Competitive effects of vertical integration in auctions

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Vertical integration (VI) debate

Vertical markets: upstream producers distribute via downstream intermediaries.

What is the effect of vertical integration on prices for buyers?

Vertical integration trade-off:

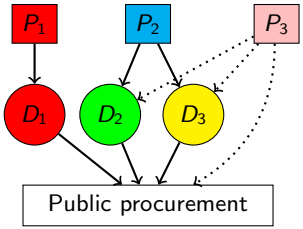
- **efficiency gain**: synergy effect and elimination of double marginalization $\Rightarrow$ reduce prices;
- **raising rivals' costs** (RRC) and **exclusion** of downstream rivals $\Rightarrow$ increase prices;

Policy debate in antitrust regarding vertical mergers in the US and EU.

Pharmaceutical industry features

1. Supply side is vertically structured:
   - producers: active ingredient defines similarity of brands;
   - distributors (wholesalers): spread out drugs of different producers;
2. Demand from public buyers has a large share:
   - regulation fosters competition at two levels;
     - brand substitution and price regulation.
     - price competition in auctions;
   - marketplace: public procurement auctions.

$\Rightarrow$ Producers and distributors have incentives for merger.



Research question

What is the effect of vertical integration on procurement prices?

Approach

I. Motivating reduced-form evidence.

II. Theoretical model to rationalize this evidence.

III. Structural estimation of costs and simulations of vertical mergers.

Overview of results

Retrospective analysis

I. **Reduced-form evidence using Russian date**:

1. Soft upstream competition: prices *increase* by 12%.
2. Tough upstream competition: prices *decrease* by 1.7%.

II. **Theory explains**:

- Point 1. via the restriction of downstream competition and raising rivals costs.
- Point 2. via the synergy of integration (reduction of transaction costs).

III. **Structural estimation**: producer and distributor costs with 2 producers.

IV. **Simulation of vertical integration (VI)**

- VI with synergy below 4% of total cost harms the buyer.
- Average synergy is around 1% of total cost.
- Structural remedy: mandatory sharing of the production technology by VI producer.

External validity

Advantages of Russian evidence:

- Public procurement of drugs is 1/3 of the overall pharmaceutical demand.
- Detailed information about bidders and purchased drugs.

External validity: countries with public healthcare systems:

- many EU countries: France, Italy, Spain;
- large developing countries: China, India, Brazil.

Contribution

1. **Effect of vertical integration:** Literature
   - Literature: ordinary markets with product differentiation (Hastings & Gilbert 2005; Hortaçsu & Syverson 07; Lee 13; Asker 16; Crawford et al. 18; Nocke & Rey 18; Luco & Marshall 19).
   - This paper: auction setting without product differentiation.

2. **Structural estimation of auctions:**
   - Literature: no intermediation cost, but information asymmetry (Hortaçsu et al 12,18).
   - This paper: intermediaries and input suppliers costs identification.

3. **Studies of the Pharma industry:**
   - vertical vs. horizontal mergers (Bjornerstedt & Verboven 16; Bonaime & Wang 19).
   - supply vs. demand side of procurement (Duggan et al. 10, Jascisens 17, Dubois et al. 21).
   - public procurement vs. retail market markups (Dubois & Lasio 18, Dubois & Sæthre 20).

Agenda

1. Reduced-form evidence
2. Model
3. Structural estimation

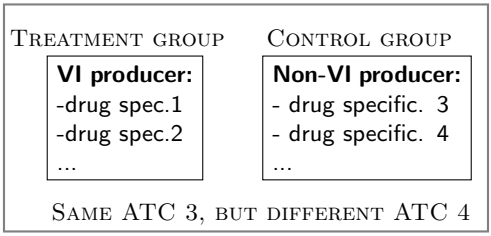
Public procurement:

- Period: July 2014 - September 2019.
- Population of procurement auctions: anti-neoplastic, antimicrobial, treating diabetes and diseases of the circulatory system market
- 814K auctions descriptive
- Bidding protocol includes:
  - IDs and bids of all bidders;
  - winner's price-per-unit and quantity for each drug;
  - brands of supplied drugs and their producers.

VI events: 2 partial mergers, 3 full mergers, 4 divestitures details

DID identification of VI effect on prices

- **Treatment group**: drugs of VI producers.
- **Control group**: drugs of Non-VI producers, but in the same ATC 3 level and different ATC 4 level as drugs in the Treatment group ATC, desc.stat.:



Specification: details

- Dependent variable: log of price-per-unit
- FE: drugs, year-quarter, drug.class-year
- Controls: quantity of drugs, auction's and buyer's characteristics

Sample: auctions with VI distributors

	Dependent variable: Log of price-per-unit	
	OLS	OLS
	(1)	(2)
ATT	−0.017***	
	(0.006)	
ATT (1 producer)		0.114*
		(0.065)
ATT (2-4 producers)		0.135**
		(0.055)
ATT (at least 5 producers)		−0.018***
		(0.006)
Drug spec. FE	850	850
Region FE	YES	YES
Year-quarter FE	YES	YES
ATC3-year FE	YES	YES
Observations	123,074	123,074
R^2	0.955	0.955

*p<0.1; **p<0.05; ***p<0.01

Robustness check

- Control for downstream competition Basic Alternative No bundling
- Staggered DID: stack regression (Cengiz et al. 19) Results.
- Only vertical mergers: exclude divestitures and all mergers have intensity 1 Results.
- Geographical markets: Drug specification-West/East Results.
- Favouritism: Procurer-Distributor FE Results.
- Impact of VI on competition Num.Applicants No bundling.

Agenda

1. Reduced-form evidence
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3. Structural estimation

Players, timing and costs structure

Inelastic demand:

- procurer buys a fixed number of drug units via a descending auction
- public reserve price r.

Players: N upstream producers $\{P_i\}_{i=1}^N$ and M downstream distributors $\{D_j\}_{j=1}^M$.

Timing:

Stage 1:

- Upstream producers observe independent private production costs $(c_i)_{i=1}^N$, $c_i \in [\underline{c}, \overline{c}]$.
- All distributors simultaneously negotiate input (wholesale) prices with all producers.
- Negotiation protocol:
  - if $N = 1$ then P_1 is price setter;
  - if $N > 1$ then each distributor runs an internal descending auction among all producers.
  - input price p_j of D_j cannot exceed $\overline{p}$. $\overline{p}$ is common knowledge and $\overline{p} \ll r$. details
  - no trade at this stage, but commitment about the price level.

Stage 2:

- Distributors observe independent private distribution costs $(d_j)_{j=1}^M$, $(tc_j = p_j + d_j)_{j=1}^M$.
- Distributors participate in the *descending auction* of the buyer.
- The winner trades with producer at the committed price and supplies the drug.

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Scenarios

Vertical separation (VS): Distributors and producers are independent firms.

Vertical integration (VI): P_1 is vertically integrated with D_1, other firms are independent.

- **Synergy effect** δ**:** D_1 can get the drug at its cost $p_1 = c_1 - \delta$ from P_1. δ is exogenous.

Goal: compare ex-ante expected buyer payment ($\mathrm{E}p^{vs}$ vs. $\mathrm{E}p^{vi}$)

Single producer

Proposition 1. Assume that P_1 cannot exclude rival distributors under VI scenario.

- No synergy ($\delta = 0$) $\Rightarrow \mathrm{E}p^{vi} = \mathrm{E}p^{vs}$.
- Positive synergy ($\delta > 0$) $\Rightarrow \mathrm{E}p^{vi} < \mathrm{E}p^{vs}$.

$\Rightarrow$ under behavioral remedy, VI does not increase the buyer payment details

Remark 1. Exclusion of rival distributors is optimal when regulated price is low Graph

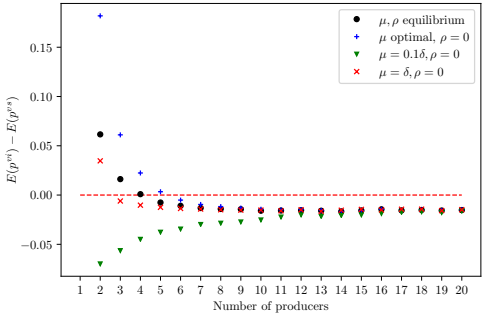
Several producers details

Proposition 2. (i) No synergy ($\delta = 0$) $\Rightarrow \lim_{N\to\infty} \mathrm{E}(p^{vi}) - \mathrm{E}(p^{vs}) = 0.$

(ii) Positive synergy ($\delta > 0$) $\Rightarrow \lim_{N\to\infty} \mathrm{E}(p^{vi}) - \mathrm{E}(p^{vs}) < 0.$

If the number of producers is large, RRC effect is negligible, synergy effect creates asymmetry.

Remark 2. Vertical integration can increase the buyer payment if number of producers is low.



$c_i \sim U[3, 4]$,

$d_j \sim U[1, 2]$,

$\delta = 0.25$,

$M = 3$

Agenda

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2. Model
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Identification

VS scenario: structure of total cost for D_j ($j \in \{\overline{1, M}\}$) multiplicative unobserved het.:

$$tc_{j,a} = \underbrace{c_{2,a}^{(N)}}_{\text{common term}} + \underbrace{d_{j,a}}_{\text{private value}} + \underbrace{\beta \mathrm{X_a}}_{\text{observed heterogen.}} \tag{1}$$

Observed data: bids from *descending* auctions with public reserve price.

Identification: extension for English auctions with unobserved heterogeneity details

- Bids are order statistics of total costs.
- Unobserved heterogeneity is the equilibrium negotiation price.

Estimation

Sample:

1. Two vertically separated producers.
2. Producers are not bidders.

} VS scenario

3. Number of applicants = Number of bidders.
4. No bundling.
5. Reserve price in [2M, 30M] RUB ([31K, 465K] USD).

} No corruption & re-negotiation

6. $\geq$ 500 observations for a drug specification.

} Estimation accuracy

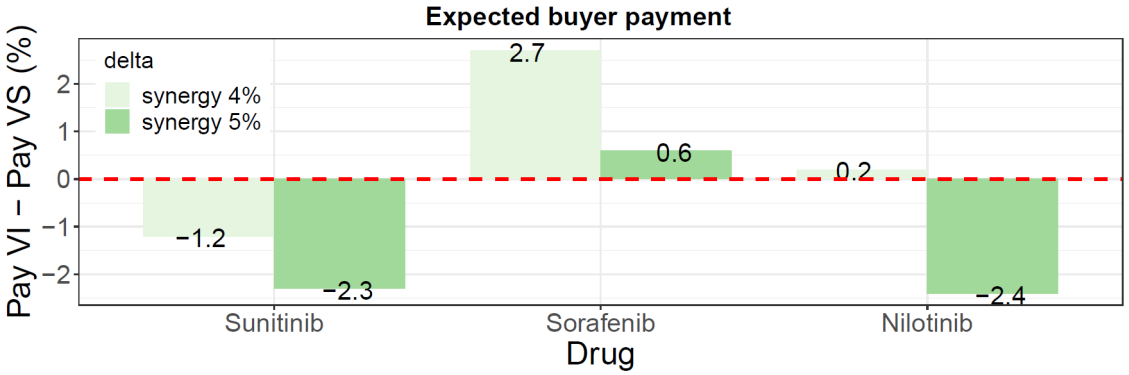
$\Rightarrow$ **Antineoplastic drugs**: Sunitinib, Sorafenib, Nilotinib.

Binding reserve price $\Rightarrow$ ML estimation likelihood

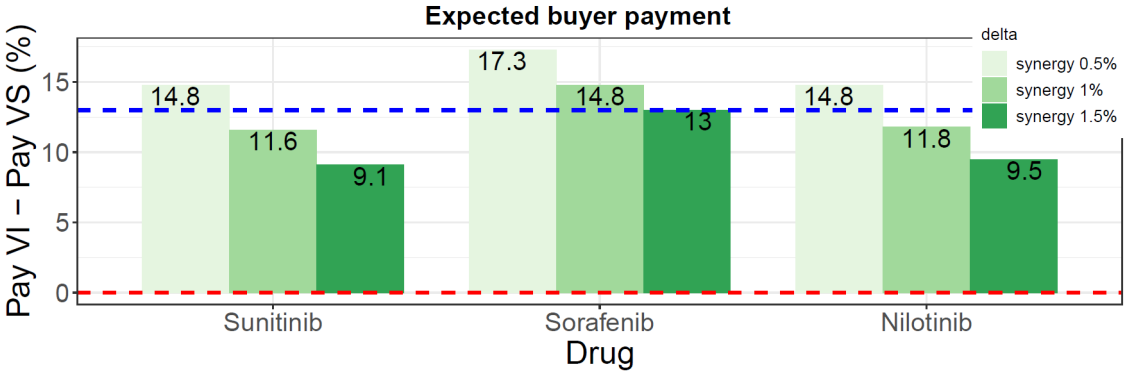
Parametric assumptions: $c_i \sim N(\mu_c, \sigma_c^2)$, $d_i \sim N(\mu_d, \sigma_d^2)$ Estimates semi-parametric

Simulation: synergy for pro-competitive merger

No synergy

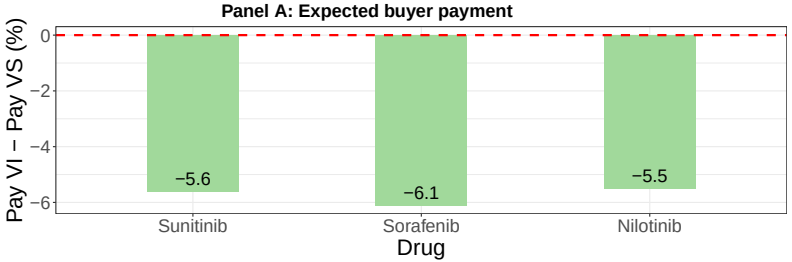


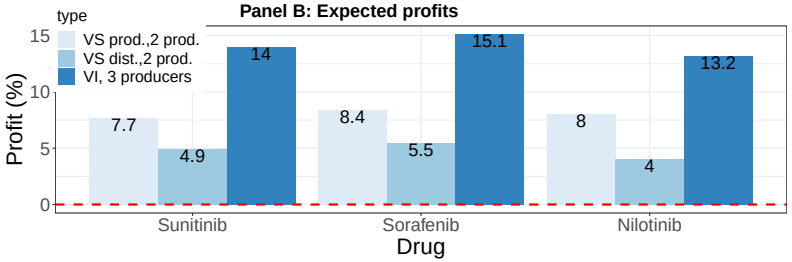
Simulation: synergy which matches the reduced-form effect



Simulation of structural remedy: 1% synergy and exogenous entry

Extensions





Conclusion

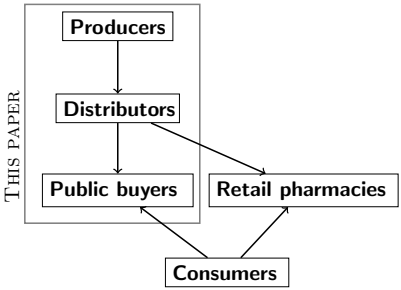
Agenda

1. VI is not anti-competitive in procurement markets if upstream competition is tough.
2. VI requires special attention if upstream competition is soft:
   - proof of substantial synergy effect;
   - mandatory sharing of production technology.

Appendix

Public Procurement of drugs in Russia

1. Public procurement (PP) is 35% of the demand (8.6 billion USD in 2019).
2. Public buyers
   - Federal and regional healthcare authorities.
   - Hospitals, polyclinics.
3. Bidders are mostly distributors.
   Producers rarely participate.



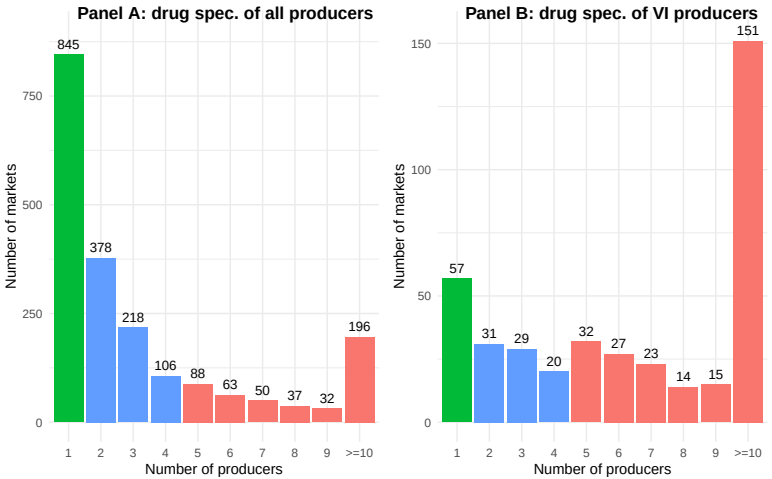
Auction for drugs main

1. Buyer describes for each drug in a bundle:
   - **Drug specification:**
     - active ingredient (Insulin glargine), but not brand (Lantus SoloStar of Sanofi) ATC;
     - AI dosage (100 un/ml, 3 ml).
   - **Quantity:** number of units in pack and number of packs (5 units/pack, 2 packs).
   - **Reserve price** is determined by the regulated prices for drugs (53 USD/pack):
     - prices of producers are regulated at the national level;
     - markups of distributors are regulated at the regional level.
2. Buyer announces a procedure: *electronic descending auctions*.
3. Potential bidders negotiate input prices with producers.
4. Bidders participate by placing their bids for the bundle. Minimal bid wins.
5. Winner supplies the bundle.

Market definition

main

Each **drug specification** (active ingredient-dosage) is a market.



Descriptive statistics main

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Bundle reserve price (M RUB)	814,684	2.73	26.55	0.001	0.20	1.56	8,332.50
Number of distinct drug spec.	814,684	2.69	4.84	1	1	2	135
Drug spec. HHI	814,684	0.67	0.38	0	0.3	1	1
Bundle has drug spec. of VI prod.	814,684	0.53	0.50	0	0	1	1
Share of drug spec. of VI prod.(%)	814,684	38.88	45.06	0	0	100	100
Number of applicants	813,523	2.73	2.16	1	1	4	23
Rebate for bundle (%)	803,983	11.63	18.25	0	0	18.3	80
VI distrib. applies (%)	814,684	7.3	26	0	0	0	100
VI distrib. wins (%)	814,684	2.5	15.5	0	0	0	100

Bundle level Drug level Interactions

Events related to VI main

Distributor	Producer	Share change	Event type	Completion date
Biocad	Pharmstandart	20% → 70%	Partial merger	31.12.2015
Eskom	Medpolymer	100% → 0%	Divestiture	04.03.2016
Biotek	Biosintez	100% → 0%	Divestiture	20.12.2016
SIA	Biokom	0% → 100%	Full merger	01.02.2017
SIA	Sintez	17% → 51%	Partial merger	01.02.2017
Eskom	Medpolymer	0% → 100%	Full merger	08.02.2017
Protek	Rapharma	0% → 100%	Full merger	17.04.2017
SIA	Sintez	100% → 0%	Divestiture	29.11.2018
SIA	Biokom	100% → 0%	Divestiture	29.11.2018

Descriptive statistics: drug level

Distributor	Producer	Obs.	Drug spec.	Mean z-price	Median z-price	St.d. z-price
Non-VI distrib.	Non-VI prod.	968598	1614	0.002	-0.063	0.999
Non-VI distrib.	VI prod.	1490452	399	0.000	-0.212	1.001
VI distrib.	Non-VI prod.	38178	1218	-0.016	-0.166	0.987
VI distrib.	VI prod.	18184	227	-0.077	-0.276	0.963

Drug level main

Identification of VI effect on prices

main

Difference-in-differences with multiple treatment events of different intensities

$$\begin{aligned} ln(price_{i,d,t,q,s,b}) = & \alpha I(d \in D, t \in T) \cdot Intensity + [\beta Num.Applicants_i] + \\ & \mu_d + \lambda_t + \nu_{ATC3-year} + \delta_q + \eta_b + X_i\theta + \varepsilon_{i,d,t,q,s,b}, \end{aligned} \tag{2}$$

- T is the period of integration between VI producer and VI distributor.
- D is the treatment group.
- **Intensity**: 1 for full mergers, 0.5 for partial mergers, -1 for divestitures.
- **DID FE**: drug specification (μ_d), year-quarter (λ_t).
- **Mergers are not random**: $\nu_{ATC3-year}$ controls for dynamic changes of demand VI markets.
- **Num.Applicants** controls for downstream competition.
- **Scale and distance** controls: quantity quantile (δ_q), buyer region (η_b).
- **Auction characteristics** X_i: number of drug specifications, duration, centralization.

Endogeneity of Number of applicants and Bundling

- Merger induced instruments: share of treated drugs and its interaction with post-VI event.
- Relevance: higher share of treated drugs $\Rightarrow$
  - VI distributor has higher cost advantage due to efficiency gain.
  - RRC effect of VI producer is stronger.
- Validity:
  1. Buyers set bundle.
  2. Buyers do not deliberately give an advantage to VI distributors via the higher share of treated drugs treated share.
  3. Price equation controls for:
     - number of drug specifications in the bundle.
     - drug specifications FE.

VI effect

With control for downstream competition

	Panel A: Log of price-per-unit of drug			
	OLS	OLS	2SLS	2SLS
	(1)	(2)	(3)	(4)
ATT	−0.017***		−0.015**	
	(0.006)		(0.006)	
ATT (1 producer)		0.114*		0.056
		(0.065)		(0.075)
ATT (2-4 producers)		0.135**		0.128**
		(0.055)		(0.055)
ATT (≥ 5 producers)		−0.018***		−0.016***
		(0.006)		(0.006)
Number of applicants			−0.092***	−0.092***
			(0.009)	(0.009)
Drug spec. FE	850	850	850	850
Observations	123,074	123,074	122,971	122,971
R^2	0.955	0.955	0.953	0.953
	Panel B: First stage. Number of applicants			
	(1)	(2)	(3)	(4)
Treat. PD share			0.009***	0.009***
			(0.001)	(0.001)
Treat. PD share*post VI			−0.003***	−0.003***
			(0.001)	(0.001)
F statistics			144.78	144.89

*p<0.1; **p<0.05; ***p<0.01

Placebo effect: VI distributor does not participate

	Panel A: Log of price-per-unit of drug			
	OLS	OLS	2SLS	2SLS
	(1)	(2)	(3)	(4)
ATT	−0.033**		−0.032*	
	(0.017)		(0.017)	
ATT (1 producer)		−0.065		−0.070
		(0.047)		(0.048)
ATT (2-4 producers)		0.028		0.025
		(0.026)		(0.025)
ATT ($\geq$ 5 producers)		−0.034**		−0.033*
		(0.017)		(0.017)
Number of applicants			−0.043**	−0.043**
			(0.020)	(0.020)
Drug spec. FE	1242	1242	1242	1242
Observations	1,909,394	1,909,394	1,905,849	1,905,849
R^2	0.962	0.962	0.963	0.963
	Panel B: First stage. Number of applicants			
			(1)	(2)
Share of treated drugs			0.008***	0.008***
			(0.001)	(0.001)
Share of treated drugs $*$ Post VI			−0.0002	−0.0002
			(0.001)	(0.001)
F statistics			64	64

*p<0.1; **p<0.05; ***p<0.01

Details about condition $\overline{p} \ll r$

- Let $G(t)$ be the log-concave cdf of $(d_j)_{j=1}^m$.
- Let $G_m(t) = 1 - (1 - G(t))^m$ be the distribution of minimum of $(d_j)_{j=1}^m$.
- Let p^* be the solution of $p = c + \frac{G_m(r-p)}{G_m'(r-p)}$.
- The assumption means $\overline{p} \leq p^*$.

main

Literature: complete information main

Costs are common knowledge

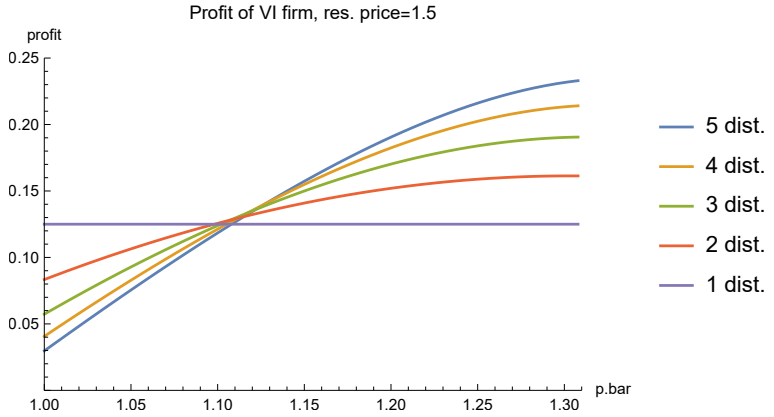
- Chicago school: VI should be authorized as they cannot do worse for consumers.
  - i) powerful contracts mimic the VI effect $\Rightarrow$ monopoly profit is feasible even without VI;
  - (ii) VI eliminates double marginalization.
- post-Chicago literature: VI can do worse for consumers
  - i) Problem of commitment (Hart and Tirole 1990) $\Rightarrow$ no monopoly power without VI.
  - (ii) If upstream market is not monopolized, but concentrated, foreclosure (RRC) appears. Overall effect of VI is ambiguous (Salinger 1988,1991; Ordover et al. 1990)
  - (iii) VI effect may be harmful for consumers if the downstream market is competitive enough (Riordan 1998; Loertscher, Resinger 2014).
  - (iv) Drawbacks:
    - foreclosure is not necessary justified by the game;
    - often either RRC or efficiency gain are introduced, but not together;
    - conclusions are driven by the choice of modeling competition.

Literature: incomplete information main

Costs are private values

- Upstream firm signals its type (White 2007) or capacity (Baake et al. 2004). It solves commitment problem, but induces inefficient output, alleviated by VI.
- Downstream firms are considered to have buyer power in the negotiation (Thomas 2011; Loertscher, Marx 2019,2020; Loertscher, Riordan 2019; Waehrer 2019)
  - auction is introduced as negotiation mechanism.
  - foreclosure is a consequence of strategic behavior, but not the assumption.
  - efficiency gain can be easily incorporated together with RRC.
  - demand is inelastic, so not concern about type of contracts.

Foreclosure by single producer



$c_1 = 1, d_j \sim U[0,1], \delta = 0, M = 5, r = 1.5$

Single producer: VS scenario

Stage 2:

- distributor j stays in the auction until the current price reaches the total cost $tc_j = p_j + d_j$
- The buyer payment is $tc_2^{(m)}$, i.e. the second lowest total cost.

Stage 1:

- Distributors are symmetric $\Rightarrow$ producer sets the same input price to distributors $p_j = p$.
- Producer maximizes profit

$$arg \max_{p \leq \overline{p}} (p - c_1) \cdot \mathrm{P}\left(d_1^{(m)} \leq r - p\right) = \overline{p} \tag{3}$$

$\Rightarrow$ Expected buyer payment (conditional on trade):

$$\mathrm{E}p^{vs} = \mathrm{E}\left(\min(\overline{p} + d_2^{(m)}, r) \middle| \overline{p} + d_1^{(m)} \leq r\right) \tag{4}$$

Single producer: VI scenario

Stage 2:

- Total cost structure:

$$\begin{cases} tc_1 = c_1 - \delta + d_1; \\ tc_j = \underbrace{c_1 + \mu}_{p} + d_j \ (j \geq 2). \end{cases} \tag{5}$$

- D_1 knows μ and participates in a descending auction
- For D_1 it is optimal to stay until price reaches

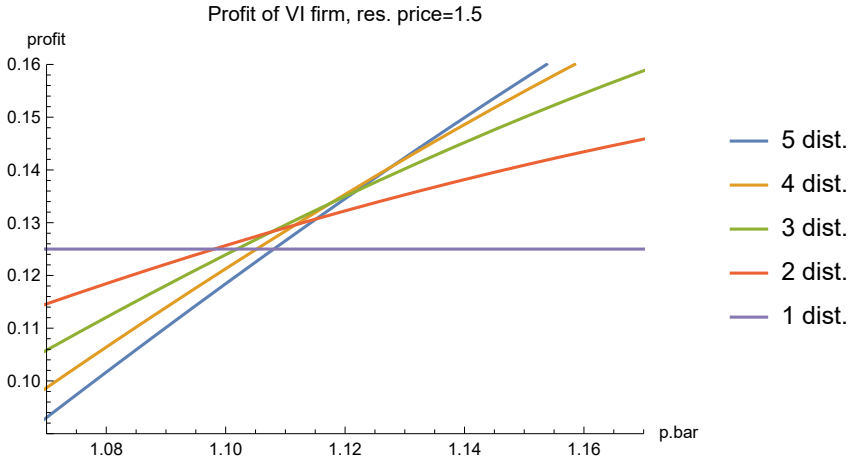
$$c_1 - \delta + \mu + d_1, \tag{6}$$

but not $tc_1 = c_1 - \delta + d_1$, because if D_1 looses then $P_1 \& D_1$ gets profit μ.

Stage 1: Producer sets the price to D_j with maximal level $p_j = \overline{p}$.

main

Foreclosure



main

Several producers: VS scenario

Stage 2:

- distributor j stays in the auction until the current price reaches the total cost $\widetilde{tc}_j = p_j + d_j$
- The winner gets $\widetilde{tc}_2^{(m)}$.

Stage 1:

- Negotiation protocol is a descending auction $\Rightarrow$ input price $p_j = c_2^{(n)}$.

$\Rightarrow$ Expected buyer payment:

$$\mathrm{E}p_{nvi} = \mathrm{E}\left(c_2^{(n)} + d_2^{(m)}\right) \tag{7}$$

Several producers: VI scenario

Stage 2: Possible cases:

- $A = \left\{ c_1 + \mu \leq c_1^{(n-1)} \right\}$ – P_1 is the input supplier of all distributors $\Rightarrow$

$$\begin{cases} tc_1 = c_1 - \delta + d_1; \\ tc_j = c_1^{(n-1)} + d_j \quad (j = \overline{2, m}). \end{cases} \tag{8}$$

D_1 stays in the auction until price is $c_1^{(n-1)} - \delta + d_1$, but not $c_1 - \delta + d_1$.

- $\bar{A} \Rightarrow$ all distributors stay in the auction until their total cost

$$\begin{cases} tc_1 = min\left(c_2^{(n-1)}, c_1 - \delta \right) + d_1; \\ tc_j = c_2^{(n)}(\mu) - \rho + d_j \quad (j = \overline{2, m}). \end{cases} \tag{9}$$

where ρ is **rebate** and $c_2^{(n)}(\mu)$ is the second smallest of $\{c_1 + \mu, c_2, \ldots, c_n\}$.

Several producers: VI scenario

Stage 2: Possible cases:

- $A = \left\{ c_1 + \mu \leq c_1^{(n-1)} \right\}$ – P_1 is the input supplier of all distributors $\Rightarrow$

$$\begin{cases} tc_1 = c_1 - \delta + d_1; \\ tc_j = c_1^{(n-1)} + d_j \quad (j = \overline{2, m}). \end{cases} \tag{8}$$

  D_1 stays in the auction until price is $c_1^{(n-1)} - \delta + d_1$, but not $c_1 - \delta + d_1$.

- $\bar{A} \Rightarrow$ all distributors stay in the auction until their total cost

$$\begin{cases} tc_1 = min\left(c_2^{(n-1)}, c_1 - \delta \right) + d_1; \\ tc_j = c_2^{(n)}(\mu) - \rho + d_j \quad (j = \overline{2, m}). \end{cases} \tag{9}$$

  where ρ is **rebate** and $c_2^{(n)}(\mu)$ is the second smallest of $\{c_1 + \mu, c_2, \ldots, c_n\}$.

Several producers: VI scenario

main

Stage 1: Equilibrium foreclosure $\mu(c_1)$ and rebate $\rho\left(c_1^{(n-1)}, c_2^{(n)}(\mu)\right)$:

$$\underset{\mu}{argmax}\, \mathrm{E}\left(c_1^{(n-1)} + d_1^{(m-1)} - c_1 - d_1 + \delta \,\middle|\, c_1, \rho, A \cap \underbrace{\left\{ d_1 - \delta \leq d_1^{(m-1)} \right\}}_{D} \right) \mathrm{P}(A \cap D | c_1, \rho)$$

$$+ \mathrm{E}\left(c_1^{(n-1)} - c_1 \,\middle|\, c_1, \rho, A \cap \bar{D} \right) \mathrm{P}(A \cap \bar{D} | c_1, \rho) \tag{10}$$

$$+ \mathrm{E}\left(tc_1^{(m-1)} - tc_1 \,\middle|\, c_1, \rho, \bar{A} \cap \underbrace{\left\{ tc_1 \leq tc_1^{(m-1)} \right\}}_{E} \right) \mathrm{P}(\bar{A} \cap E | c_1, \rho);$$

$$\underset{\rho}{argmax}\, \left(c_2^{(n)}(\mu) - \rho - c_1^{(n-1)} \right) \mathrm{P}\left(\bar{E} \,\middle|\, c_2^{(n)}(\mu), c_1^{(n-1)}, \underbrace{\{c_1 + \mu > c_1^{(n-1)}}_{\bar{A}} \geq c_1 - \delta\}, \mu \right). \tag{11}$$

Interaction of producers and distributors

Within cluster 'active ingredient—buyer region' (auctions above 1 M RUB, median):

1. distributors work with
   - 3.1 producers (on average), median is 2.
   - these are 40% of all national producers of an AI.
2. producers work with
   - 3.4 distributors (on average), median is 3.
   - these are 3% of all national distributors of an AI.

main

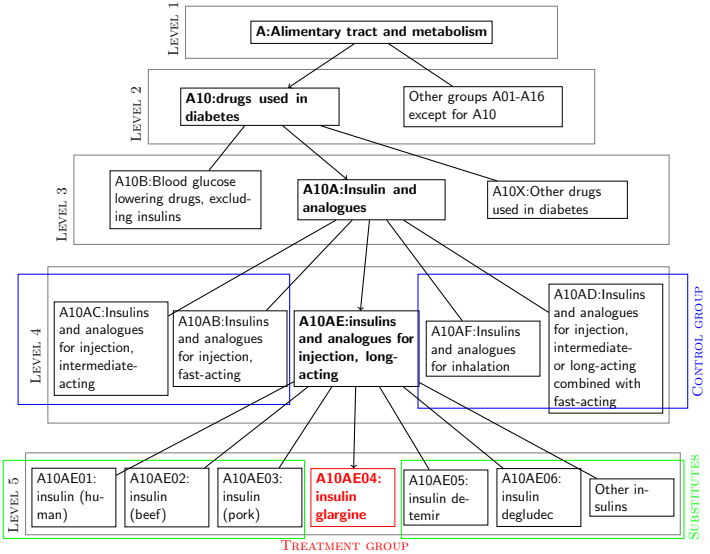
Descriptive statistics of treatment and control group

Supplier	Producer	Obs.	Drug spec.	Mean z-price	Median z-price	St.d. z-price
biocad	Control	59	2	-0.624	-0.944	1.069
biocad	Treatment	378	16	-1.231	-1.266	0.701
biotek	Control	4229	218	-0.069	-0.195	0.924
biotek	Treatment	10526	100	-0.160	-0.296	0.890
eskom	Control	364	22	0.382	0.127	1.177
eskom	Treatment	3871	67	0.369	0.264	1.102
protek	Control	146	43	-0.190	-0.374	1.008
protek	Treatment	248	22	-0.166	-0.342	0.810
sia	Control	1370	159	-0.043	-0.101	0.928
sia	Treatment	3161	117	-0.192	-0.413	0.813
unmerged	Control	525362	843	0.001	-0.079	1.000
unmerged	Treatment	1490452	399	0.001	-0.212	1.000

treatment regression

ATC structure

auction treatment



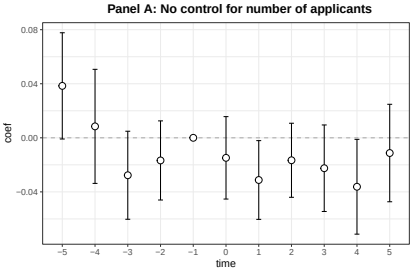
VI effect on share of treated drugs bundle, IV

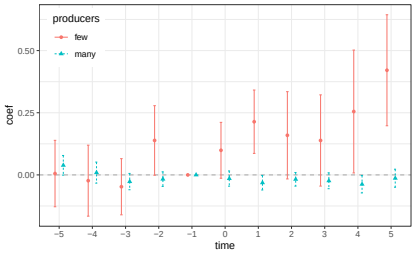
	Dependent variable: Share of treated drugs			
	Share(total)	Share(1 prod.)	Share(2-4 prod.)	Share($\geq$ 5 prod.)
	(1)	(2)	(3)	(4)
ATT=(Treat.Share$>$ 1%)*post VI	22.362***	0.167***	0.540***	21.655***
	(0.664)	(0.018)	(0.039)	(0.638)
ATT*VI distr. part.	−3.562***	−0.079*	0.079	−3.562***
	(0.841)	(0.048)	(0.147)	(0.841)
Procurer FE	8055	8055	8055	8055
Year-quarter FE	YES	YES	YES	YES
Observations	849,468	849,468	849,468	849,468
R^2	0.267	0.019	0.015	0.264

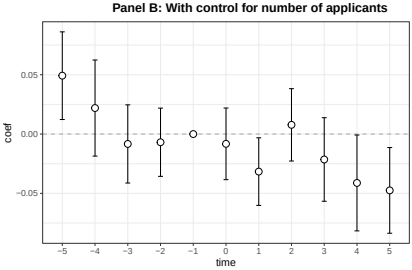
*p<0.1; **p<0.05; ***p<0.01

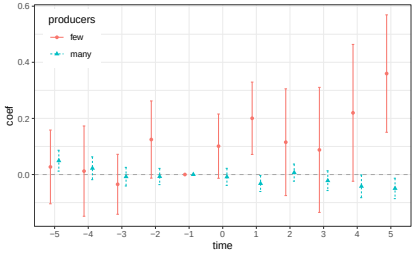
Test for pre-trends of prices: VI distr. participates

main OLS | main IV









Regressions for won and lost auctions

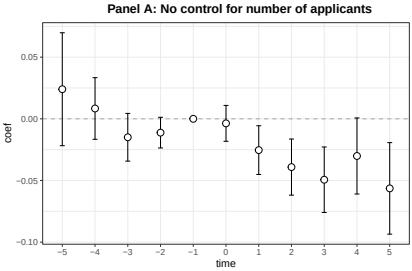
main

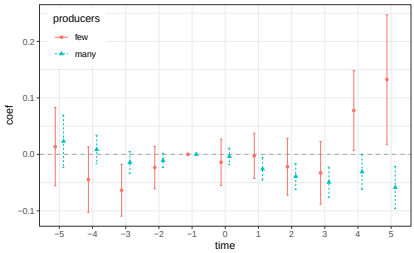
	Dependent variable: Log of price-per-unit of drug			
	VI dist. wins	VI dist. wins	VI dist. loses	VI dist. loses
	(1)	(2)	(3)	(4)
ATT	0.008		−0.013**	
	(0.015)		(0.006)	
ATT (1 producer)		0.486***		0.062
		(0.140)		(0.065)
ATT (2-4 producers)		0.142		0.216***
		(0.140)		(0.054)
ATT (at least 5 producers)		0.007		−0.014**
		(0.015)		(0.006)
Drug spec. FE	519	519	786	786
Region FE	YES	YES	YES	YES
Year-quarter FE	YES	YES	YES	YES
ATC3-year FE	YES	YES	YES	YES
Observations	24,149	24,149	98,925	98,925
R^2	0.964	0.964	0.954	0.954

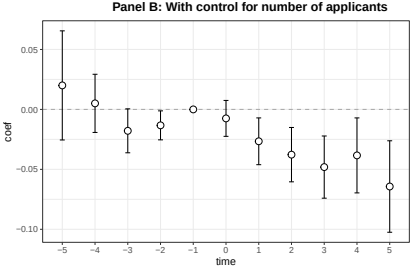
*p<0.1; **p<0.05; ***p<0.01

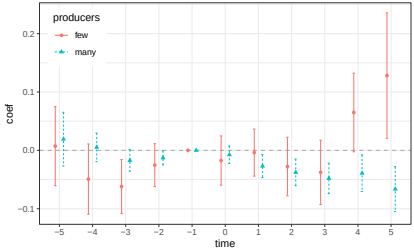
Test for pre-trends of prices: VI distr. does not participate

main









Stack regression

main

	Log of price-per-unit			
	OLS	OLS	2SLS	2SLS
	(1)	(2)	(3)	(4)
ATT	0.004		−0.026**	
	(0.010)		(0.012)	
ATT (1 producer)		0.110		0.087
		(0.163)		(0.152)
ATT (2-4 producers)		0.112**		0.079*
		(0.048)		(0.048)
ATT ($\geq$ 5 producers)		0.004		−0.026**
		(0.010)		(0.012)
Num. of applicants			−0.083***	−0.083***
			(0.007)	(0.007)
F stat. (1st stage)			109.03	108.99
Drug spec. FE	592	592	591	591
Region FE	YES	YES	YES	YES
Stack-year-quarter FE	YES	YES	YES	YES
R^2	0.954	0.954	0.954	0.954
Note:			*p<0.1; **p<0.05; ***p<0.01	

VI effect on prices (alternative instrument) main

	Dependent variable: Log of price per unit of drug			
	Orig. instr.	Orig. instr.	Altern. instr.	Altern. instr.
	(1)	(2)	(3)	(4)
ATET	−0.015**		−0.016***	
	(0.006)		(0.005)	
ATET (1 producer)		0.056		0.084
		(0.075)		(0.068)
ATET (2-4 producers)		0.128**		0.133**
		(0.055)		(0.054)
ATET (at least 5 producers)		−0.016***		−0.017***
		(0.006)		(0.005)
Num. of applicants	−0.092***	−0.092***	−0.048***	−0.048***
	(0.009)	(0.009)	(0.004)	(0.004)
	Dependent variable: Number of applicants			
	Orig. instr.	Orig. instr.	Altern. instr.	Altern. instr.
Treat. PD share	0.009***	0.009***		
	(0.001)	(0.001)		
Treat. PD share*post VI	−0.003***	−0.003***		
	(0.001)	(0.001)		
Max. num. of applicants			0.213***	0.213***
			(0.006)	(0.006)
F statistics	144.78	144.89	1085.96	1086.46
R^2	0.525	0.525	0.548	0.548

Auctions with one active ingredient (alternative instrument) main

	Dependent variable: Log of price-per-unit of drug			
	OLS	OLS	2SLS	2SLS
	(1)	(2)	(3)	(4)
ATT	0.007		0.010	
	(0.008)		(0.008)	
ATT (1 producer)		0.158		−0.040
		(0.223)		(0.228)
ATT (2-4 producers)		0.409***		0.354***
		(0.076)		(0.074)
ATT (at least 5 producers)		0.005		0.009
		(0.008)		(0.008)
Num. of applicants			−0.043***	−0.043***
			(0.003)	(0.003)
Drug spec. FE	707	707	707	707
Observations	64,150	64,150	64,116	64,116
R^2	0.966	0.966	0.967	0.967

	Panel B: First stage. Number of applicants			
	(1)	(2)	(3)	(4)
Max. num. of applicants			0.437***	0.437***
			(0.008)	(0.008)
F statistics			2804.69	2802.34
R^2			0.670	0.670

*p<0.1; **p<0.05; ***p<0.01

VI effect on prices (favouritism) main

	Dependent variable: Log of price-per-unit of drug			
	OLS	OLS	2SLS	2SLS
	(1)	(2)	(3)	(4)
ATT	−0.025***		−0.013**	
	(0.006)		(0.006)	
ATT (1 producer)		0.103*		0.055
		(0.063)		(0.071)
ATT (2-4 producers)		0.135**		0.139**
		(0.057)		(0.058)
ATT (at least 5 producers)		−0.026***		−0.014**
		(0.006)		(0.006)
Num. of applicants			−0.086***	−0.085***
			(0.012)	(0.012)
# drug spec. FE	850	850	850	850
Buyer-Supplier FE	21853	21853	21842	21842
Observations	123,074	123,074	122,971	122,971
R^2	0.968	0.968	0.968	0.968

*p<0.1; **p<0.05; ***p<0.01

VI effect on prices (only VI mergers with equal weights) main

	Dependent variable: Log of price-per-unit of drug			
	OLS	OLS	2SLS	2SLS
	(1)	(2)	(3)	(4)
ATT	−0.022***		−0.019**	
	(0.007)		(0.007)	
ATT (1 producer)		0.080**		0.035
		(0.032)		(0.040)
ATT (2-4 producers)		0.139***		0.112***
		(0.030)		(0.031)
ATT (at least 5 producers)		−0.027***		−0.022***
		(0.007)		(0.007)
Num. of applicants			−0.088***	−0.088***
			(0.009)	(0.009)
# of drug spec. FE	850	850	850	850
Observations	123,074	123,074	122,971	122,971
R^2	0.955	0.955	0.954	0.954

*p<0.1; **p<0.05; ***p<0.01

VI effect on prices (geographical markets) main

	Dependent variable: Log of price-per-unit of drug			
	OLS	OLS	2SLS	2SLS
	(1)	(2)	(3)	(4)
ATT	−0.017***		−0.015**	
	(0.006)		(0.006)	
ATT (1 producer)		0.124**		0.050
		(0.062)		(0.072)
ATT (2-4 producers)		0.099**		0.091**
		(0.041)		(0.042)
ATT (at least 5 producers)		−0.018***		−0.016***
		(0.006)		(0.006)
Num. of applicants			−0.092***	−0.092***
			(0.009)	(0.009)
# drug spec. FE	850	850	850	850
Observations	123,074	123,074	122,971	122,971
R^2	0.955	0.955	0.953	0.953

*p<0.1; **p<0.05; ***p<0.01

VI effect on competition (one active ingredient) main

	Dependent variable: Number of applicants	
	(1)	(2)
ATT	0.164***	
	(0.040)	
ATT (1 producer)		−3.232***
		(0.701)
ATT (2-4 producers)		−1.164***
		(0.341)
ATT (at least 5 producers)		0.170***
		(0.040)
Max. num. of applicants	0.437***	0.437***
	(0.008)	(0.008)
F statistics	2804.69	2802.34
Observations	64,116	64,116
R^2	0.670	0.670

*p<0.1; **p<0.05; ***p<0.01

Identification of VI effect on competition

$$Num.Applicants_{i,t,b} = \alpha Share_i \cdot I(t \in T) \cdot Intensity + \beta Share_i + \lambda_t + \eta_b + X_i\theta + \varepsilon_{i,m,d,t}$$

- $Share_i$: share of treated drugs in the bundle;
- T is the period of integration between VI producer and VI distributor;
- **Intensity**: 1 for full mergers, 0.5 for partial mergers, -1 for divestitures.
- **Fixed Effects**: year-quarter, buyer ID.
- X_i: number of drug spec., duration, ln(reserve price), centralisation;
- **Clustering of errors**: buyer ID.
- **Samples:**
  1. auctions, where VI distributors participate.
  2. auctions, where VI distributors do not participate.

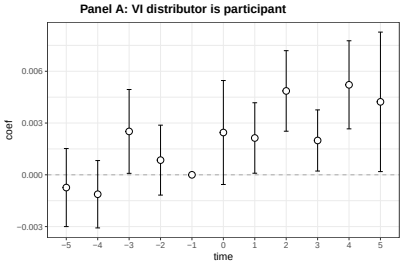
,

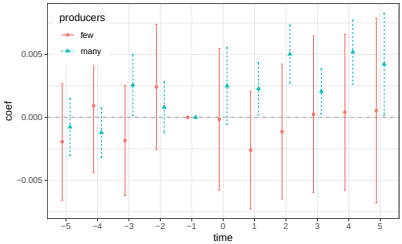
VI effect on competition

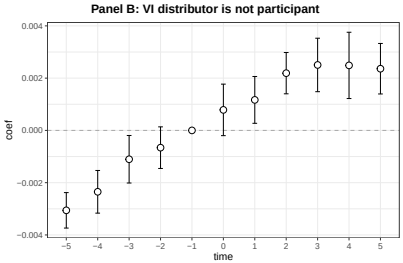
pre-trend | main

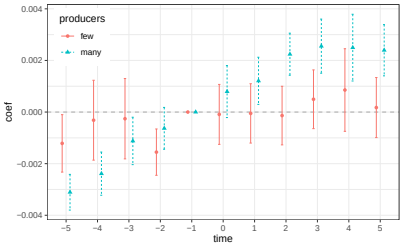
	Dependent variable: Number of applicants			
Sample	VI dist. part.	VI dist. part.	Indir. rival wins	Indir. rival wins
Model	(1)	(2)	(3)	(4)
Num. of drugs	−0.098***	−0.097***	−0.036***	−0.036***
	(0.007)	(0.007)	(0.003)	(0.003)
Treat. PD share	0.018***		0.013***	
	(0.001)		(0.0003)	
Treat. PD share*post VI	0.003***		0.002***	
	(0.001)		(0.0003)	
Treat. PD share (1 producer)		0.008***		0.010***
		(0.002)		(0.001)
Treat. PD share (2-4 producers)		0.004**		0.001
		(0.002)		(0.0005)
Treat. PD share ($\geq$ 5 producers)		0.018***		0.013***
		(0.001)		(0.0003)
Treat. PD share (1 producer)*post VI		−0.008**		−0.001
		(0.003)		(0.001)
Treat. PD share (2-4 producers)*post VI		0.0003		0.001**
		(0.002)		(0.0004)
Treat. PD share ($\geq$ 5 producers)*post VI		0.003***		0.002***
		(0.001)		(0.0003)
Procurer FE	3697	3697	7927	7927
Year-quarter FE	YES	YES	YES	YES
Observations	61,259	61,259	784,463	784,463
R^2	0.460	0.462	0.266	0.269

Parallel pre-trends of the number of applicants main









Multiplicative form

$$TC_{j,a} = \underbrace{C_{2,a}^{(N)}}_{\text{common term}} \cdot \underbrace{D_{j,a}}_{\text{private value}} \cdot \underbrace{e^{\beta X_a}}_{\text{observed heterogen.}} \tag{12}$$

$$\begin{aligned} \text{winning bid: } & b_{1,a}^{(m)} = TC_{2,a}^{(M)} \\ \text{other bids: } & b_{k,a}^{(m)} = TC_{k+1,a}^{(M)} \end{aligned} \tag{13}$$

Back to the additive form:

$$tc_{j,a} = ln(TC_{j,a}),\ c_{2,a}^{(N)} = ln\left(C_{2,a}^{(N)}\right),\ d_{j,a} = ln\left(D_{j,a}\right) \tag{14}$$

$$tc_{j,a} = \underbrace{c_{2,a}^{(N)}}_{\text{common term}} + \underbrace{d_{j,a}}_{\text{private value}} + \underbrace{\beta X_a}_{\text{observed heterogen.}} \tag{15}$$

main

Unobserved heterogeneity

Total cost structure:

$$tc_{j,a} = \underbrace{c_{2,a}^{(N)}}_{\text{common term}} + \underbrace{d_{j,a}}_{\text{private value}} + \underbrace{\beta \mathrm{X_a}}_{\text{observed heterogen.}} + \underbrace{u_a}_{\text{unobserved heterogen.}} \tag{16}$$

Reserve price structure

$$r_a = \tilde{r}_a + \beta \mathrm{X_a} + u_a \tag{17}$$

Additional assumptions:

4. Independence: $c_{i,a} \perp d_{j,a} \perp X_a \perp u_a$
5. Normalization: $E(u_a) = 0$

main

Extension for English auctions with unobserved heterogeneity (Freyberger, Larsen 2017)

$$tc_{j,a} = \underbrace{c_{2,a}^{(N)}}_{\textit{common term}} + \underbrace{d_{j,a}}_{\textit{private value}} + \underbrace{\beta \mathrm{X_a}}_{\textit{observed heterogen.}} \tag{18}$$

Descending auctions with public reserve price

- D_j enters if $tc_{j,a} \leq r_a \Rightarrow$ endogenous entry because of binding reserve price.
- Bids are order statistics of total costs: $ln(b_{k,a}^{(m)}) = tc_{k+1,a}^{(M)}$
- Assumptions:
  1. Independence: $c_{i,a} \perp d_{j,a} \perp X_a$;
  2. Normalization: $E\left(c_{2,a}^{(N)}\right) = 0$.

Step 1. Homogenization of auctions: subtract observed heterogeneity $\beta \mathrm{X_a}$

Step 2. Two bids identify CDF of $c_{2,a}^{(N)}$ and $d_{2,a}^{(M)}$

Step 3. Inversion of the order statistics' CDF $\Rightarrow$ CDF of $c_{i,a}$ and $d_{j,a}$.

Details on identification

main

Step 1. Homogenization: subtract observed heterogeneity from bids and reserve price.

$$ln(b_{k,a}^{(m)}) = \beta X_a + u_{k,a}^{(m)} \tag{19}$$

Step 2. $c_{2,a}^{(N)}$ is unobserved heterogeneity $\Rightarrow$ two bids with three bidders identify CDF

$$c_{2,a}^{(N)} : E\left(c_{2,a}^{(N)}\right) = 0, \quad Var\left(c_{2,a}^{(N)}\right) = cov\left(u_{1,a}^{(m)}, u_{2,a}^{(m)}\right) \tag{20}$$

$$d_{k,a}^{(M)} : E\left(d_{k,a}^{(M)}\right) = E\left(u_{k,a}^{(m)}\right), \quad Var\left(d_{k,a}^{(M)}\right) = Var\left(u_{k,a}^{(m)}\right) - Var\left(c_{2,a}^{(N)}\right) \tag{21}$$

Step 3. Inversion of the order statistics.

$$c_i : F(x) = F^{-1}_{Beta(2,N-1)}\left(F_{c_2^{(N)}}(x)\right) \tag{22}$$

$$d_j : G(x) = F^{-1}_{Beta(k,M+1-k)}\left(G_{d_k^{(M)}}(x)\right) \tag{23}$$

Semi-parametric approach

Approximate any pdf by the Hermite polinomials

$$f(y) \approx \left(\sum_{k=0}^{K} \theta_k H_k \left(\frac{y-\mu}{\sigma} \right) \right)^2 \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{1}{2}\left(\frac{y-\mu}{\sigma}\right)}, \tag{24}$$

$$H_1(x) = 1,\ H_2(x) = x,\ H_k(x) = \frac{1}{\sqrt{k}} \left[x H_{k-1}(x) - \sqrt{k-1} H_{k-2}(x) \right], \tag{25}$$

$$\sum_{k=0}^{K} \theta_k^2 = 1 \tag{26}$$

main

Likelihood function

$$p_0 = \mathrm{P}(m=0) = \mathrm{P}(tc_j > r \; \forall \, j) = \int_{-\infty}^{\infty} [1 - G(r-z)]^M \, dF_{c_2^{(N)}}(z) \tag{27}$$

$$p_1 = \mathrm{P}(m=1) = \int_{-\infty}^{\infty} MG(r-z) \, [1 - G(r-z)]^{M-1} \, dF_{c_2^{(N)}}(z) \tag{28}$$

$$\begin{aligned} p_2(x) =& \mathrm{P}(tc_2^{(M)} = x, m=2) = \mathrm{P}(tc_1^{(M)} < x, \; tc_2^{(M)} = x, \; tc_3^{(M)} > r) = \\ & \int_{-\infty}^{\infty} MG(x-z) g(x-z) \, [1 - G(r-z)]^{M-2} \, dF_{c_2^{(N)}}(z) \text{ for } x \leq r \end{aligned} \tag{29}$$

Likelihood function

$$p_k(x,y) = \mathrm{P}(tc_2^{(M)} = x, tc_3^{(M)} = y, m = k) = \tag{30}$$
$$\mathrm{P}(tc_1^{(M)} < x,\ tc_2^{(M)} = x, tc_3^{(M)} = y, tc_j^{(M)} \in (y,r]\,(j = \overline{4,k}), tc_{k+1}^{(M)} > r) =$$
$$\int_{-\infty}^{\infty} \frac{M!}{(k-3)!(M-k)!} G(x-z)g(x-z)g(y-z)\left[G(r-z) - G(y-z)\right]^{k-3} \cdot$$
$$\left[1 - G(r-z)\right]^{M-k} dF_{c_2^{(N)}}(z) \text{ for } x \le y \le r \text{ and } k \ge 3$$

Log-likelihood

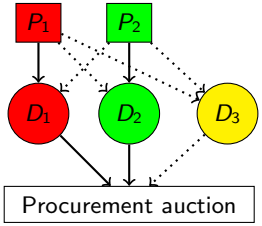
$$l = \sum_{s:m=0} ln(p_0) + \sum_{s:m=1} ln(p_1) + \sum_{s:m=2} ln(p_2(x_s)) + \sum_{s:m=k\ge 3} ln(p_k(x_s, y_s)) \tag{31}$$

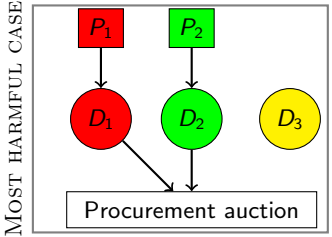
Constraint:

$$\mathrm{E}\left(c_2^{(N)}\right) = \int_{-\infty}^{\infty} zn(n-1)F(z)\left[1 - F(z)\right]^{n-2} dz = 0 \tag{32}$$

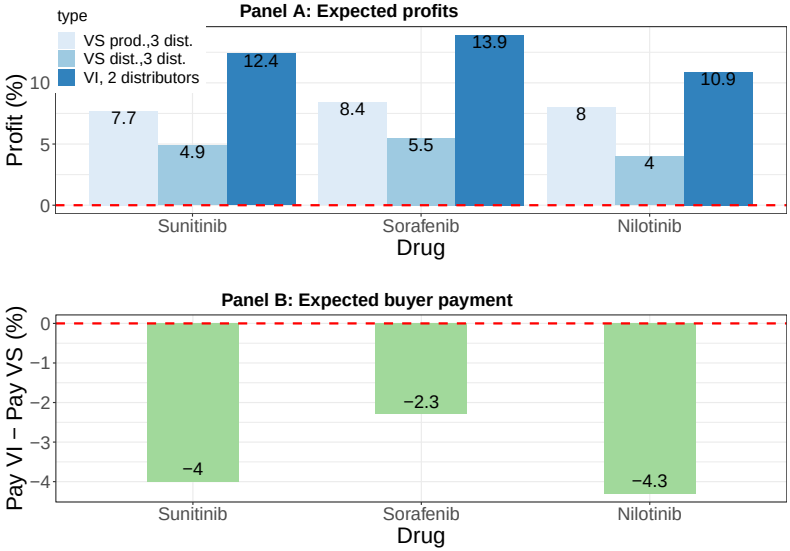
main

Two vertical integrated distributors



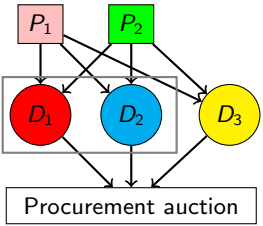


Simulation: two VI distributors, 1% synergy (main)

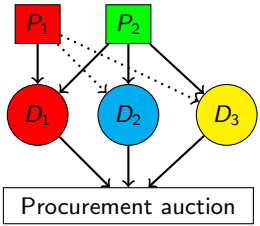


Collusion of D_1 and D_2

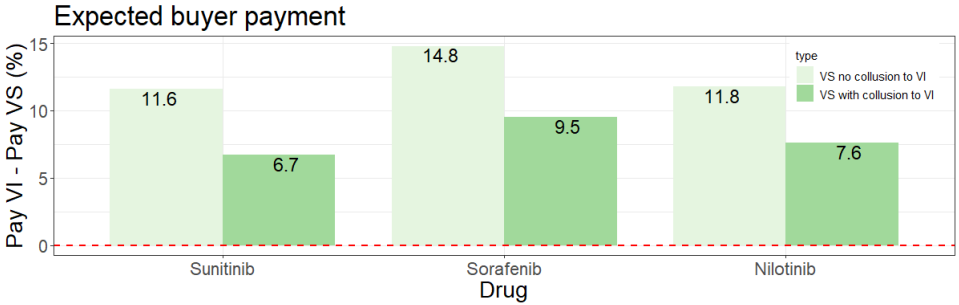
VS scenario with collusion



VI scenario without collusion



Simulation: collusion of D_1 and D_2, 1% synergy (main)



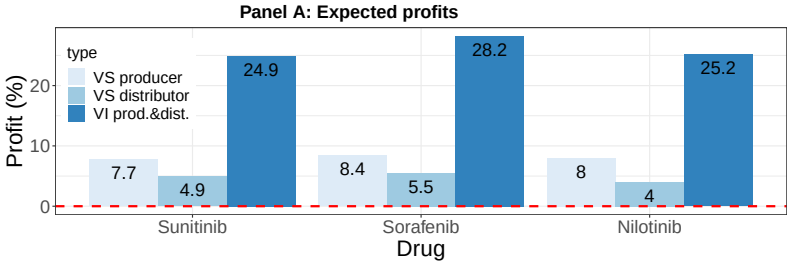
Estimated parameters

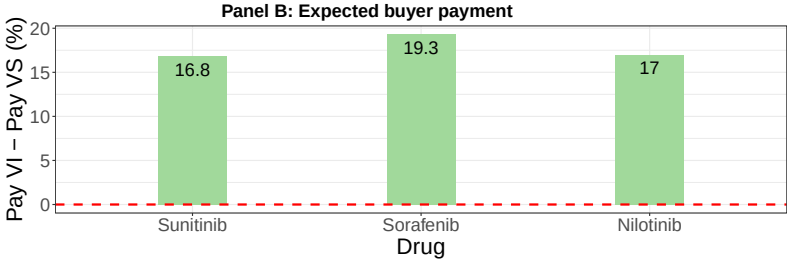
Main

		Sunitinib	Sorafenib	Nilotinib
Producer cost parameters	μ_c	-0.0749	-0.0846	-0.0775
		(0.0456)	(0.0241)	(0.0543)
	σ_c	0.1329	0.1501	0.1374
		(0.0815)	(0.1332)	(0.1009)
Distributor cost parameters	μ_d	9.1466	7.4769	7.7138
		(0.0137)	(0.1386)	(0.0577)
	σ_d	0.1730	0.1959	0.1420
		(0.0935)	(0.0711)	(0.0935)
Observed heterogeneity	ln(quantity)	-0.0512	-0.042	-0.061
		(0.007)	(0.007)	(0.009)
	Regional FE	Y	Y	Y
	Year FE	Y	Y	Y
	Observations	789	730	569
Total cost in log	$\mu_c + \mu_d$	9.0717	7.3923	7.6363
Total cost in RUB	$e^{\mu_c+\mu_d}$	8705	1623	2072

Simulation: VI without synergy

Main





Extensions Main

- Two integrated distributors (details).
- Collusion of distributors (details).

Research agenda Main

1. Interactions in vertical markets:
   - Identification in auctions with bargaining power.
   - Evaluation of mergers in the Pharma and Movie industry.
   - Matching and network formation between producers and distributors.
2. Preferences for domestic producers in the Pharma industry:
   - Effect of preferences.
   - Effect of localization.
3. Public procurement:
   - Changes in perception of corruption due to COVID.
   - Regional protectionism, regional development, and governance.