	yes	yes	yes
Adj. R2	0.38	0.12	0.14
Avg. Outcome	1.19	17.80	0.04
N	18554	18554	18554

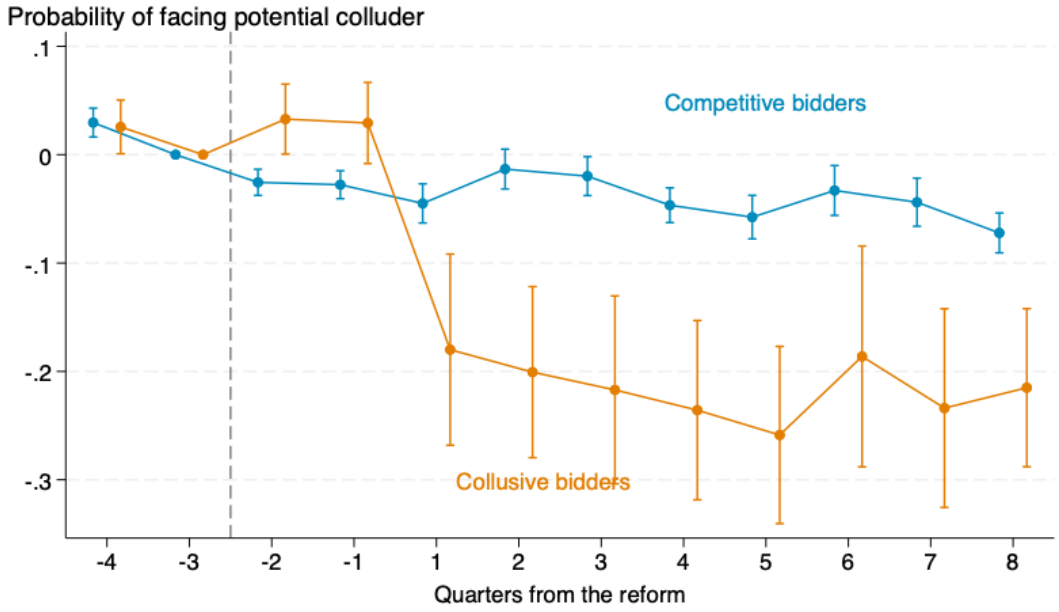
Notes: All specifications include the fixed effects indicated at the bottom of the table. Stage 1 and Stage 2 refer to the preselection stage and the main auction, respectively. Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B.6: Competitive bidders' opening bids in the preselection stage before the reform

	(1) OLS
Pot. Colluder Participates	0.001
	(0.002)
$\geq$3 bidders	-0.021***
	(0.002)
$\geq$4 bidders	-0.019***
	(0.002)
$\geq$5 bidders	-0.052***
	(0.003)
Constant	0.959***
	(0.004)
Bidder FE	yes
Month FE	yes
Year FE	yes
Procurer FE	yes
CPV Category FE	yes
Adj. R2	0.32
Avg. Outcome	0.95
N	53323

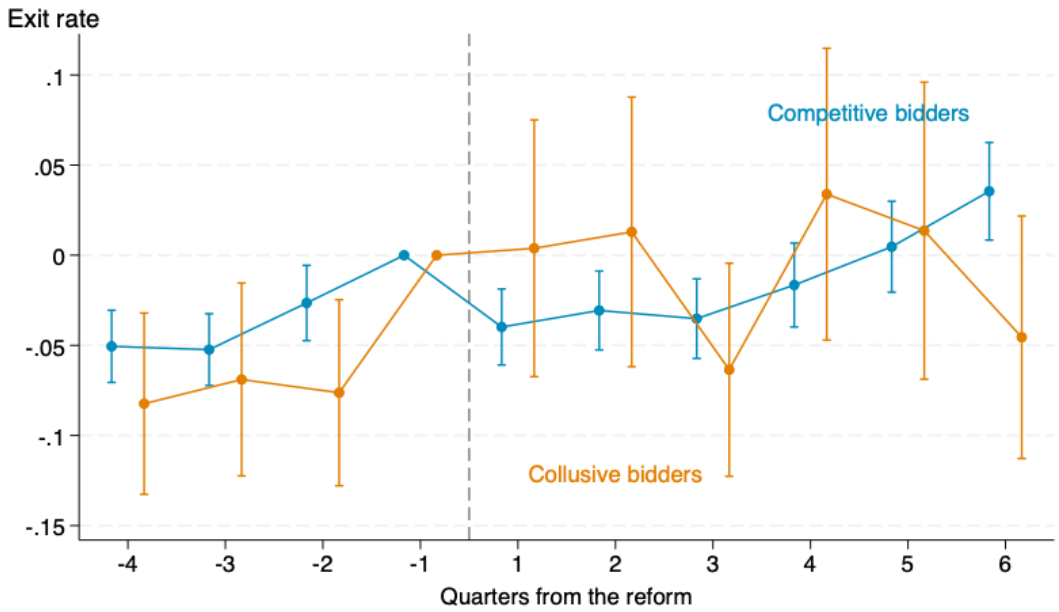
Notes: All specifications include the fixed effects indicated at the bottom of the table. Opening bids are normalized by the reserve price. Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure B.10: Effect on the probability of facing a potential colluder in the preselection stage (Placebo)



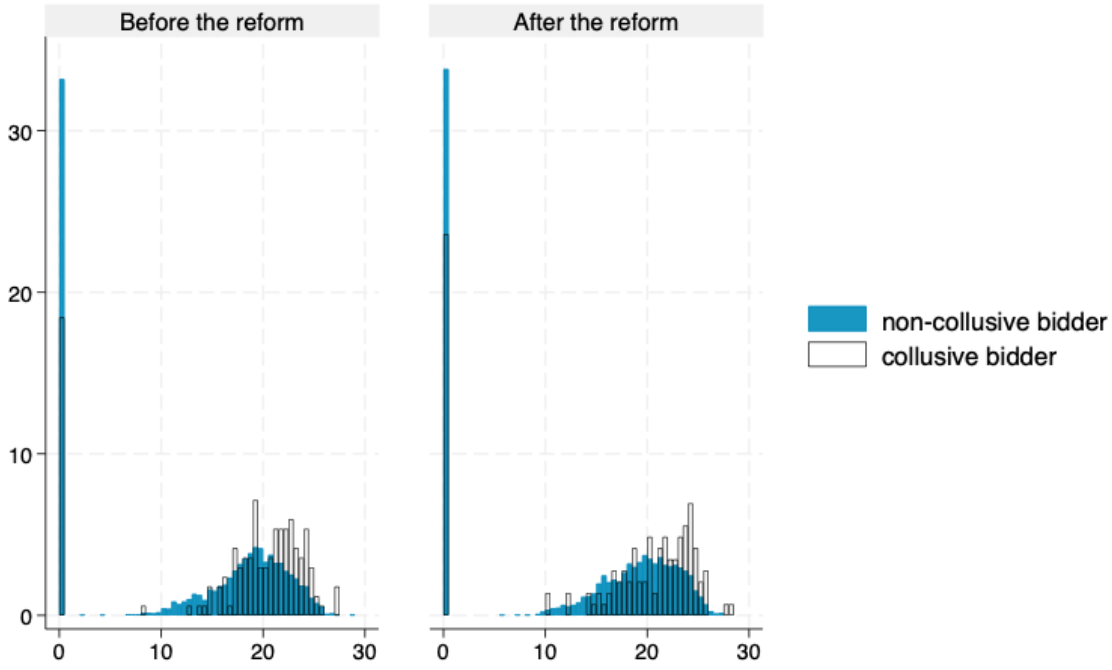
Notes: The graph plots event study coefficients from a regression of an indicator taking the value one if bidder faces a potential colluder the full set of quarter indicators and bidder, procurer, and CPV category fixed effects. The omitted category is three quarters before the reform and collusive bidders are only defined based on data before August 2016. The model is estimated separately for collusive and competitive bidders.

Figure B.11: Effect of the reform on the exit rate



Notes: The graph plots event study coefficients from a regression of exit rates on the full set of quarter indicators. The omitted category is one quarter before the reform to show changes in the exit rate relative to the last prereform quarter. The model is estimated separately for collusive and competitive bidders.

Figure B.12: Log revenue distribution on the EKS platform



Notes: The graph plots the distribution of log revenues generated on the EKS platform for collusive and competitive bidders one year before (l.) and one year after the reform (r.).

Table B.7: Overall economic activity of bidders registered in the RFS

	(1) Full Sample		(2) Competitive Bidders		(3) Collusive Bidders		(4) (2) − (3)
	Mean	SD	Mean	SD	Mean	SD	Diff
Total sales (million EUR)	8.88	75.31	9.11	76.91	3.49	11.15	5.62***
Total assets (million EUR)	6.13	81.22	6.26	82.93	3.11	8.21	3.15
Profits (pre-tax, k EUR)	433.88	7577.98	445.00	7738.29	176.11	693.07	268.89
# employees <5	0.36	0.48	0.36	0.48	0.41	0.49	-0.05
5 ≤ # employees <20	0.31	0.46	0.31	0.46	0.30	0.46	0.01
20 ≤ # employees <100	0.32	0.47	0.32	0.47	0.32	0.47	0.01
100≤ # employees	0.05	0.21	0.05	0.22	0.04	0.18	0.01
Observations	3369		3227		142		

Notes: The table summarizes firm-level variables for the firms in our sample that were registered in the RFS in Slovakia. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

B.3 Testing Competition

Probability of close bidding under competition Suppose N bidders randomly draw a bid from some symmetric distribution: $b_i \sim F^\gamma$, where $b_i \in [0,1]$ and γ indicates the auction group. The n-th lowest bid is denoted by B_n. Define $T_{k,n,N}$ as the distance between the n-th and the $(n+k-1)$-th lowest bids among N bids. Hence

$$T_{k,n,N} = B_{n+k-1} - B_n \text{ where } n+k-1 \leq N.$$

The probability that $T_{k,n,N} \leq t$ is given by (we have to take care a little because the support is bounded!)

$$Pr(T_{k,n,N} \leq t|\gamma) = \int_0^{1-t} Pr(T_{k,n,N} \leq t|B_n = x, \gamma) f_n^\gamma(x) dx + \int_{1-t}^1 f_n^\gamma(x) dx$$

where $f_n^\gamma(x)$ is the n-th order statistic given by

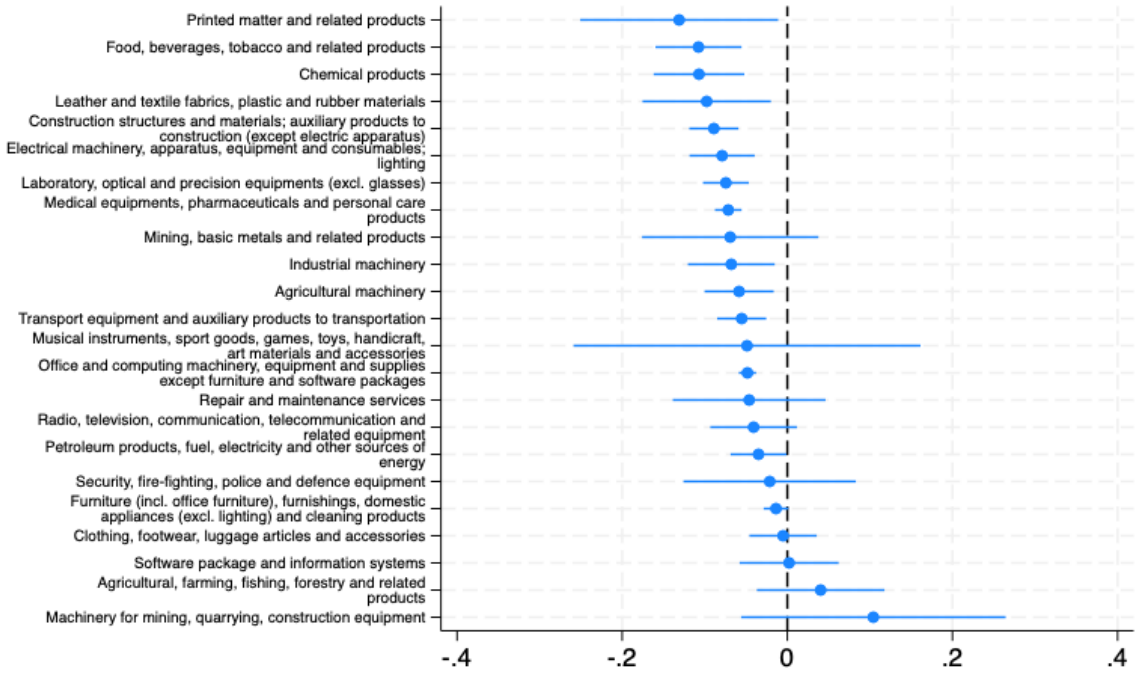
$$f_n^\gamma(x) = \frac{N!}{n-1!N-n!} f^\gamma(x) F^\gamma(x)^{n-1} (1 - F^\gamma(x))^{N-n}.$$

$Pr(T_{k,n,N} \leq t|B_n = x, \gamma)$ is equal to the c.d.f. of the $k-1$-th order statistic among $N-n$ i.i.d. random variables with truncated distribution:

$$Pr(T_{k,n,N} \leq t|B_n = x, \gamma) = \sum_{j=k-1}^{N-n} \frac{N-n!}{j!(N-n-j!)} \left(\frac{F^\gamma(x+t) - F^\gamma(x)}{1 - F^\gamma(x)} \right)^j \left(\frac{1 - F^\gamma(x+t)}{1 - F^\gamma(x)} \right)^{N-n-j}$$

Combining those two expressions above, we get $Pr(T_{k,n,N} \leq t|\gamma)$. However, we are not

Figure B.13: Savings gap before the reform by CPV category



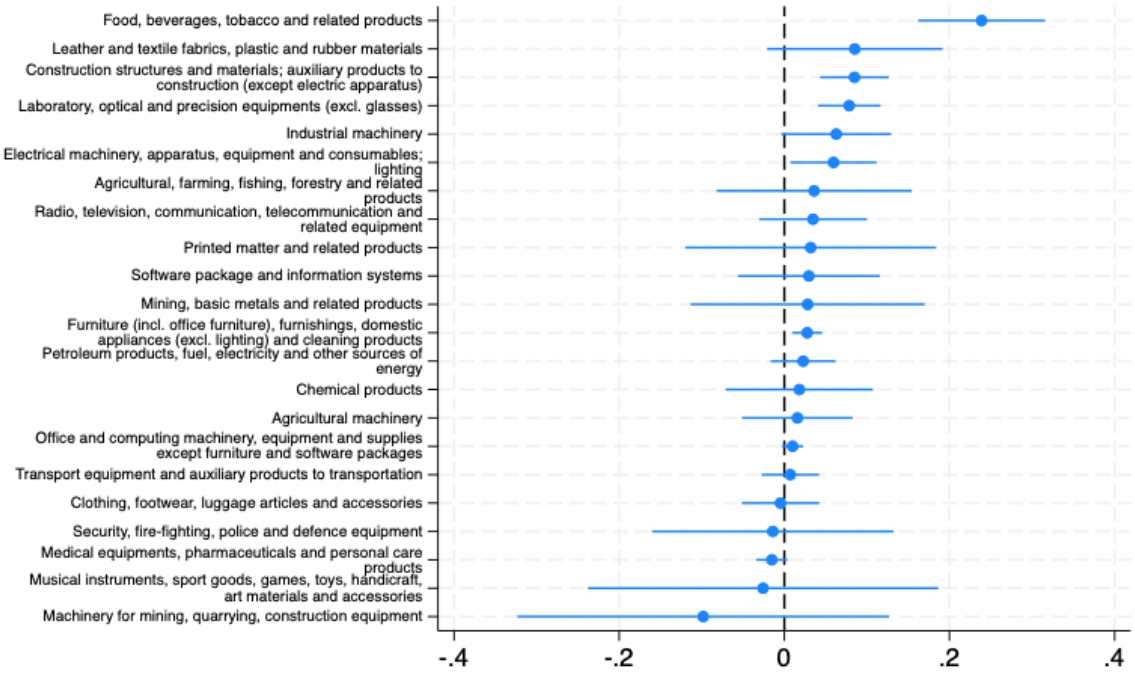
Notes: The graph plots the coefficient and 95% confidence interval of *Collusive* in regression specification (4) run separately for each CPV category at the 2-digit level.

done yet, as we are interested in the distance of *any* k consecutive bids, not only the n-th and the $n+k-1$-th, being smaller than t. Now, if $N > k$, then there are multiple sequences of k bids which might be close. Note however, that events $T_{k,n,N}$ and $T_{k,n+1,N}$ are not necessarily mutually exclusive, so we have to correct for overlaps (i.e., more than three bids being in a given interval). The final expression for the probability of close bidding, i.e. that the distance of at least three bids is smaller than 0.001, in an auction with N total bidders is therefore:

$$\rho_N^\gamma = \sum_{n=1}^{N-2} Pr(T_{3,n,N} \leq 0.001|\gamma) - \sum_{n=1}^{N-3} Pr(T_{4,n,N} \leq 0.001|\gamma)$$

Hypothesis testing H_0 is that costs are drawn independently, and bidders are following a strictly increasing competitive bid function, such that bids are i.i.d realization from distribution F^γ. Suppose we observe close bidding among at least three bidders in m out of M auctions. We reject the null hypothesis if the probability of observing the occurrence of close bidding in at least m auctions is below 1%.

Figure B.14: Effect of the reform on collusive auctions by CPV category



Notes: The graph plots the coefficient and 95% confidence interval of $Collusive \times Post$ in regression specification (4) run separately for each CPV category at the 2-digit level.

The p value is:

$$P(\text{reject } H_0 | H_0, \gamma) = \sum_{k=m}^{M} \frac{M!}{m!(M-m)!} (\rho_N^\gamma)^m (1-\rho_N^\gamma)^{M-m}$$

Fitting the bid distribution Since normalized bids are bounded between 0 and 1, we chose a beta distribution to fit to the bid distribution. To this end, for each CPV category on the 3 digits level, we assume that $b_i^\gamma \sim Beta(a^\gamma, b^\gamma)$. Moreover, we chose a beta regression parameterization:

$$\mu(X_i^\gamma, \beta_1^\gamma) = \frac{a^\gamma}{a^\gamma + b^\gamma} = \frac{\exp(X_i^\gamma \beta_1^\gamma)}{1 + \exp(X_i^\gamma \beta_1^\gamma)}$$
$$\phi(\beta_2^\gamma) = a^\gamma + b^\gamma = \exp(\beta_2^\gamma)$$

To allow for bid distributions to be different depending on the number of bidders participating, we chose X_i^γ to be a set of dummies indicating whether at least four, five, six or seven bidders participate in the auction (in addition to a constant). Using this parameterization, Table B.8 shows the aggregate observed and counterfactual close bidding probability for each CPV category. The last column (# p values < 0.01) reports how

many p values out of the total number of number-of-bidder groups in each CPV category are below 0.01.

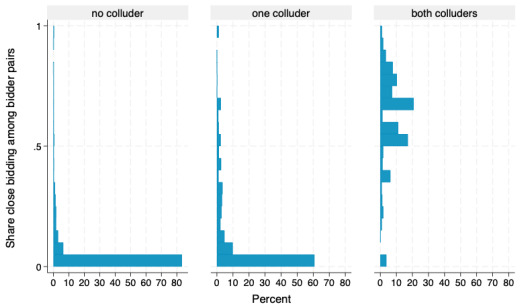
Table B.8: Counterfactual close bidding probabilities and p values

CPV Category (3-digit)	# auctions	Share w. close bidding (%)	Counterfactual probability (%)	# p values < 0.01
Office machinery	2383	18.42	1.47	12/15
Computer equipment	1305	21.38	2.14	13/16
Furniture	576	22.40	0.39	15/18
Medical equipments	547	23.03	1.77	5/9
Miscellaneous transport equipment	315	14.29	0.26	6/12
Personal care products	305	13.44	0.32	10/11
Vehicle parts	264	3.79	0.13	2/7
Domestic appliances	263	11.79	0.54	6/11
Cleaning and polishing products	243	19.75	0.69	10/14
Pharmaceutical products	191	24.08	4.34	3/5
Furnishing	177	15.82	0.68	6/11
Construction materials	136	25.00	0.50	8/10
Textile articles	107	32.71	0.12	10/12
Motor vehicles	104	36.54	6.98	2/6
Lighting equipment	98	11.22	0.12	5/11
Optical instruments	87	21.84	3.84	4/10
Animal products, meat and meat products	85	4.71	0.62	1/9
Television and radio receivers	75	18.67	2.33	3/8
Accumulators, batteries	74	16.22	0.21	4/10
Instruments for checking physical characteristics	74	9.46	0.43	2/7
Occupational clothing	69	24.64	1.58	3/14
Miscellaneous machinery	68	20.59	0.71	5/7
Tools, locks, keys, etc.	67	19.40	0.10	7/9
Miscellaneous equipment	63	28.57	1.29	4/8
Basic inorganic and organic chemicals	61	4.92	0.47	0/5
Harvesting machinery	53	39.62	7.94	2/7
Printed books, brochures and leaflets	53	11.32	1.75	1/5
Paints	53	9.43	0.63	1/5
Miscellaneous food products	47	17.02	1.67	2/6
Miscellaneous fabricated products	42	9.52	0.32	3/8
Dairy products	41	7.32	1.68	1/6
Measuring instruments	41	7.32	0.05	3/8
Emergency and security equipment	40	10.00	1.04	3/8
Leather, textile, rubber and plastic waste	38	36.84	0.72	6/8
Document creation, drawing, etc.	38	23.68	2.38	2/9
Stamps, cheque forms, banknotes, etc.	37	8.11	0.08	2/8
Networks	37	24.32	0.94	2/8
Machinery for power production	37	16.22	1.18	2/10
Telecommunications equipment and supplies	36	11.11	1.27	1/6
Footwear	33	27.27	1.26	5/8
Sports goods and equipment	33	24.24	0.86	5/6
Fertilisers and nitrogen compounds	32	31.25	3.43	3/5
Fine and various chemical products	30	10.00	0.55	1/6
Machinery for textile	30	43.33	2.27	4/7
Tanks, reservoirs and containers	30	23.33	1.90	2/6
Tractors	29	20.69	2.69	1/5
Information systems and servers	29	20.69	2.12	2/10
Cable, wire and related products	28	10.71	0.49	1/7

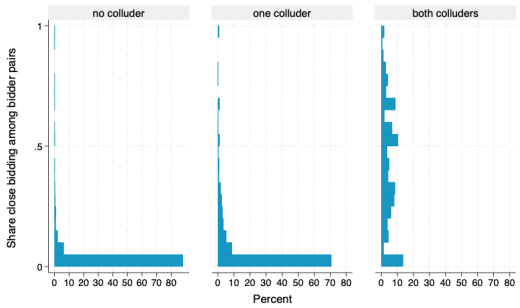
Electric motors, generators and transformers	26	7.69	1.41	0/8
Machine tools	26	7.69	0.70	1/8
Fruit, vegetables	23	4.35	0.97	0/5
Checking and testing apparatus	23	13.04	0.78	1/6
Cooling and ventilation equipment	21	19.05	0.41	2/8
Software package utilities	21	28.57	0.40	3/9
Special clothing and accessories	20	25.00	0.27	4/8
Agricultural and forestry machinery	18	22.22	0.67	2/6
Structural products	18	27.78	2.97	2/8
Electrical equipment and apparatus	17	11.76	0.70	2/9
Textile fabrics	16	56.25	2.54	4/7
Transmission apparatus	16	6.25	1.25	1/5
Garments	15	33.33	1.01	4/8
Networking software package	14	14.29	3.52	0/6
Luggage, saddlery, sacks and bags	13	15.38	2.94	2/5
Construction machinery	12	41.67	2.35	2/5
Lifting and handling equipment	11	18.18	0.82	1/5
Paper or paperboard registers, etc.	10	10.00	0.07	1/6

B.4 Robustness

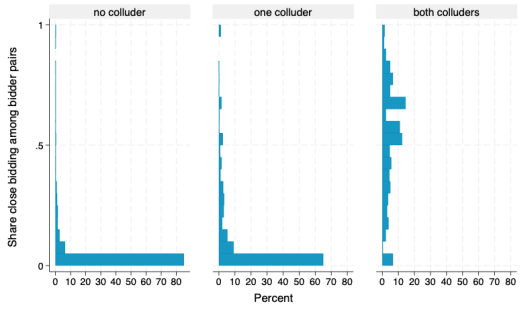
Figure B.15: Distribution of the share of close bidding among bidder pairs (weighted)



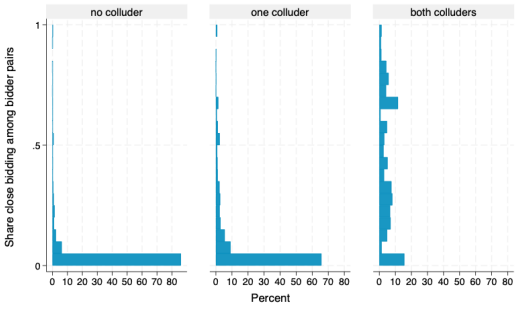
(a) 95th firm percentile



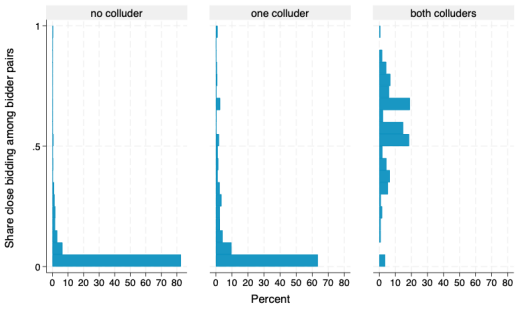
(b) 85th firm percentile



(c) Bid range of 0.05%



(d) Bid range of 0.5%



(e) 90th firm percentile and stable groups

Notes: We consider the share of close bidding in prereform auctions in which a bidder pair participated and weight by the number of these auctions.

Table B.9: Effect of the reform on the probability of facing a cartel member in the pre-election stage

	Add. criterion	Firm percentile		Bid range	
	(1)	(2)	(3)	(4)	(5)
	stable group	95th	85th	0.05 %	0.5 %
Post	-0.037***	-0.003	-0.031**	-0.022*	-0.010
	(0.010)	(0.010)	(0.011)	(0.011)	(0.012)
Pot. Colluder × Post	-0.205**	-0.293***	-0.186***	-0.229***	-0.304***
	(0.070)	(0.071)	(0.032)	(0.046)	(0.054)
≥3 bidders	0.021***	0.020***	0.084***	0.048***	0.054***
	(0.005)	(0.006)	(0.012)	(0.006)	(0.008)
≥4 bidders	0.022***	0.026***	0.062***	0.044***	0.066***
	(0.003)	(0.003)	(0.005)	(0.003)	(0.011)
≥5 bidders	0.124***	0.135***	0.179***	0.152***	0.172***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)
Constant	0.077***	0.088***	0.144***	0.099***	0.135***
	(0.011)	(0.012)	(0.015)	(0.012)	(0.013)
Bidder FE	yes	yes	yes	yes	yes
Month FE	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes
Procurer FE	yes	yes	yes	yes	yes
CPV Category FE	yes	yes	yes	yes	yes
Adj. R2	0.36	0.35	0.40	0.37	0.37
Avg. Outcome	0.15	0.15	0.28	0.21	0.23
N	144148	144148	144148	144148	144148

Notes: Fixed effects included in the specifications are indicated at the bottom of the table. Standard errors in parentheses are clustered at the bidder level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B.10: Effect of the reform on overall savings

	Add. criterion	Firm percentile		Bid range	
	(1)	(2)	(3)	(4)	(5)
	stable group	95th	85th	0.05 %	0.5 %
Post	-0.018**	-0.018*	-0.022**	-0.019**	-0.022**
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Collusive	-0.039***	-0.046***	-0.057***	-0.051***	-0.060***
	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)
Collusive × Post	0.020***	0.023***	0.028***	0.019***	0.033***
	(0.005)	(0.005)	(0.003)	(0.004)	(0.004)
≥2 bidders	0.084***	0.084***	0.086***	0.085***	0.084***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
≥3 bidders	0.074***	0.074***	0.077***	0.075***	0.076***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
≥4 bidders	0.045***	0.045***	0.046***	0.045***	0.047***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
≥5 bidders	0.082***	0.083***	0.086***	0.084***	0.086***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Constant	0.007	0.007	0.011*	0.008	0.010*
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Month FE	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes
Procurer FE	yes	yes	yes	yes	yes
CPV Category FE	yes	yes	yes	yes	yes
Adj. R2	0.39	0.39	0.39	0.39	0.39
Avg. Outcome	0.14	0.14	0.14	0.14	0.14
N	48842	48842	48842	48842	48842

Notes: Fixed effects included in the specifications are indicated at the bottom of the table. Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

B.5 The Competition Authority and Legal Framework

The Antimonopoly Office of the Slovak Republic (AMO SR) is the national competition authority in Slovakia. Analogously to similar authorities in other EU member states, its role is to oversee mergers and prevent prohibited practices such as abuses of a dominant market position or formation of cartels.

The practice of bid-rigging in public procurement is considered by the AMO SR to be one of the most serious forms of cartel agreements, being explicitly prohibited by Act No. 136/2001 Coll. on Protection of Competition. The AMO SR can punish such a breach by imposing a fine of up to 10% of a firm's turnover. A taxonomy of collusion practices in procurement, together with an explanation of the harmful effects of bid-rigging, is available on the website of the competition authority (**?**), highlighting that

the national competition authority is well aware of potential bid-rigging in procurement markets. Moreover, there is a reward scheme in place, offering 1% of the imposed fine as a reward (capped at EUR 100,000) for cartel-relevant information and evidence such as e-mails, written documents or other information that would lead to a raid. In addition, the reward scheme is supported by a leniency program that allows a reduction in the fine for the first cartel member that provides decisive evidence on the existence of the cartel and thus implicates other cartel members. Alternative instruments available to the AMO SR instead of fines are "commitments," which obligate an infringing entity to remove the identified anticompetitive element, and "settlements," under which fines can be reduced in exchange for acknowledgment of participation in the breach and acceptance of related liabilities.

However, the existing legal framework to prevent the formation and maintenance of cartels is applied relatively rarely, as cartels are difficult to detect. Since 2010, there have been only 32 cases against suspected cartel behavior initiated by the AMO SR.[68] Out of these, 22 (69%) resulted in a punishment (fines and, in several cases, also bans on participation in public procurement), while the remaining cases were either dismissed or overturned by second instance decisions. The average fine amount was EUR 920,014. In total, the AMO SR has imposed fines worth more than EUR 20.2 million since 2010. The most frequently investigated sector is construction, with 9 separate cases (28% of all cases). Other common sectors are IT services, machines and engineering, and office supplies, each with 3 cases. The AMO SR opened 4 cases against professional associations, and the remaining cases involved 96 distinct companies or entrepreneurs.

In 2016, the AMO SR started analyzing the behavior of bidders in auctions on the EKS platform after receiving multiple complaints and later published its findings, consisting primarily of anecdotal evidence, in a short policy document (**?**). In response to the increased interest and complaints, the EKS modified its auction rules on February 2017 without giving longer notice, giving rise to the discontinuity that we study. The reform occurred more than 3 months before the findings of the AMO SR were published.

[68] These calculations are based on decisions published on the website of the AMO SR, processed by the authors.