Downstream Price Effects of Upstream Monopolization in Active Pharmaceutical Ingredient Markets

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I. Motivation

Low cost ratio of API in FPP

Packaging

Transportation

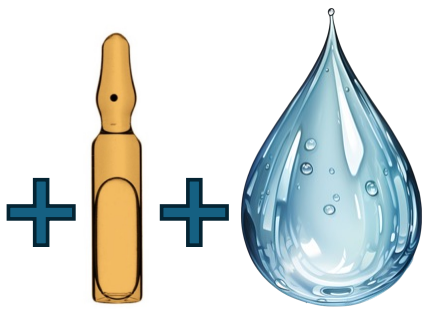
Storage

Tax

¥4/1ml:1mg

¥7,500/kg

¥0.0075/mg



¥0.35/pcs

¥0.02/1ml

I. Motivation

Pharmaceutical price forming

- Behavioral causes of rising drug prices (Cuddy, 2020; Clark et al, 2022)
- Substantial number of antitrust cases in API
- Downstream effects of upstream monopolization

Identifying downstream price effects

- Administrative penalty announcements
- Synthetic control process for counterfactual prices
  - Abadie and Gardeazabal (2003)
- **Differential FPP price effects**

I. Motivation

Vertical relationship

- **Inelastic** final demand
- Low cost ratio: is a **50,000%** passthrough rate reasonalble?
- Is passthrough theory a good candidate?
- Downstream market structure, coordination, ...

Three key questions:

- Average downstream price effect?
- Price effects and FPP market structures?
- Likelihood of API monopolization?

I. Motivation

Main findings

- **75%** FPP price increase on average
- **130%** lower in **single-dominant** FPP
- **4 times higher** likelihood in **balanced duopolistic** markets

Mechanism

- **API monopolization facilitates coordination between balanced duopolists**
  - Schinkel et al (2008), Gu et al (2019)
- Low concentrated FPPs lack the ability
- Exclusive FPPs lack the incentive

I. Motivation

Highlights

- Theory of **vertical relationships**
- Complex pharmaceutical system in China
- Policy guidance
  - Antitrust scrutiny
  - Health authority
  - Industrial policy: subsidy in value chain

Roadmap

- Institutional background
- Data
- Synthetic control process
- Empirical estimation

II. Background

Antitrust ecforcement

- State/Provincial AMR initiates investigation (triggered by reports or surveillance)
- Gather evidence
  - E.g., contracts, internal documents, business data
- Assess enterprises' alleged behaviors
- Issue **administrative penalty announcements**
  - Involved enterprises, type and duration, key evidence, forfeiture and fine, ...
  - Disclose to the public
  - Mark the close of the case

II. Background

API monopolization cases

APIs Involved	Ann. M.	Case Dur.	# Firm	Viol.	Penalty
Promethazine Hydrochloride	2011.11	2011.6	2	A	7.030
Ligustrazine Hydrochloride	2015.01	Unknown	2	A	Unknown
Allopurinol	2015.10	2013.10-2014.3	2	A	0.439
Estazolam	2016.07	2015.1-2016.5	3	C	2.604
Phenol	2016.11	2014.2-2015.12	2	A	0.500
Methyl Salicylate	2017.01	2015.1-2015.12	1	A	2.210
Isoniazid	2017.07	2014.12-2017.7	2	A	0.444
Glacial Acetic Acid	2018.12	2017.10-2018.12	3	C	12.834
Chlorpheniramine	2018.12	2018.2-2018.12	2	A	12.431
Calcium Gluconate	2020.04	2015.8-2017.12	3	A	325.5
Bromhexine Hydrochloride	2020.11	2015.9-2016.12	1	A	2.474
Batroxobin	2021.01	2019.11-2020.6	1	A	100.7
Fluocinolone Acetonide	2021.04	2008-2013, 2017.5-2019.12	3	C	50.778
Camphor	2021.06	2018.3-2019.12	3	C	16.88
Phenol	2021.10	2014.2-2017.3	1	A	11.045
Pralidoxime Chloride	2021.11	2018.3-2019.12	1	C	6.58
L-Carnitine	2023.01	2018.11-2019.6	1	C	133
Epinephrine	2023.05	2016.6-2019.7	2	A and C	320
Iodized Oil	2023.11	2016.6-2020.3	1	A	1.564

II. Background

Pharmaceutical system in China

- Pricing: negotiated prices (300), volume-based bidding (400), **independently pricing** (90%+)
- Procurement: provincial platform
  - Institutions act as **price taker**
  - **0-markup** rate in public hospital
- Payment: BMIP (part A/B)
  - Low average elasticity
- Policy shock: overall impacts
  - Case-sepecific effects: average across cases

III. Data

Firm-level panel

- Chemical drugs, public hospital, provincial platforms, 2013-Q1 to 2021-Q2
- 20 representative cities
- "Drug": a specification of a product name
- "Market": a product name

Processing

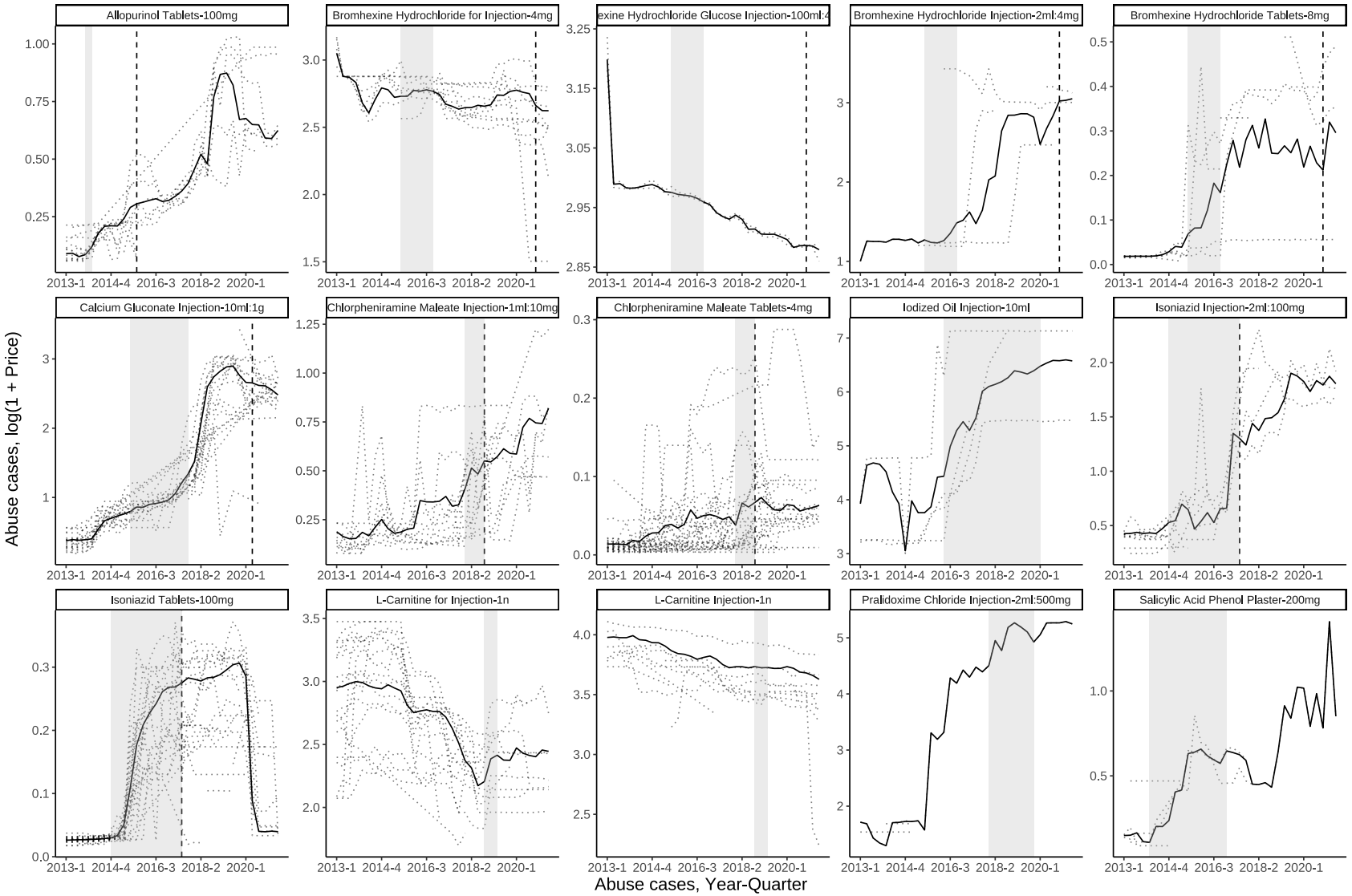
- Exclude vertically integrated firms
- Market concentration indicators
- Aggregate at the firm-level (Abadie et al, 2010)
- Quarterly national sales for each drug
- 24 treated drugs with balanced panel

III. Data

Descriptive statistics

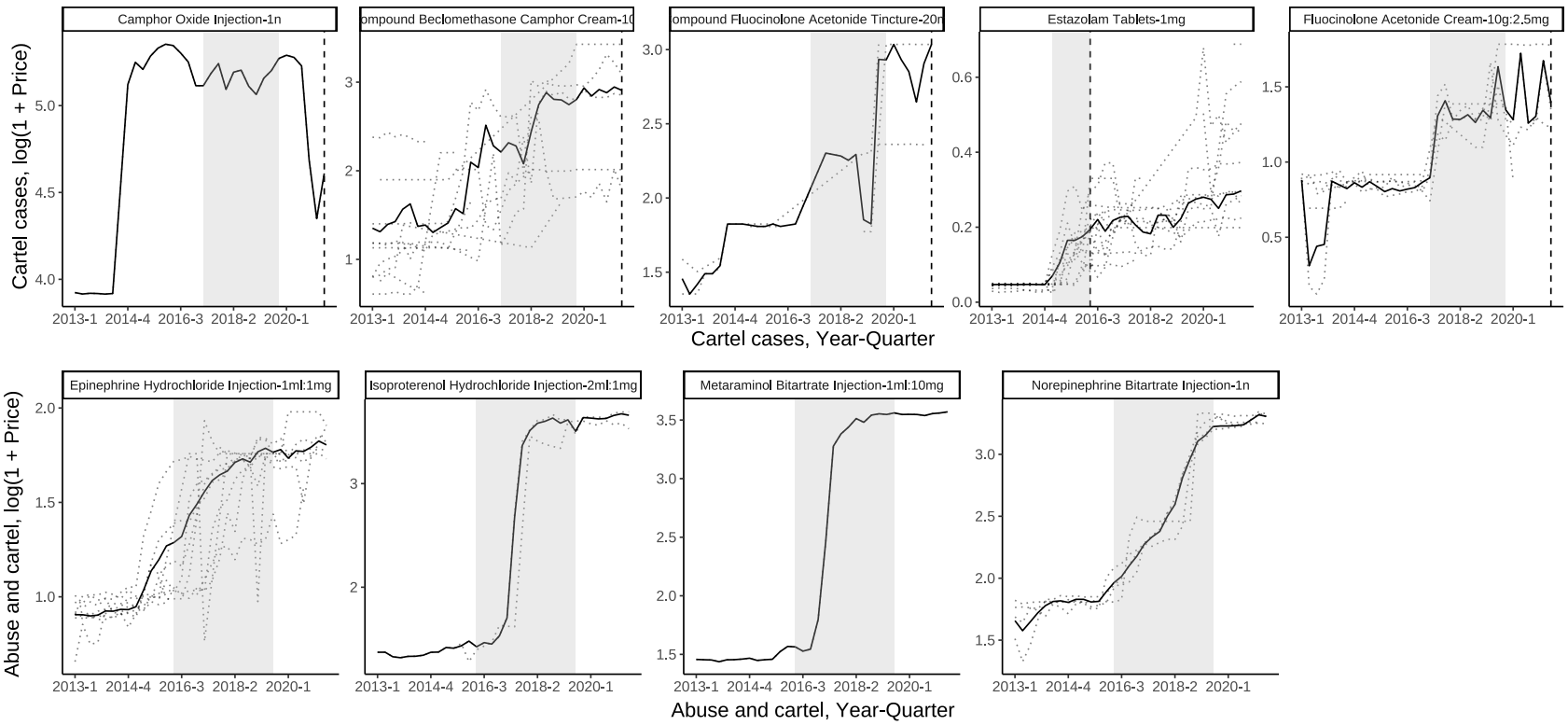
	Stat	Qty	Amt	Price	N^f	HHI	CR1	CR2	CR3
Treated	mean	1,713,554	6,704,183	27.364	1.620	0.662	0.734	0.874	0.931
#. Obs	sd	5,025,119	18,120,674	75.089	1.571	0.316	0.268	0.183	0.129
1,401	min	1	4	0.013	1.000	0.096	0.153	0.296	0.403
#. drug	median	58,913	409,958	5.231	1.000	0.668	0.797	1.000	1.000
60	max	35,866,881	142,506,397	730.431	14.000	1.000	1.000	1.000	1.000
Control	mean	917,250	6,793,604	177.917	1.937	0.736	0.799	0.919	0.957
#. Obs	sd	3,980,272	23,131,687	4063.481	1.921	0.284	0.236	0.147	0.102
193,862	min	1	1	0.004	1.000	0.054	0.093	0.179	0.257
#. drug	median	48,064	494,503	10.783	1.000	0.840	0.914	1.000	1.000
8,182	max	110,609,593	925,624,326	710571.727	36.000	1.000	1.000	1.000	1.000
Pool	mean	922,964	6,792,962	176.836	1.935	0.735	0.799	0.918	0.957
#. Obs	sd	3,989,294	23,099,570	4048.902	1.919	0.285	0.236	0.147	0.103
195,263	min	1	1	0.004	1.000	0.054	0.093	0.179	0.257
#. drug	median	48,128	494,170	10.688	1.000	0.839	0.913	1.000	1.000
8,242	max	110,609,593	925,624,326	710571.727	36.000	1.000	1.000	1.000	1.000

III. Data


Allopurinol Tablets-100mg
Bromhexine Hydrochloride for Injection-4mg
exine Hydrochloride Glucose Injection-100ml:4
Bromhexine Hydrochloride Injection-2ml:4mg
Bromhexine Hydrochloride Tablets-8mg
Calcium Gluconate Injection-10ml:1g
Chlorpheniramine Maleate Injection-1ml:10mg
Chlorpheniramine Maleate Tablets-4mg
Iodized Oil Injection-10ml
Isoniazid Injection-2ml:100mg
Isoniazid Tablets-100mg
L-Carnitine for Injection-1n
L-Carnitine Injection-1n
Pralidoxime Chloride Injection-2ml:500mg
Salicylic Acid Phenol Plaster-200mg
2013-1 2014-4 2016-3 2018-2 2020-1
Abuse cases, log(1 + Price)
Abuse cases, Year-Quarter

III. Data

(Cont'd)



IV. Counterfactual

Counterfactuals: **ATT**

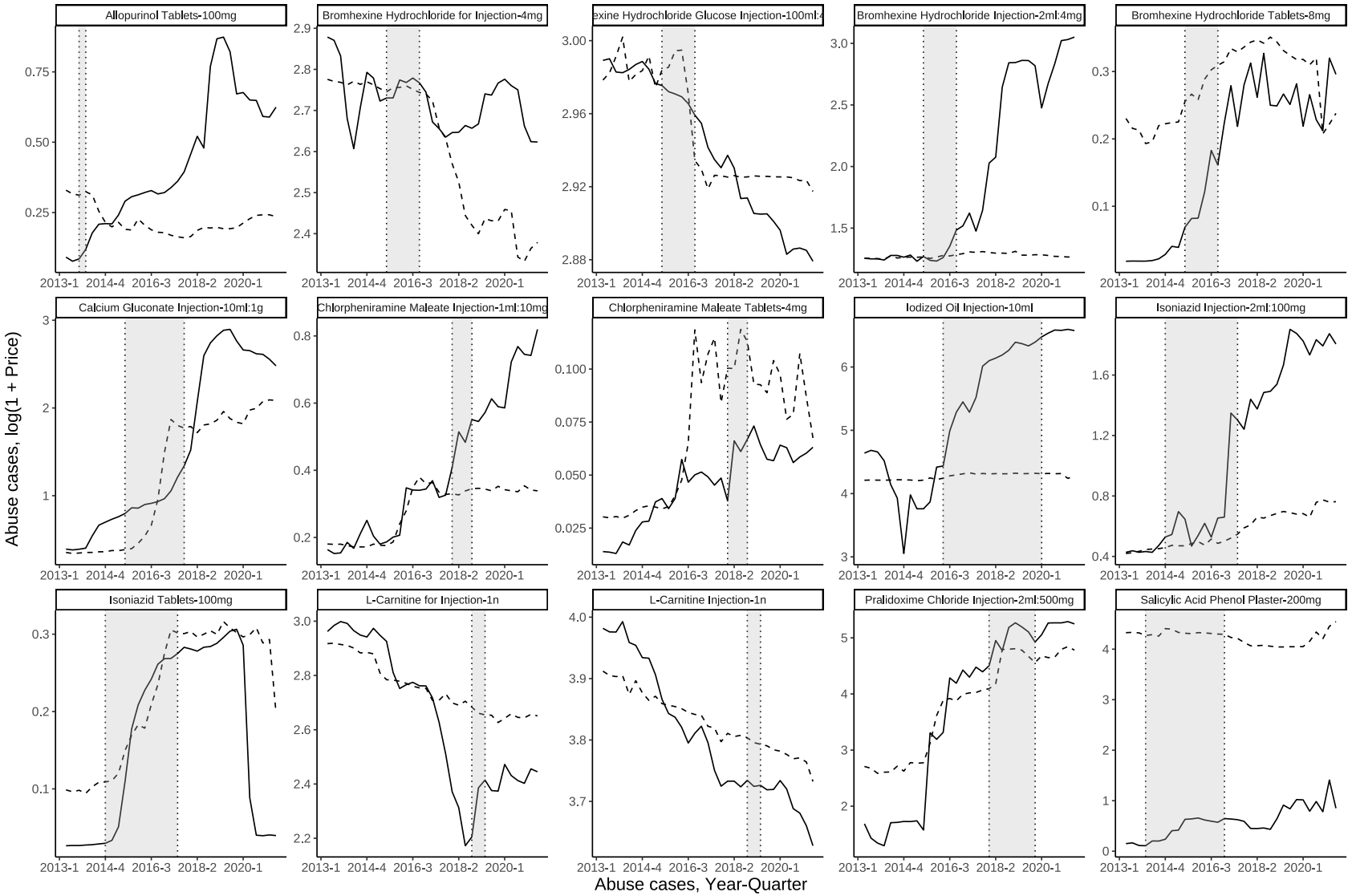
- "Weighted avg": $\hat{P}_{1t}^{N} = \sum_{j=2}^{J+1} w_j P_{jt}$
  - $w_j \geq 0$ and $\sum_{j=2}^{J+1} w_j = 1$
- Optimal unit weights: $\min_{\mathbf{W} \in \Lambda_J} \|\mathbf{X}_1 - \mathbf{X}_0 \mathbf{W}\|_V$
- Optimal predictor weights:

$$\min_{\mathbf{V} \in \Lambda_k} \left(\mathbf{P}_1 - \mathbf{P}_0 \mathbf{W}^*(\mathbf{V})\right)' \left(\mathbf{P}_1 - \mathbf{P}_0 \mathbf{W}^*(\mathbf{V})\right)$$

Synthetic control process

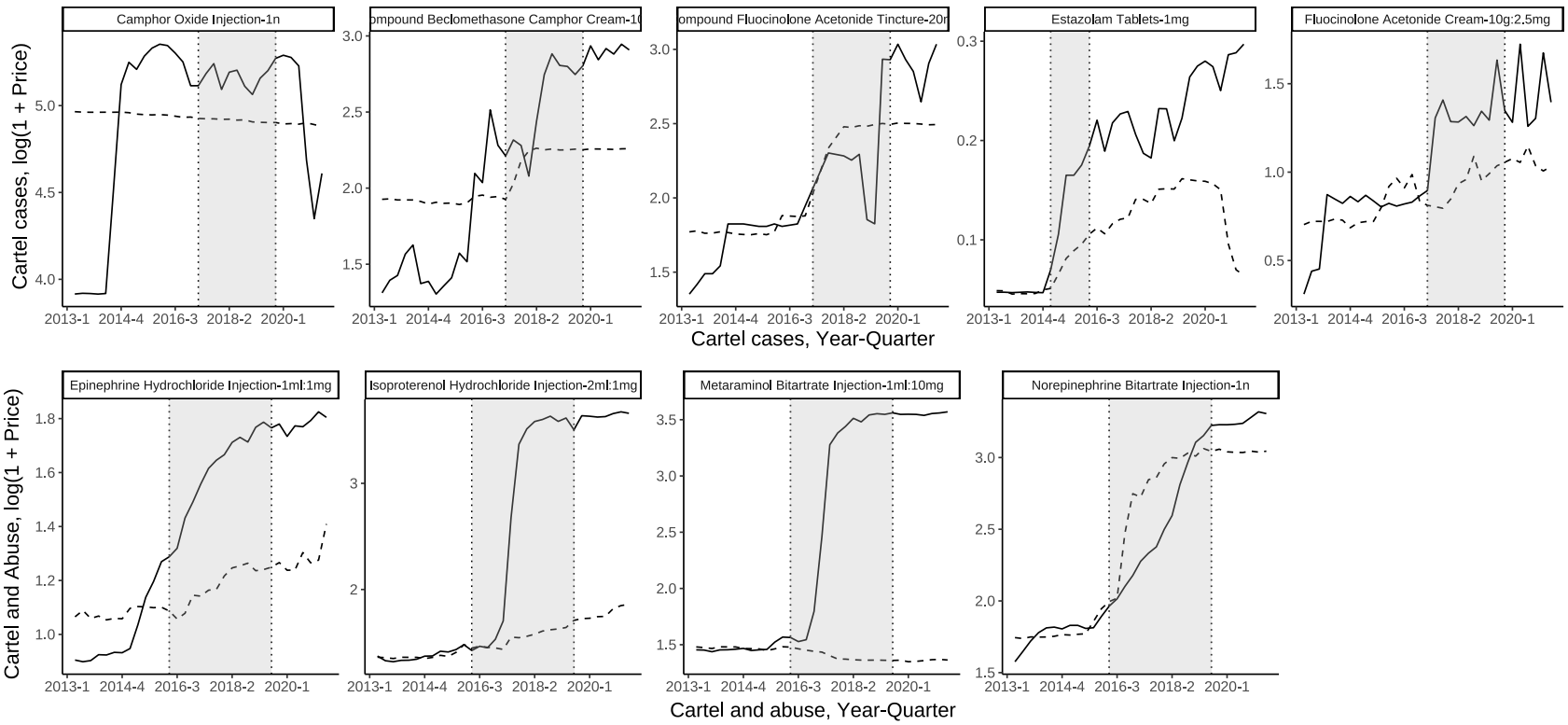
- Treatment span: case duration
- Donor pool: major-category
- drug-quarter level predictors: N^f, CR1, CR2, CR3, HHI
- drug level predictors: total sales Qty and Amt

IV. Counterfactual



IV. Counterfactual

(Cont'd)



- Placebo test confirms robustness

V. Empirical Estimation

Average downstream price effect

$$\log P_{jt} = \alpha + \delta D_j^{up} + D_j^{up} \times (\beta_1 D_j^{syc} + \beta_2 D_{jt}^{m} + \beta_3 D_j^{syc} \cdot D_{jt}^{m}) + \gamma' \mathbf{Z}_{jt} + \lambda_t + \lambda_j + \epsilon_{jt}.$$

- 24 treated units $\mathbf{P}_1^j$, 24 counterfactuals $\hat{\mathbf{P}}_1^j$
- 8,218 control units: self-selection issues (Cunningham et al, 2021)
- $D_j^{up} = 1$: treated and counterfactual
- $D_j^{syc} = 1$: counterfactual
- $D_{jt}^{m} = 1$: treated/counterfactual unit during its case period
- β_3: **ATT**
- $\mathbf{Z}_{jt}$: HHI_{jt}, N_{jt}^f and $\log Q_{jt}$
- λ: time and product fixed effect

V. Empirical Estimation

Average downstream price effect

	$\log P_{jt}$		
	Full	Top 20	Top 10
D_j^{up}	-0.604	-0.699	-0.618
	(0.364)	(0.319)	(0.317)
$D_j^{up} \times D_j^{syc}$	0.459*	0.196	0.008
	(0.158)	(0.213)	(0.169)
$D_j^{up} \times D_{jt}^{m}$	0.898**	0.908***	0.924***
	(0.199)	(0.166)	(0.123)
$D_j^{up} \times D_j^{syc} \times D_{jt}^{m}$	-0.701*	-0.745**	-0.756***
	(0.219)	(0.155)	(0.053)
HHI_{jt}	0.219*	0.220*	0.220*
	(0.067)	(0.067)	(0.067)
N_{jt}^{f}	0.001	0.001	0.001
	(0.011)	(0.011)	(0.011)
$\log Q_{jt}$	-0.050***	-0.049***	-0.050***
	(0.006)	(0.006)	(0.006)
Prod. FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
#Obs	195,465	195,465	195,465
DF.Residual	190,611	190,611	190,611
R^2	0.94	0.939	0.94
Adj. R^2	0.938	0.938	0.938

V. Empirical Estimation

Price effects and FPP market structures

$$P_{jt}/P_{jt}^{syc} - 1 \propto 100 \times \mathrm{MS}_{jt} + \bar{P}_j^{pre} + N_{jt}^f + \mathrm{Dur}_j + \mathrm{Viol}_j + \lambda_t + \lambda_g$$

- 24 Treated units and 24 counterfactuals during case period
- MS indices: CR1, CR2, CR3, HHI, and $I(\mathrm{CR1}_{jt} > 0.6)$
- $\bar{P}_j^{pre}$: average price prior to the case
- Dur_j: duration
- Viol_j: dummy for cartel/abuse
- λ: time and general name fixed effect

V. Empirical Estimation

Price effects and FPP market structures

	$P_{jt}/P_{jt}^{syc} - 1$				
	(1)	(2)	(3)	(4)	(5)
N_{jt}^{f}	0.325*	0.383*	0.255	0.412**	0.342*
	(0.157)	(0.165)	(0.169)	(0.153)	(0.151)
Duration_{j}	0.269	0.283	0.161	0.215	0.199
	(0.336)	(0.345)	(0.357)	(0.322)	(0.316)
$\bar{P}_{j}^{pre}$	-0.002	0.004	0.004	-0.005	-0.010
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
$\text{CR1}_{jt} > 0.6$					-1.369**
					(0.478)
$100 \times \text{CR1}_{jt}$	0.044***				
	(0.007)				
$100 \times \text{CR2}_{jt}$		0.055***			
		(0.010)			
$100 \times \text{CR3}_{jt}$			0.057***		
			(0.016)		
$100 \times \text{HHI}_{jt}$				0.045***	0.065***
				(0.006)	(0.009)
Cartel case	-2.147	-2.166	-1.536	-1.957	-2.010
	(1.652)	(1.709)	(1.791)	(1.572)	(1.541)
Abuse case	2.466*	2.798*	3.084*	2.715*	2.845**
	(1.128)	(1.152)	(1.198)	(1.082)	(1.061)
G.N. FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
#Obs	214	214	214	214	214
DF.Residual	173	173	173	173	172
R^2	0.65	0.633	0.602	0.676	0.691
Adj. R^2	0.569	0.548	0.51	0.601	0.617

V. Empirical Estimation

Likelihood of API monopolization

$$\log\left(\frac{\Pr(D_{jt}^{m}=1)}{1-\Pr(D_{jt}^{m}=1)}\right) \propto \mathrm{MS}_{jt} + \log P_{jt} + \log Q_{jt} + N_{jt}^{f} + \lambda_t + \lambda_c$$

- Full sample (60 treated drugs), logit regression
- MS classifier
- λ: time and major-category fixed effect
- Between-group log-odds ratio differences, avg. across periods

V. Empirical Estimation

Likelihood of API monopolization

	$\Pr(D^m_{jt}=1)$			
	(1)	(2)	(3)	(4)
$I(\text{CR1}_{jt} > 0.6)$	-0.699**			
	(0.267)			
$I(\text{CR2}_{jt} > 0.6, \text{CR1}_{jt} < 0.6)$		0.278		
		(0.243)		
$I(\text{CR2}_{jt} > 0.6, \text{CR1}_{jt} < 0.4)$			0.711*	
			(0.344)	
$I(\text{CR3}_{jt} > 0.6, \text{CR2}_{jt} < 0.6)$				1.381**
				(0.472)
$\log P_{jt}$	-0.113	-0.127	-0.129	-0.115
	(0.106)	(0.120)	(0.120)	(0.118)
$\log Q_{jt}$	-0.049	-0.047	-0.047	-0.049
	(0.070)	(0.069)	(0.069)	(0.070)
N^f_{jt}	-0.259	-0.171	-0.168	-0.257
	(0.146)	(0.140)	(0.144)	(0.165)
Cate. FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
#Obs	126,257	126,257	126,257	126,257
DF.Residual	126,218	126,218	126,218	126,218
R^2	0.076	0.071	0.072	0.08
Adj. R^2	0.061	0.056	0.057	0.065
AIC	4,791.632	4,817.223	4,813.828	4,770.048

VI. A Bargaining Theory

Primitives

- Bargaining between FPP firms and the government
- Supply: industry association for n firms; no cost
- Demand: inelastic unit demand with size Q; reservation price W

Initial Nash bargaining

- $P_0 = \arg\max_P (W - P)^{1-\alpha} P^{\alpha}$
- Disagreement points are 0
- Bargaining power of firms: $\alpha(n) \in [0, 1]$ with $\alpha'(n) < 0$
- Initial price $P_0 = \alpha W$
  - reaches its maximum $\bar{P} = \alpha(1)W$ at $n = 1$

VI. A Bargaining Theory

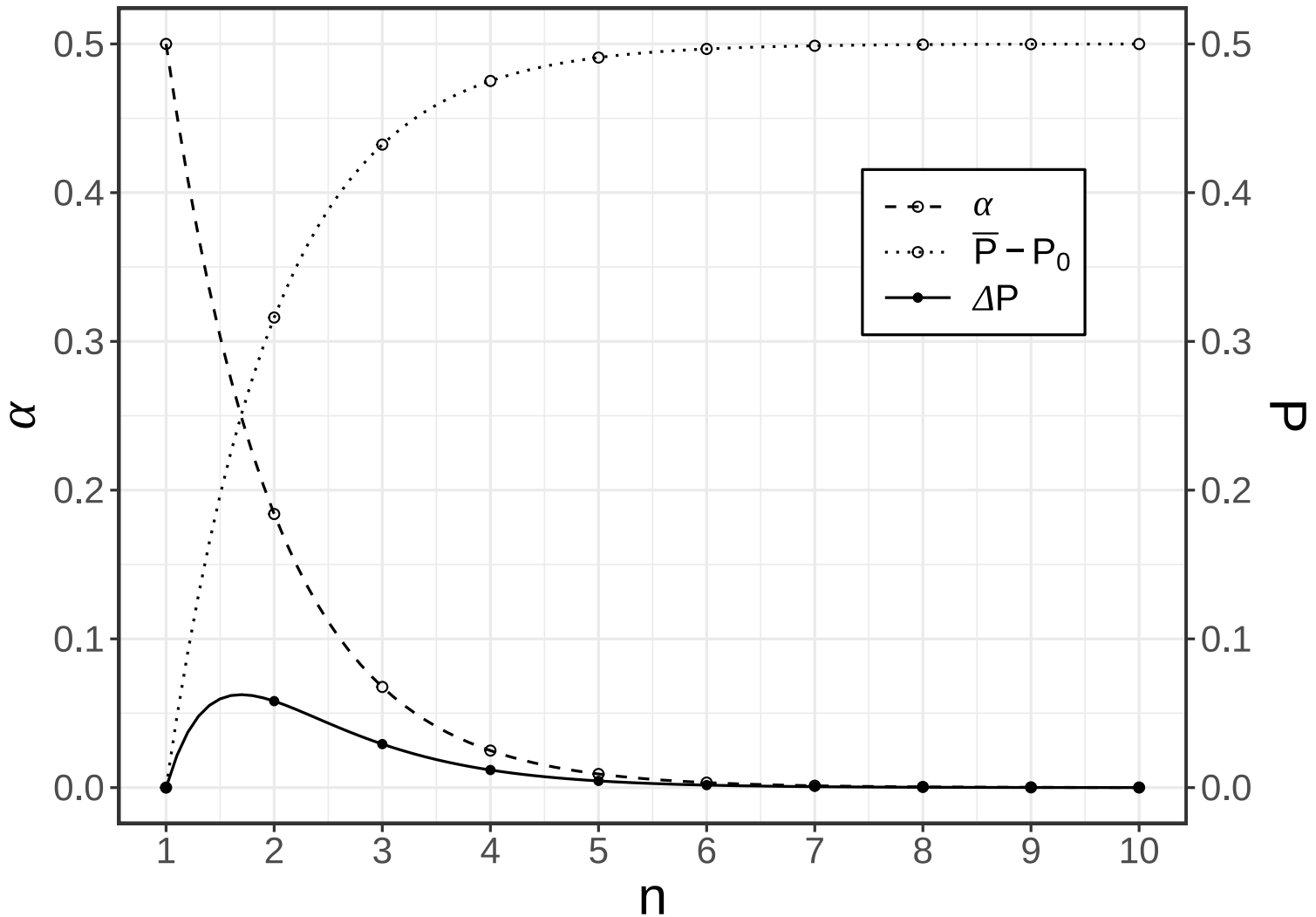
Heterogeneous API monopolization $\Rightarrow$ downstream re-negotiation

- Disagreement point for firms: P_0
- Disagreement point for government: $\bar{P}$
- $P_1 = \arg\max_P \left[(W - P) - (W - \bar{P})\right]^{1-\alpha} \left[P - P_0\right]^{\alpha}$
- Re-bargaining price $P_1 = P_0 + \alpha(\bar{P} - P_0)$

Downstream price effect

- Downstream ability: $\alpha(n) = Ae^{-(n-1)}$ with $A \in [0, 1]$, decreasing with n
- Downstream incentive: $\bar{P} - P_0$, increasing with n
- Downstream price effect: $\Delta P = P_1 - P_0$
- $\Delta P'(n) = \alpha'(n)(\bar{P} - P_0) - \alpha(n)P_0'(n) = AW\alpha'(n)(1 - 2e^{-(n-1)})$
  - inverted-U shape with threshold at $n = 2$

VI. A Bargaining Theory



VII. Concluding Remarks

- API cases have led to an average downstream price increase of 75%
- The price effect in single-dominant downstream markets is 130% lower than in oligopolistic markets
- The odds ratio of API mono. is 49.7% of the average with single-dominated downstream, while 397.9% with balanced duopolistic downstream.
- We suggest that API mono. influences downstream coordination, representing a vertical relation beyond double marginalization