Contracting on Price, Compensating on Quality: Evidence from Centralized Drug Procurement

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Motivation

- In most procurement settings, **price & quantity** are contractible, but **quality** is not.

- A twist for drugs: lower efficacy can **increase**, not decrease, demand — compensatory dosing.

- Our study trace the full causal chain: **contract** → **manufacturing** → **patient prescriptions** → **health outcomes**.

Research Questions

1. How do firms adjust when price and quantity are contractible but post-award quality is not?
2. How does hospital utilization reveal otherwise invisible quality changes?
3. And what are the *health consequences on patients* followed with the post-award quality changes?

Preview of Findings

- **Supply side: Winning firms alter manufacturing processes post-award**
  - Manufacturing post-approval changes (MPACs) increase 8.5× relative to pre-CVBP levels, driven by firms with larger revenue losses.
  - Packaging changes signal cost-cutting, not capacity expansion.
- **Demand side: Compensatory dosing**
  - Hospitals with suppliers' packaging changes exhibit 24.7% greater utilization increases.
  - Claim-level evidence: 19% higher quantity per claim, 17% higher average daily quantity post-MPACs.
- **Health outcomes: Packaging MPACs predict patient deterioration**
  - 30-day readmission +0.8pp (3.8%); 90-day readmission +1.2pp (3.3%).
  - Length of stay +0.4 days. No detectable ICU effect.
- **Welfare: Procurement savings overstated**
  - Effective price reduction is 4–18pp smaller than the nominal 64%.

Contributions

- **Procurement can trade price savings for hidden product quality**. Post-award moral hazard occurs in the delivered product, not merely through contractual renegotiation. Price compression and demand commitment jointly weaken incentives to maintain non-contractible quality.
- **For drugs, lower quality can increase utilization intensity**. We identify compensatory dosing: lower efficacy reduces participation but raises dosage among continuing users. As a result, observed quantity can reveal latent quality deterioration, and nominal price cuts can overstate effective savings.

Evidence across the chain: regulatory manufacturing records $\rightarrow$ national hospital transactions $\rightarrow$ patient-level prescriptions and health outcomes.

Related Literature

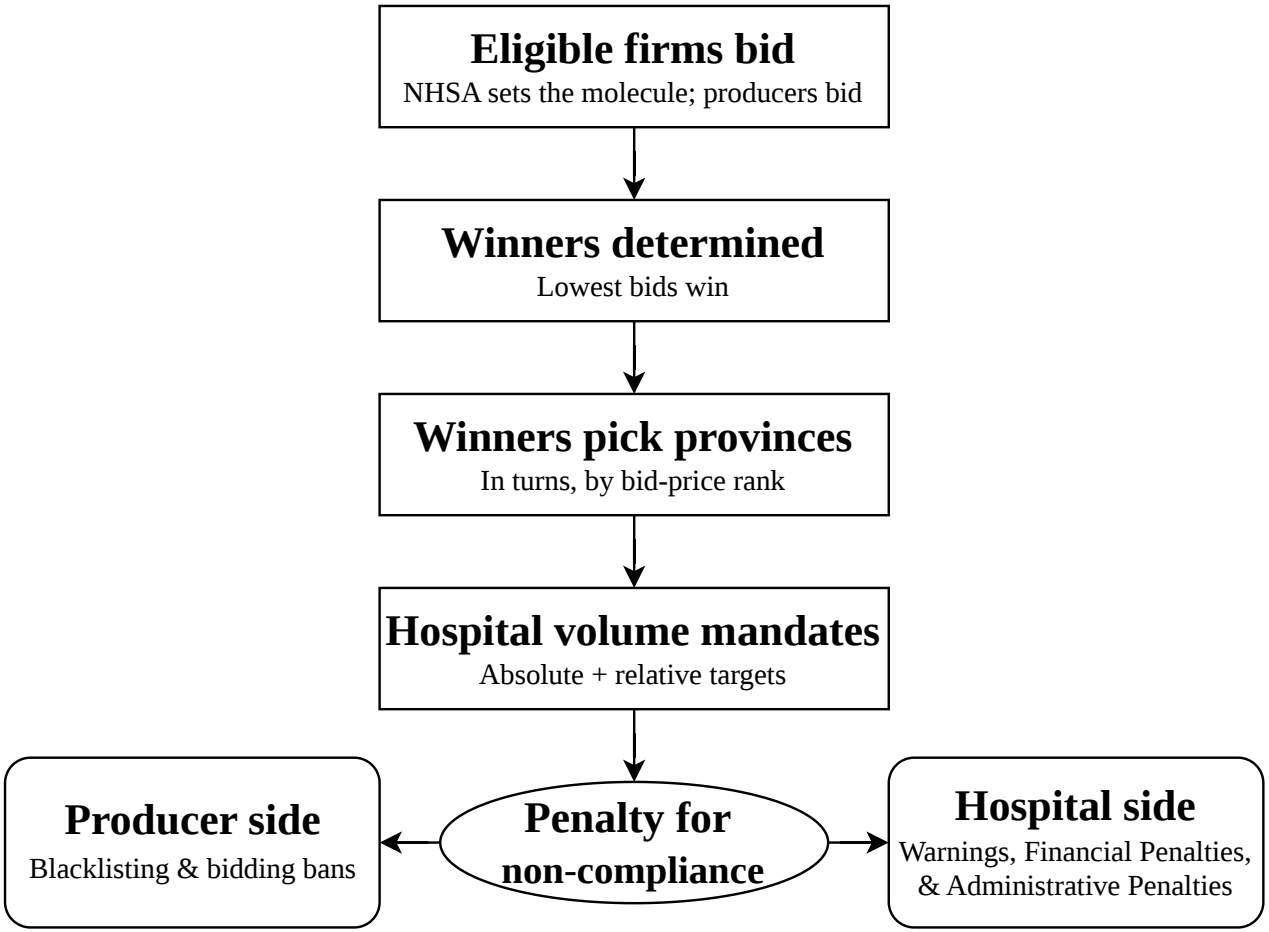
- **Post-award moral hazard in procurement**:
  - Bajari and Tadelis, (2001); Bajari et al. (2014); Decarolis (2014); Lewis and Bajari (2014).
  - We document distortions in product quality, not contractual adjustments.
- **Competition and quality in healthcare**:
  - Cooper et al. (2011); Gaynor et al. (2013); Currie et al. (2023); Janssen and Zhang (2023); Diwan et al. (2026)
  - We show moral hazard among pharmaceutical firms.
- **Generic–brand substitution and drug utilization under centralized procurement.**
  - Ji (2023); Liu et al. (2023); Cao et al. (2024); Ding et al. (2025); Jiang et al. (2025); Xia and Zhao (2026)
  - These document price and utilization effects; we trace the quality channel driving utilization.

Why CVBP is an ideal setting

- **Scale and Scope**:
  - Average price reductions exceeding 50%;
  - Covering over 85% of national prescription dispensing through hospital (within public insurance network) system
- **Enforcement**:
  - Winners guaranteed 50–80% of reported hospital demand
  - NHSA as a single payer, administering two primary public insurance with near-universal coverage (95%)
  - Additional provincial supplementary policies implemented (coinsurance, reference pricing, savings retention)
- **Limited Post-award monitoring**:
  - CVBP mainly targets on generics.
  - Historical concerns about generic quality, which led to bioequivalence reform in 2016.
  - CVBP eligibility condition:passing bioequivalence evaluation

Centralized Volume-Based Procurement (CVBP)

Piloted in 4+7 cities (Dec 2018), nationwide from Dec 2019, 11 rounds through Feb 2026. ▸ Timeline of CVBP



Post-Approval Changes (PACs)

- China regulates PACs by severity:
  - **Major**: rare, require central NMPA approval.
  - **Moderate**: packaging materials, APIs, production process – provincial filing only.
  - **Minor**: pack size, inserts, expiration dates – minimal quality impact.
- Focus on the **Moderate** type, "manufacturing PACs (MPACs)" – with potential quality implications
- Policy caught up with the concern: Round 12 (June 2026) explicitly prohibits downgrading or altering packaging materials during the contract period.
- Packaging material changes switching to cheaper ones have the risk of moisture ingress, light exposure, oxidation, and leaching.

Why Can Centralized Procurement Reduce Quality?

- CVBP changes both the margin and the market discipline faced by winning suppliers.
- A regulator awards a contract at fixed unit price p via competitive bidding. Hospitals commit to purchasing λ share of demand from winning suppliers.
- Demand for winning suppliers is $D(q, \lambda) = \bar{D}[\lambda + (1 - \lambda)R(q)]$
- Post-award, the winner chooses non-contractible quality q to maximize:

$$\max_{q \in [\underline{q}, \bar{q}]} \Pi(p, q) = (p - c)\, D(q, \lambda) - \psi(q)$$

  where , $\psi(q)$ is the cost of maintaining quality $(\psi' > 0, \psi'' > 0)$.
- Proposition 1: $\frac{\partial q^*}{\partial p} > 0$, $\frac{\partial q^*}{\partial \lambda} < 0$.
- $p \downarrow \rightarrow$ return to maintaining quality $\downarrow \rightarrow q^* \downarrow$
- $\lambda \uparrow \rightarrow$ less demand at risk $\rightarrow q^* \downarrow$

How Do Physicians and Patients Respond?

- Physicians and patients observe noisy signal $s = e(q) + \epsilon$,
- Perceived efficacy after observing s is $m = e_0 + \omega(\gamma)(s - e_0)$; e_0 prior expected efficacy, $0 < \omega(\gamma) < 1,\ \omega'(\gamma) > 0$
- γ efficacy salience: how quickly and cearly efficacy is learned from treatment experience
- $q \downarrow \rightarrow m \downarrow \rightarrow$
  - Extensive margin: use/continue focal drug $\downarrow$
    $M(m,p) \equiv Prob(B_0(m) - \alpha p - K \geq 0)$
  - Intensive margin: dosage conditional on use $\uparrow$
    $x^*(m,p) \equiv argmax_{x \geq 0} B(mx) - \alpha p x$
  - Aggregate utilization is ambiguous; compensatory dosing is identified from the intensive margin. $Q(q,p,\gamma) \equiv E[M(m,p)x^*(m,p)|q,\gamma]$
- $\gamma \uparrow \rightarrow$ stronger response to a given quality change
- $p_{eff} = \frac{p}{e(q)}$, Lower quality makes the effective price cut smaller than the nominal price cut.

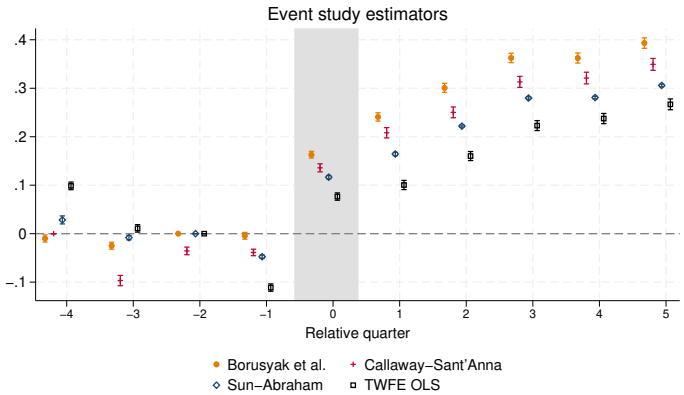
Data Overview

1. **National Hospital Drug Transaction Data** (2019.01–2023.06)
   - Universe of all prescription drug transactions from hospitals in public-insurance network: date, volume, price, product identity, hospital, firm, strength, formulation
   - Focus on five representative therapeutic classes: PPI, ACE inhibitors, HMG (statins), SSRIs, SABA inhalers
   - Includes both procured and non-procured molecules.
2. **Inpatient Claims Data** (2022.01 – 2026.03)
   - A northern province; all inpatient claims; claims with drug molecules included in Rounds 5, 7, 8, and 9 of CVBP.
   - Quantity: Total quantity per claim; Average daily quantity = total quantity/length of stay
   - Patient health outcomes: 30- and 90-day readmissions, length of stay, and ICU admissions.
3. **Post-Approval Changes**: package material, APIs, production process
4. **Complementary Data Sources**: Hospital/Drug/Firms Attributes

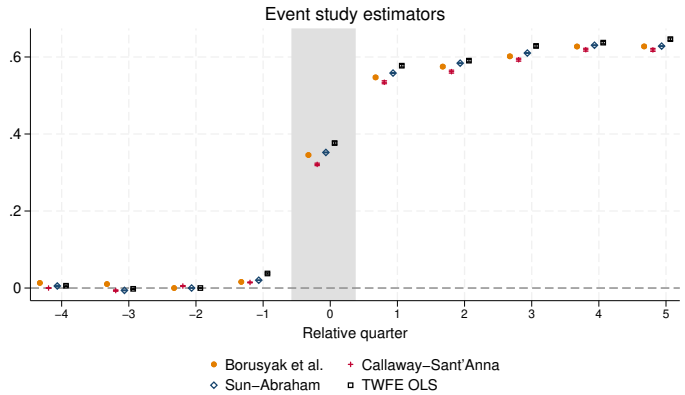
Summary Statistics

Baseline: CVBP ↑ Total Utilization (Staggered DiD)

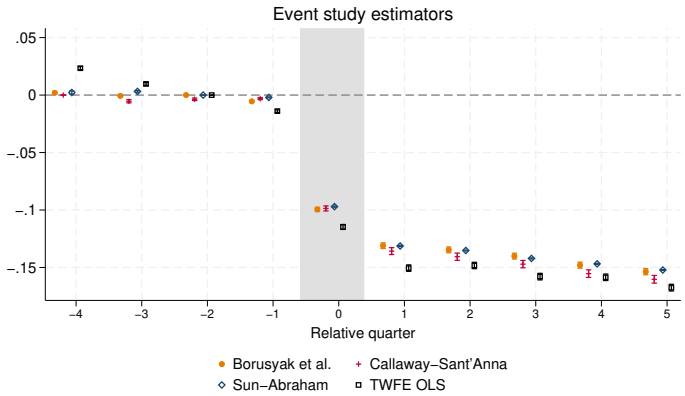
(a) Log (DDDs) ↑ 23.8%



(b) Share of Winning ↑ 60.1%



(c) Share of Banded ↓ 15.7%



Supplier Behavior: MPACs before and after Bid Winning

- Winning suppliers may conduct MPACs to save costs after winning a tender, which may lead to a quality downgrade and utilization change.
- *"Any part of the manufacturing process can be manipulated to make data look good for drug evaluations by FDA"*. (Eban, "Bottle of Lies", 2019).
- We compare MPACs between winning and non-winning firms:

$$MPAC_{fdt} = \beta_0 + \beta_1 \textit{procured}_{dt} + \beta_2 \textit{procured}_{dt} * Win_{fd} + \alpha_{fd} + \mu_t + \epsilon_{fdt}$$

The MPACs involve the following three types:

- (i) *Package materials*.
- (ii) *API changes*.
- (iii) *Production process*.

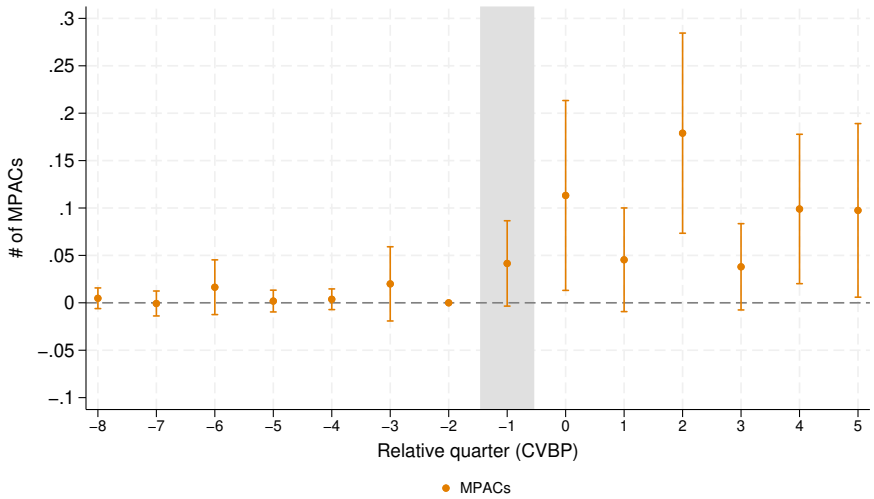
▸ Details and Examples

Table 1: Average Effects of CVBP on MPACs

	MPACs				Other PACs
	(1) All	(2) Package	(3) API	(4) Process	(5)
Procured	-0.003	-0.000	0.001	-0.004**	0.019
	(0.005)	(0.002)	(0.004)	(0.002)	(0.012)
Procured × Winning	0.085***	0.015**	0.042***	0.038**	-0.035
	(0.024)	(0.008)	(0.015)	(0.015)	(0.027)
Producer × Molecule FE	✓	✓	✓	✓	✓
Quarter FE	✓	✓	✓	✓	✓
Mean of Y (Before CVBP)	0.010	0.005	0.005	0.002	0.145
# of observations	8510	8510	8510	8510	8510
R^2	0.13	0.08	0.12	0.11	0.20

▸ Other Changes

(a) All MPACs



(b) MPACs by Type

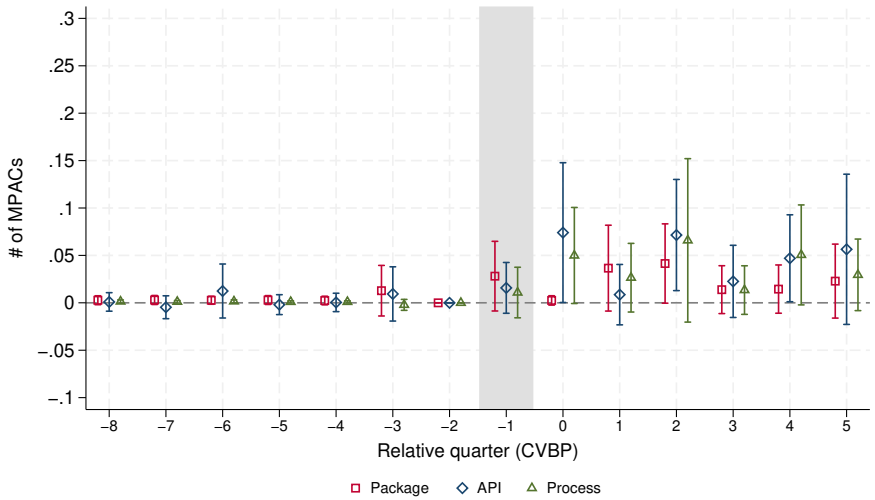


Figure 2: Event Study: Effects of CVBP on Winning Firms' MPACs

Supplier Behavior: Motives for MPACs

- What are the motives for the winning firms to conduct MPACs after winning the bids?
- We estimate the following equation at the winning firm-molecule-supplying province level:

$$winMPAC_{fdp} = \beta_1 g(bid_{fd}) + \beta_2 X_f + \beta_3 h(demand_{fdp}) + \alpha_d + \varepsilon_{fdp}$$

  - $g(bid_{fd})$: captures the bidding characteristics.
  - X_f: characteristics of winning firm.
  - $h(demand_{fdp})$: supplying province p's demand.

Table 2: Winning Firms' MPACs: Supply- and Demand-Side Factors

	(1) MPACs	(2) Package	(3) API	(4) Process
(a) Supply-Side Factors				
Bid Price	-0.168***	-0.087*	0.003	-0.013
	(0.044)	(0.050)	(0.048)	(0.051)
Changes in Revenue	-0.360***	-0.058***	-0.288***	-0.036*
	(0.022)	(0.020)	(0.018)	(0.022)
Changes in Supply	0.031***	0.002	0.021***	0.006***
	(0.002)	(0.002)	(0.002)	(0.002)
Top Producers	-0.108***	-0.102***	-0.074**	-0.068*
	(0.036)	(0.032)	(0.029)	(0.035)

Winning firms with lower bid prices, larger expected revenue losses, higher expected supply are more likely to engage in MPACs. Top producers are less likely to engage in MPACs.

No sig. relationship between MPACs and supplying provinces' features

	(1) MPACs	(2) Package	(3) API	(4) Process
(b) Demand-Side Factors				
Log (Pre-CVBP DDDs)	-0.012	-0.005	-0.018*	0.004
	(0.010)	(0.007)	(0.010)	(0.009)
Share of Rural Hospitals	0.087	-0.101	0.177	0.101
	(0.145)	(0.095)	(0.145)	(0.117)
Log (Average Wage)	0.034	0.035	0.092	-0.059
	(0.093)	(0.060)	(0.089)	(0.070)
Log (Education)	0.258	-0.218	0.231	0.203
	(0.186)	(0.138)	(0.186)	(0.142)
Payment Policies (Before MPACs)	-0.009	-0.032	-0.021	0.028
	(0.041)	(0.031)	(0.039)	(0.032)
Balance Policies (Before MPACs)	-0.054	0.013	-0.010	-0.025
	(0.043)	(0.034)	(0.040)	(0.033)
Payment Policies (After MPACs)	-0.077	-0.040	-0.047	0.012
	(0.049)	(0.027)	(0.046)	(0.035)
Balance Policies (After MPACs)	-0.065	0.032	-0.042	-0.056*
	(0.043)	(0.026)	(0.041)	(0.030)
Molecule FE	✓	✓	✓	✓
Mean	0.30	0.08	0.21	0.09
# of observations	499	499	499	499
R^2	0.63	0.56	0.53	0.48

Demand-side Response (1): Hospital-level Analysis

- **Do MPACs affect drug utilization?**

$$ln(Q_{idt}) = \beta_0 + \beta_1 procured_{dt} + \beta_2 procured_{dt} \cdot winMPAC_{idt} + \beta_3 procured_{dt} \cdot winMPAC_{id} + \alpha_{id} + \mu_t + \epsilon_{idt},$$

  - β_2: differential utilization change after a winning firm's MPAC.
  - $procured_{dt} = 1$ when $t \geq t_d^*$; $\quad winMPAC_{idt} = 1$ when $t \geq t'_{id}$.

Table 3: The Effects of MPACs on Drug Utilization

	Log (DDDs)					
	(1)	(2)	(3)	(4)	(5)	(6)
Procured	0.276***	0.277***	0.288***	0.273***	5.421***	5.514***
	(0.004)	(0.005)	(0.006)	(0.005)	(0.200)	(0.201)
Procured × winMPACs		0.171***			0.168***	
		(0.008)			(0.008)	
Procured × otherPACs			0.007			
			(0.004)			
Procured × winMPACs (Package)				0.247***		0.278***
				(0.021)		(0.021)
Procured × winMPACs (API)				0.085***		0.071***
				(0.009)		(0.009)
Procured × winMPACs (Process)				0.133***		0.172***
				(0.019)		(0.019)
Hospital × Molecule FE	✓	✓	✓	✓	✓	✓
Quarter FE	✓	✓	✓	✓	✓	✓
Procured × Hospital's Controls					✓	✓
Procured × City's Controls					✓	✓
Mean of Y (Before CVBP)	10203.28					
# of observations	1763809	1763809	1763809	1763809	1763809	1763809
R^2	0.81	0.81	0.81	0.81	0.81	0.81

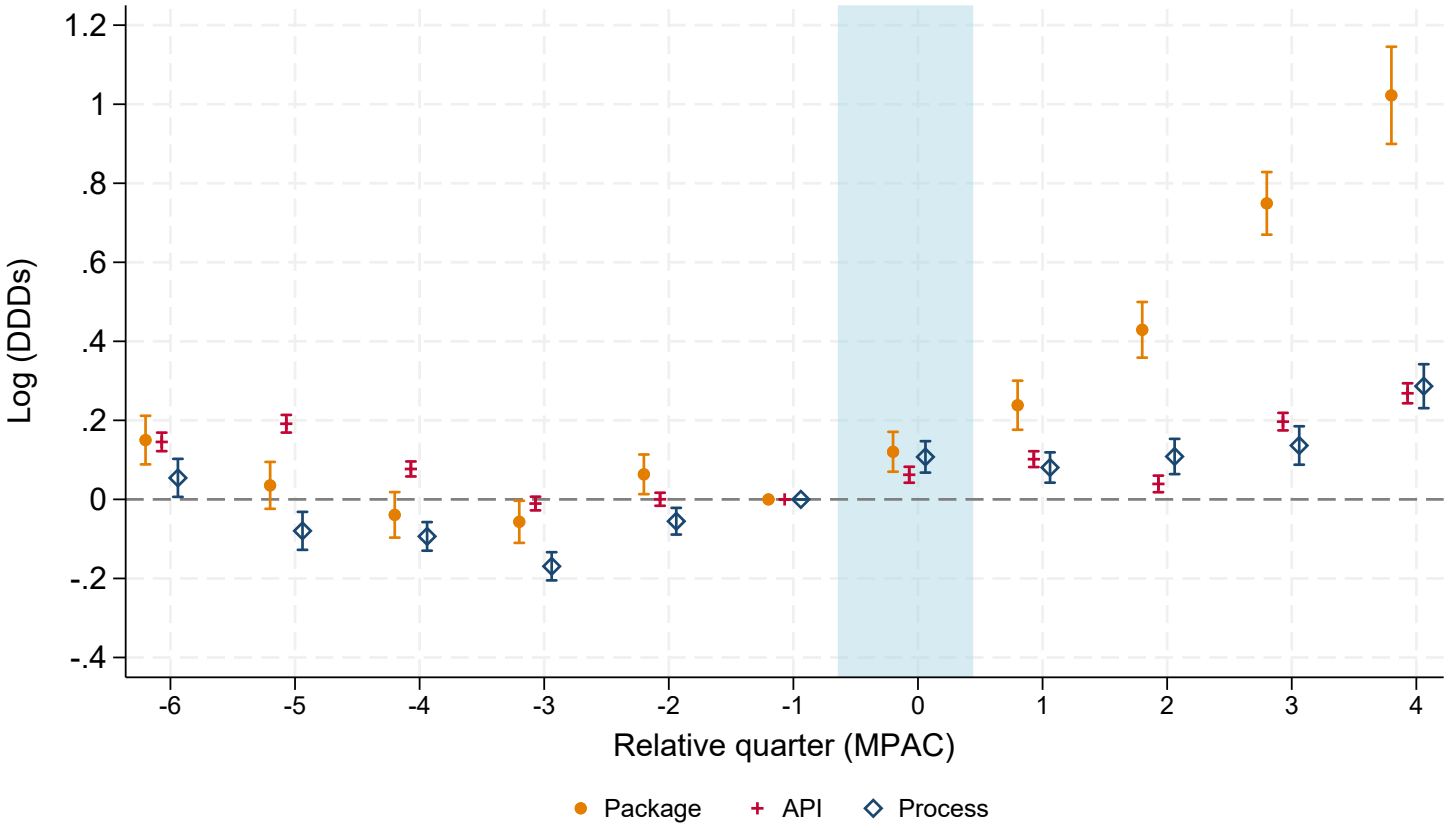


Figure 3: Event Study: Effects of MPACs on Drug Utilization

- We apply the same logic to the utilization effects of branded-to-generic switching using the hospital-level transaction data.

(Perceived) Quality Downgrading | Heterogeneous Analysis

Demand-side Response (2): Claim-level Analysis

- **Do MPACs affect drug utilization at the intensive margin?**

$$\ln(Q_{cdt}) = \beta_0 + \beta_1 MPAC_{dt} + \mathbf{X_{i(c)t}}'\gamma + \alpha_{h(c)d} + \mu_t + \epsilon_{cdt},$$

  - $\ln(Q_{cdt})$ represents log quantity of molecule d prescribed at visit c, hospital h, quarter t.
  - $MPAC_{dt}$ indicates whether molecule d's winning firm conducted an MPAC prior to quarter t.
  - $\mathbf{X_{it}}'$ includes gender and 5-year age bin.
  - We replace $\mathbf{X_{i(c)t}}$ with patient fixed effects $\sigma_{i(c)}$, which fix a patient pool and absorb all time-invariant patient characteristics.

Table 4: Effect of MPACs on Claim Drug Utilization

Panel A: Log (Total Quantity per Claim)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MPACs	0.045***				0.032**			
	(0.010)				(0.013)			
MPACs (Package)		0.195***				0.186***		
		(0.029)				(0.034)		
MPACs (API)			0.011				-0.009	
			(0.013)				(0.018)	
MPACs (Process)				0.053**				0.063**
				(0.025)				(0.030)
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Hospital × Molecule FE	✓	✓	✓	✓	✓	✓	✓	✓
Quarter FE	✓	✓	✓	✓	✓	✓	✓	✓
Patient FE					✓	✓	✓	✓
Mean of Y (Before MPAC)	9.25	7.17	9.22	8.45	9.13	7.24	9.05	8.43
# of observations	3732808	3098091	3514659	2688382	2479939	1918773	2272297	1535129
R^2	0.66	0.65	0.67	0.71	0.78	0.78	0.79	0.84

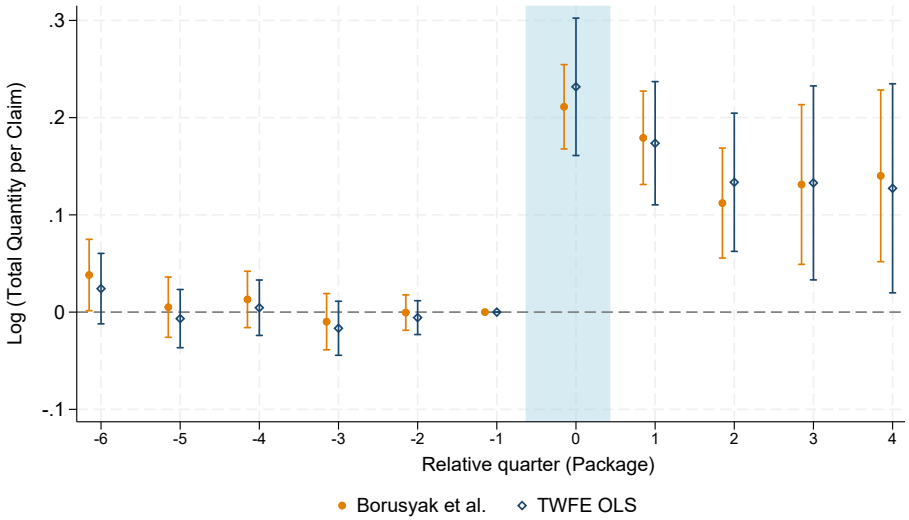
Effect of MPACs on Claim Drug Utilization

Panel B: Log (Average Quantity per Day)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MPACs	0.034***				0.021			
	(0.010)				(0.013)			
MPACs (Package)		0.173***				0.165***		
		(0.025)				(0.031)		
MPACs (API)			-0.012				-0.028	
			(0.015)				(0.019)	
MPACs (Process)				0.066***				0.066**
				(0.025)				(0.028)
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Hospital × Molecule FE	✓	✓	✓	✓	✓	✓	✓	✓
Quarter FE	✓	✓	✓	✓	✓	✓	✓	✓
Patient FE					✓	✓	✓	✓
Mean of Y (Before MPAC)	0.98	0.76	0.97	0.94	0.92	0.72	0.90	0.92
# of observations	3732808	3098091	3514659	2688382	2479939	1918773	2272297	1535129
R^2	0.59	0.56	0.59	0.61	0.77	0.77	0.78	0.81

▸ Heterogenous Analysis

(a) Log (Total Quantity per Claim)



(b) Log (Average Quantity per Day)

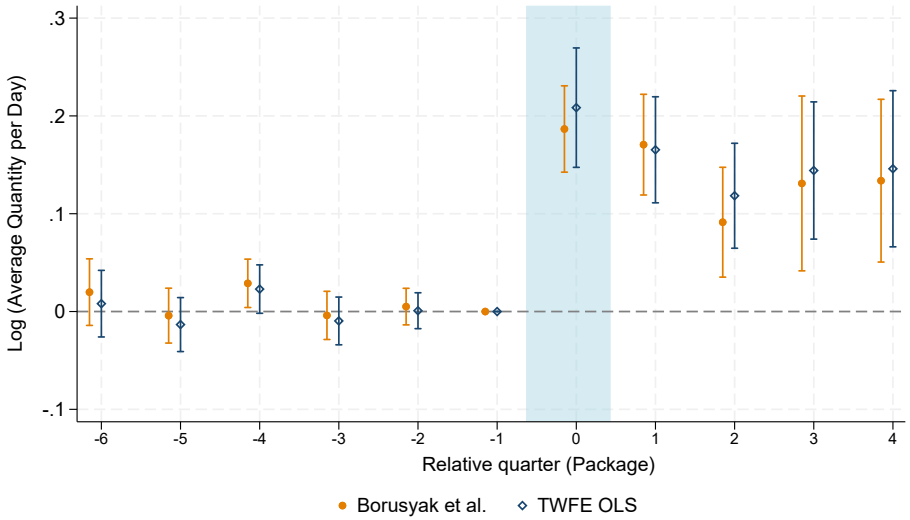


Figure 4: Event Study: Effects of MPACs (Packaging Material) on Claim Drug Utilization

Ruling Out Alternative Mechanisms

- Marketing Effort: No significant change in marketing spend around MPAC adoption (100 firms, 2015–2025). ▸ Result
- Pack Size: Pack size changes explain only 4% vs. the 17.7% baseline increase; claims data are unaffected by packaging. ▸ Result ▸ Result
- Unmet Need: Effects are similar across urban/rural regions; claim counts (extensive margin) even decrease for packaging MPACs. ▸ Heterogeneity by Location ▸ Extensive Margin
- Perceived Quality: Fixed CVBP pricing removes incentives for quality upgrades; perceived quality gains would reduce, not increase, dosing.

Demand-side Consequences (3): Health Outcomes

- **Do MPACs affect health outcomes?**

$$y_{ct} = \beta_0 + \beta_1 MPAC_{ct} + \mathbf{X_{i(c)t}}'\gamma + \alpha_{h(c)g(c)} + \mu_t + \epsilon_{ct},$$

  - y_{ct} represents 30-day and 90-day readmission, length of stay, and ICU admission during the index hospitalization.
  - $MPAC_{ct}$ indicates whether claim c 's focus molecule d (from rounds 5 and 7–9) underwent an MPAC by quarter t.
  - $\alpha_{h(c)g(c)}$ represents hospital-by-molecule group fixed effects, comparing claims with the same combination of focus molecules $g(c)$.

Table 5: Effect of MPACs on Health Outcomes

Panel A: Readmission Rate

	30-day Readmission				90-day Readmission			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MPACs	0.005***				0.005***			
	(0.002)				(0.002)			
MPACs (Package)		0.008***				0.012***		
		(0.003)				(0.004)		
MPACs (API)			0.007***				0.006**	
			(0.002)				(0.003)	
MPACs (Process)				0.008				0.012**
				(0.006)				(0.006)
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Hospital × Molecule Group FE	✓	✓	✓	✓	✓	✓	✓	✓
Quarter FE	✓	✓	✓	✓	✓	✓	✓	✓
Mean of Y (Before MPAC)	0.17	0.21	0.18	0.17	0.31	0.36	0.33	0.30
# of observations	2,741,181	2,203,189	2,580,365	1,821,183	2,685,345	2,147,590	2,527,444	1,768,499
R^2	0.09	0.08	0.08	0.10	0.12	0.12	0.11	0.12

Effect of MPACs on Health Outcomes (Continued)

Panel B: Other Health Outcomes

	Log (Length of Stay)				ICU Admission			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MPACs	0.019***				-0.006			
	(0.005)				(0.010)			
MPACs (Package)		0.037***				-0.004		
		(0.012)				(0.012)		
MPACs (API)			0.034***				-0.011	
			(0.007)				(0.017)	
MPACs (Process)				-0.016*				-0.000
				(0.009)				(0.008)
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Hospital × Molecule Group FE	✓	✓	✓	✓	✓	✓	✓	✓
Quarter FE	✓	✓	✓	✓	✓	✓	✓	✓
Mean of Y (Before MPAC)	10.94	11.25	11.12	12.09	0.02	0.01	0.02	0.01
# of observations	2,767,854	2,229,769	2,605,961	1,846,686	2,767,854	2,229,769	2,605,961	1,846,686
R^2	0.25	0.23	0.24	0.25	0.56	0.56	0.54	0.53

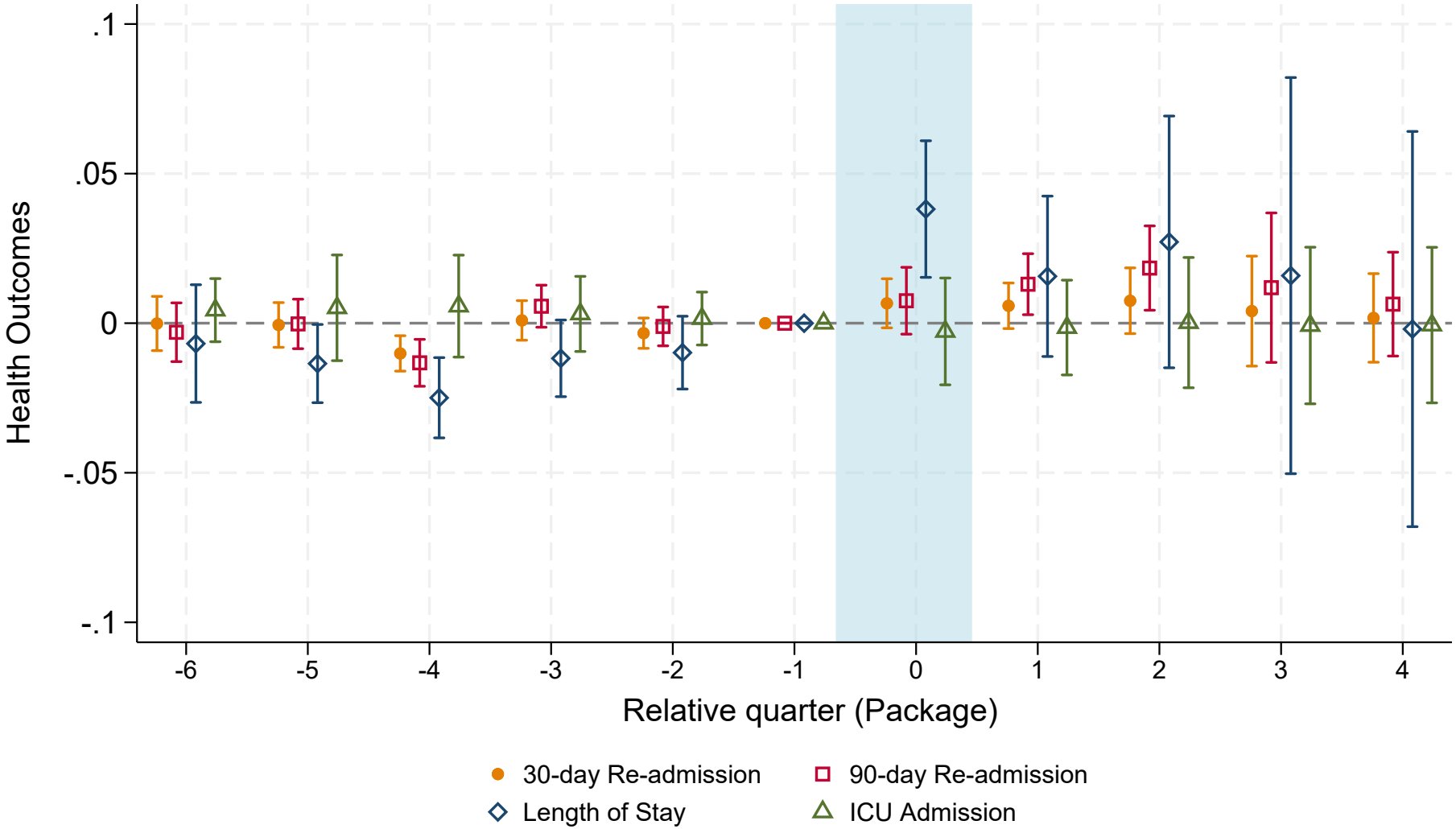
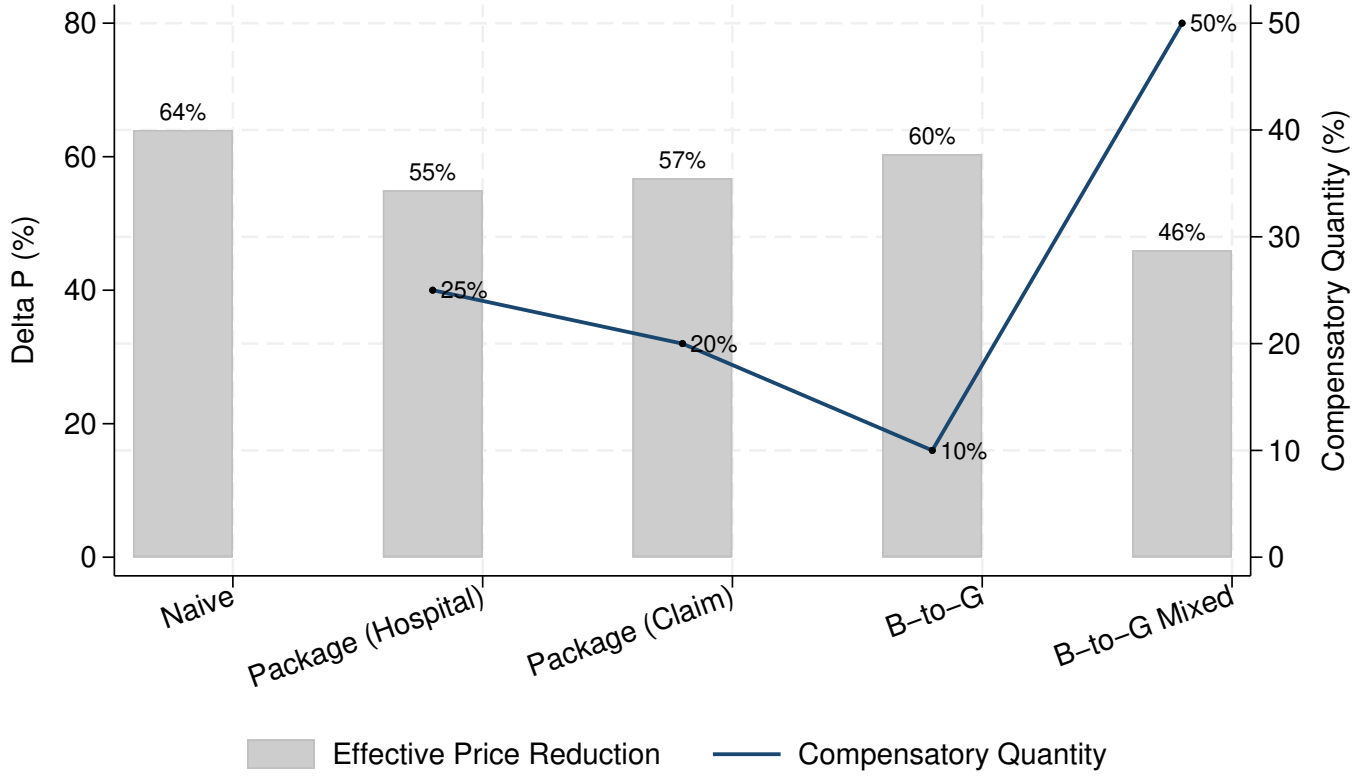


Figure 5: Event Study: Effects of MPACs (Packaging Material) on Health Outcomes

Welfare: Effective Price Reduction

Preferred estimate: $64\% \to 57\%$ using the **claim-level intensive-margin response**.



Alternative calibrations using hospital utilization and branded-to-generic switching imply 46–60%.

Conclusion

Centralized procurement achieves large price reductions, but **price-only contracts create post-award moral hazard**.

- Lower-bidding winners are more likely to alter manufacturing processes post-award.
- Packaging MPACs raise quantity per claim by 19% and average daily quantity by 17%—consistent with compensatory dosing.
- Health costs are real: readmissions rise by 0.8pp, length of stay by 0.4 days.
- Effective price reduction falls to 46–60% from the nominal 64%.
- **Policy implications:**
  - Incorporate utilization data and MPAC history into contract design;
  - Scrutinize quality-reducing MPACs while permitting capacity-expanding ones.

- Thank you for your time and comments!
- Contact: Nina Yin, ninayin@cufe.edu.cn.

Timeline of CVBP for Prescription Drugs

Table 6: Timeline of CVBP for the First 11 Rounds

Round	# of molecules	Bidding	Implementation
4+7 Pilot	25	2018.12	2019.3
Pilot Expansion	25	2019.9	2019.12
2	32	2020.1	2020.4
3	55	2020.8	2020.11
4	45	2021.2	2021.5
5	61	2021.6	2021.10
6 (Insulin Only)	16	2021.11	2022.5
7	61	2022.7	2022.11
8	39	2023.3	2023.7
9	41	2023.11	2024.3
10	62	2024.12	2025.4
11	55	2025.10	2026.2

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Sample Construction

- **Treatment group:** Molecules (ATC-5) procured in rounds 1–5 (excluding the initial 4+7 pilot molecules).
- **Control group:** Other molecules in the same ATC-4 class not procured in rounds 1–7. (Ensures within-class comparability of indication and substitution patterns.)
- **Estimation window:** Relative quarters -4 to $+5$ around implementation to maintain a balanced panel and reduce long-horizon confounding.

Figure 6: Data Structure for Analysis

Robustness Checks for Average Effects

- ES without the control group ▸ No control group
- Leave-one-out analysis ▸ Leave-one-out
- Test for violation of parallel pre-trends (Rambachan and Roth, 2023) ▸ Rambachan and Roth
- Balanced sample ▸ Balanced-sample

(a) Number of hospitals

(b) Market share by expenditure

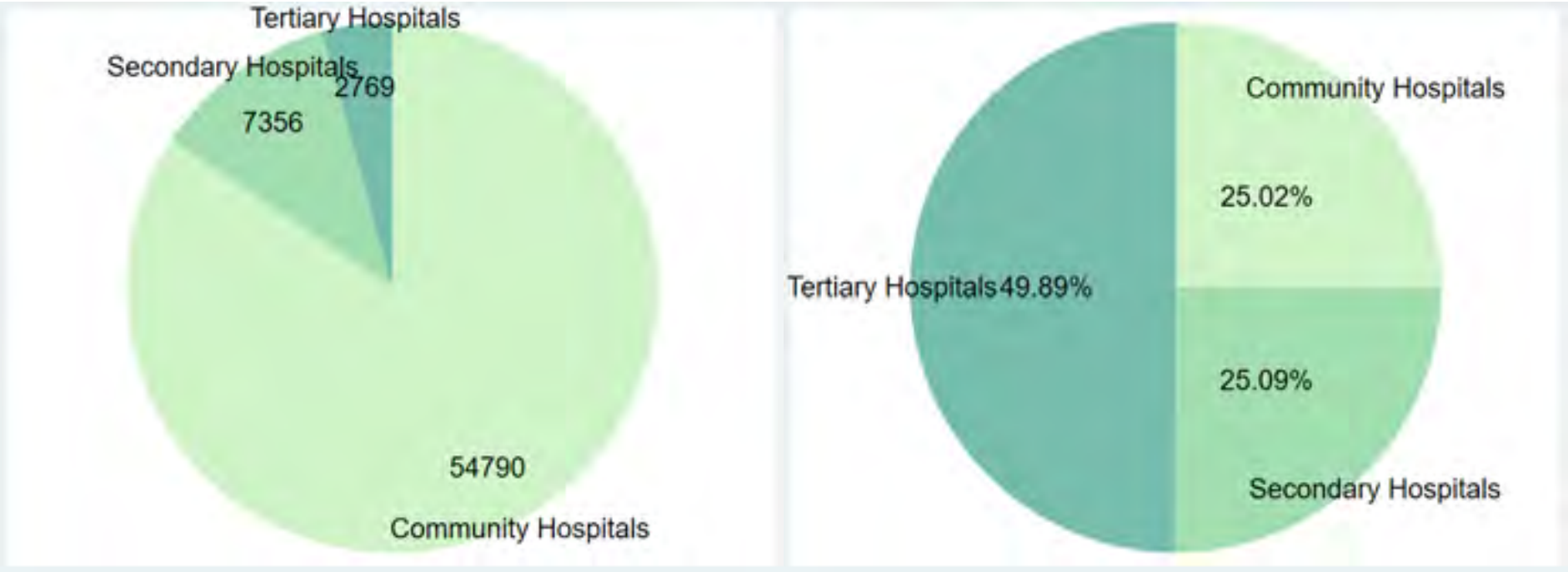

Figure 7: Summary of hospitals in our sample

Notes: These figures show the distribution of hospitals in our dataset according to their hospital level. Panel (a) reports the number of hospitals and panel (b) presents their market share by expenditure.

(a) Number of community hospitals (b) Number of other community hospitals

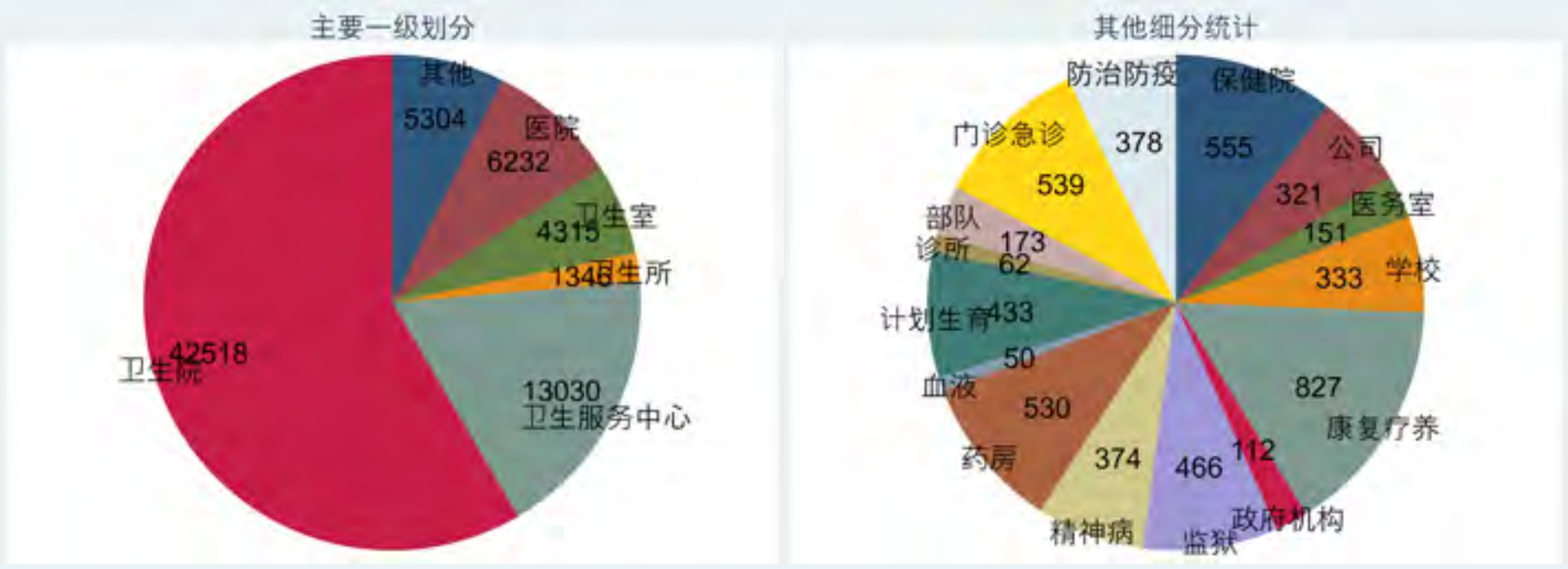

Figure 8: Summary of community hospitals in our sample

Notes: These figures show the distribution of community hospitals in our dataset.

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Summary Statistics

	Panel (a): Hospital Transaction Data					
	Procured All	Pre-CVBP	Post-CVBP	Difference		Non-Procured
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Mean (SD)	Mean (SD)	Mean (SD)	Diff	P-Value	Mean (SD)
Average Price	4.55 (12.16)	7.23 (16.72)	2.79 (7.31)	-4.44	0.00	3.79 (4.48)
Total DDDs	11326.78 (38502.85)	9037.4 (30435.57)	12833.2 (42926.89)	3795.76	0.00	10083.47 (33165.82)
Expenditure	33364.49 (180789.80)	48668.3 (247584.20)	23293.9 (116623.80)	-25374.36	0.00	32356.91 (123733.40)
Share of Winning	0.44 (0.48)	0.10 (0.28)	0.67 (0.44)	0.57	0.00	0.00 (0.00)
Share of Branded	0.16 (0.34)	0.24 (0.41)	0.10 (0.28)	-0.14	0.00	0.33 (0.46)
Tertiary Hospitals	0.14 (0.34)	0.14 (0.34)	0.14 (0.35)			0.14 (0.35)
Secondary Hospitals	0.21 (0.41)	0.20 (0.40)	0.21 (0.41)			0.21 (0.41)
Primary Care Institutions	0.65 (0.48)	0.66 (0.47)	0.65 (0.48)			0.65 (0.48)
Rural Hospitals	0.55 (0.50)	0.55 (0.50)	0.56 (0.50)			0.49 (0.50)
Observations	1,190,023	472,293	717,730			909,759
	Panel (b): Insurance Claim Data					
	MPAC All	Pre-MPAC	Post-MPAC	Difference		Non-MPAC
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Mean (SD)	Mean (SD)	Mean (SD)	Diff	P-Value	Mean (SD)
Total Quantity per Claim	9.42 (12.58)	9.25 (12.18)	9.60 (13.00)	0.34	0.00	6.10 (10.52)
Average Quantity per Day	1.03 (1.60)	0.98 (1.45)	1.09 (1.75)	0.11	0.00	0.73 (1.45)
Age	60.93 (22.53)	62.51 (22.02)	59.21 (22.95)	-3.31	0.00	57.09 (19.65)
Female	0.49 (0.50)	0.48 (0.50)	0.49 (0.50)	0.01	0.00	0.53 (0.50)
Tertiary Hospitals	0.59 (0.49)	0.59 (0.49)	0.59 (0.49)			0.68 (0.46)
Secondary Hospitals	0.36 (0.48)	0.37 (0.48)	0.36 (0.48)			0.28 (0.45)
Primary Care Institutions	0.05 (0.21)	0.04 (0.21)	0.05 (0.21)			0.04 (0.18)
Observations	1,189,821	618,362	571,459			2,556,773

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Details of MPACs by Type

- (i) *Package*:
  - replacing or adding packaging materials suppliers, e.g.:
    - ★ 新增“重庆正川永成医药材料有限公司”为本品“中硼硅玻璃管制镀聚二甲基硅氧烷膜注射剂瓶”供应商
  - changes in packaging materials, e.g.:
    - ★ 本品包装材料在双铝膜（聚酯/铝/聚乙烯药用复合膜）包装的基础上增加铝塑（药用铝箔和聚氯乙烯/聚偏二氯乙烯固体药用复合硬片）包装
- (ii) *API*:
  - replacing or adding of API suppliers, e.g.:
    - ★ 增加辛伐他汀片原料药“辛伐他汀”的产地“江西大地制药有限责任公司”
  - changes in standards about API, e.g.:
    - ★ 申请变更本品所用原料药（艾司奥美拉唑钠）内控标准中鉴别分析方法
- (iii) *Production process*:
  - production scale changes, e.g.:
    - ★ 在原批准批量20万片的基础上增加40万片的生产批量
  - changes in production machines, e.g.:
    - ★ 精烘包干燥设备由热风循环烘箱变更为真空干燥箱
  - changes in production method, e.g.:
    - ★ 申请变更制剂生产工艺，具体为本品灌装装量设定方式改变

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Details of other PACs by Type

- (i) *Pack Size*:
  - 增加“7片/板，2板/盒”、“14片/板，1板/盒；2板/盒；4板/盒”的包装规格
- (ii) *Shelf Life*:
  - 本品有效期为12个月，现延长有效期为18个月
- (iii) *China Pharmacopoeia*:
  - 本品执行标准由“WS1-XG-018-2017”变更为“《中国药典》2015年版第一增补本”
- (iv) *Package Inserts*:
  - 对本品说明书中【不良反应】、【注意事项】、【药物相互作用】等项做相应修订

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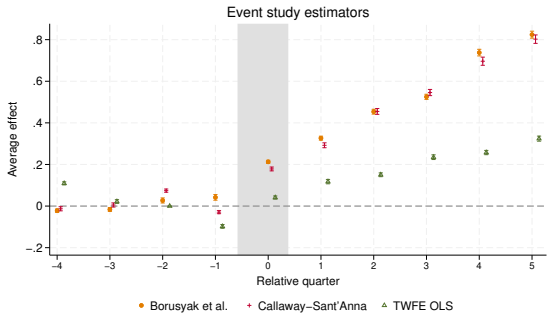
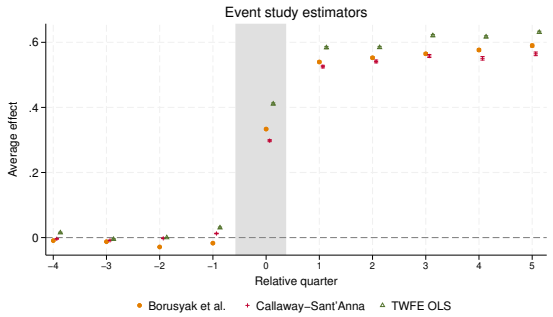
Event Study without the Control Group

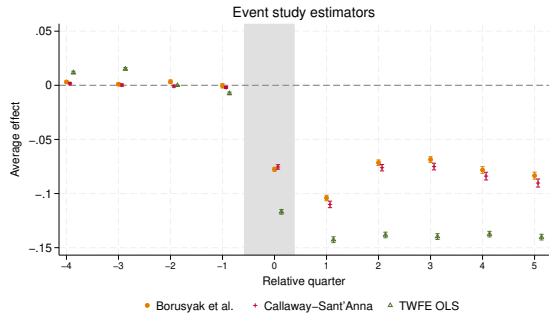
(a) Log (Total DDDs)



(b) Share of Winning



(c) Share of Banded



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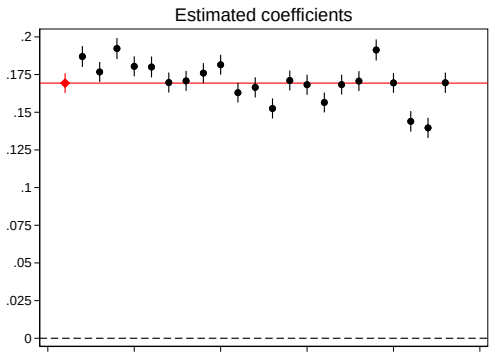
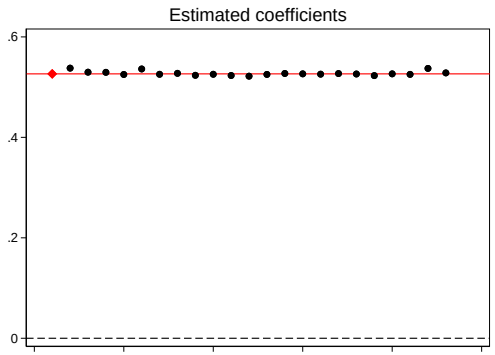
Dropping One Particular Molecule

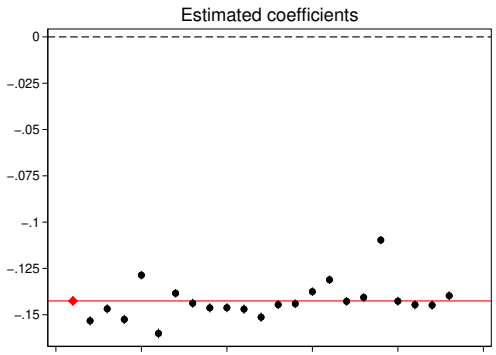
(a) Log (Total DDDs)



(b) Share of Winning



(c) Share of Banded



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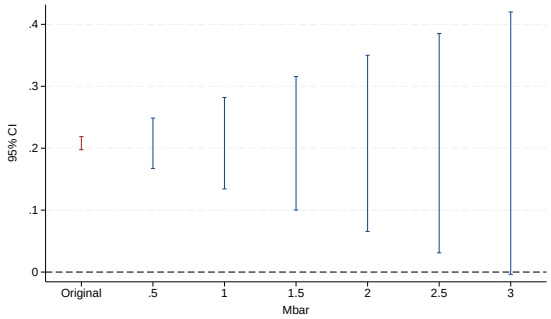
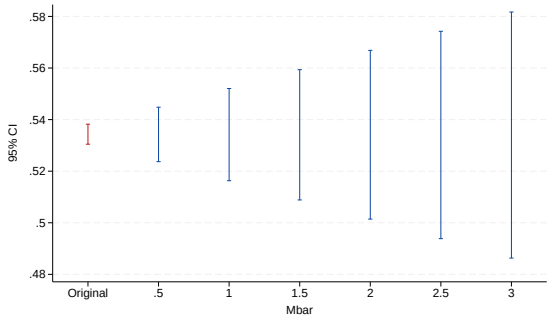
Sensitivity Analysis

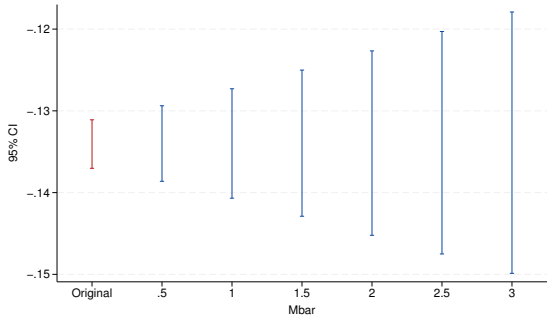
(a) Log (Total DDDs)



(b) Share of Winning



(c) Share of Banded



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Average Effects of the CVBP with Balanced Sample

	Dependent Variables: Log (Total DDDs)			
	(1) OLS: Baseline	(2) OLS: Sample w/i only Pre/Post	(3) Poisson: Sample w/i only Pre/Post	(4) Poisson: Balanced Sample w/i only Pre/Post
Procured	0.214***	0.205***	0.143***	0.180***
	(0.004)	(0.004)	(0.008)	(0.009)
Constant	7.674***	7.600***	10.442***	10.146***
	(0.001)	(0.001)	(0.003)	(0.004)
Hospital × Molecule FE	✓	✓	✓	✓
Quarter FE	✓	✓	✓	✓
Mean of Y (Before VBP)	9037.47	8154.00	8154.00	2961.94
Mean of Y (After VBP)	13454.02	10891.28	10891.28	5162.76
# of observations	1923491	2248564	2248564	5617116
R^2	0.81	0.82		

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Demand-side Response (2): Branded-to-Generic Switching

- Branded-generic Switching: Switching from branded to generic drugs incurs disruption/(perceived) quality change $\rightarrow$ ambiguous effects
- Consider the following model:

$$\begin{aligned} Q_{idt} &= \beta_0 + \beta_1 \mathit{procured}_{dt} \\ &+ \beta_2 \mathit{procured}_{dt} * \mathit{switchBG}_{id} \\ &+ \beta_3 \mathit{procured}_{dt} * \mathit{priceDif}_{id} \\ &+ \beta_4 \mathit{procured}_{dt} * X_i \\ &+ \alpha_{id} + \mu_t + \epsilon_{idt}, \end{aligned}$$

where X_i denotes hospital characteristics, such as hospital tier, location (rural/urban, rich/poor).

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Demand-side Response (2): Branded-to-Generic Switching

	Extensive	Intensive			
	(1)	(2) Hospital	(3) City	(4) Both	(5) PSM
SwitchBG	-0.019***				
	(0.003)				
Procured		0.157***	5.398***	5.455***	6.355***
		(0.011)	(0.200)	(0.200)	(0.390)
Procured × SwitchBG		0.038***	0.056***	0.103***	0.162***
		(0.008)	(0.008)	(0.008)	(0.020)
Procured × PriceDif		0.095***	0.095***	0.105***	0.631***
		(0.011)	(0.011)	(0.012)	(0.134)
Hospital FE	✓				
Molecule FE	✓				
Hospital × Molecule FE		✓	✓	✓	✓
Quarter FE		✓	✓	✓	✓
Procured × Post × Hospital's Controls		✓		✓	✓
Procured × Post × City's Controls			✓	✓	✓
Mean of Y	0.79				
Mean of Y (Before CVBP)		10203.28			
# of observations	170990	1763809	1763809	1763809	1106112
R^2	0.46	0.81	0.81	0.81	0.83

▸ Summary Statistics ▸ PSM

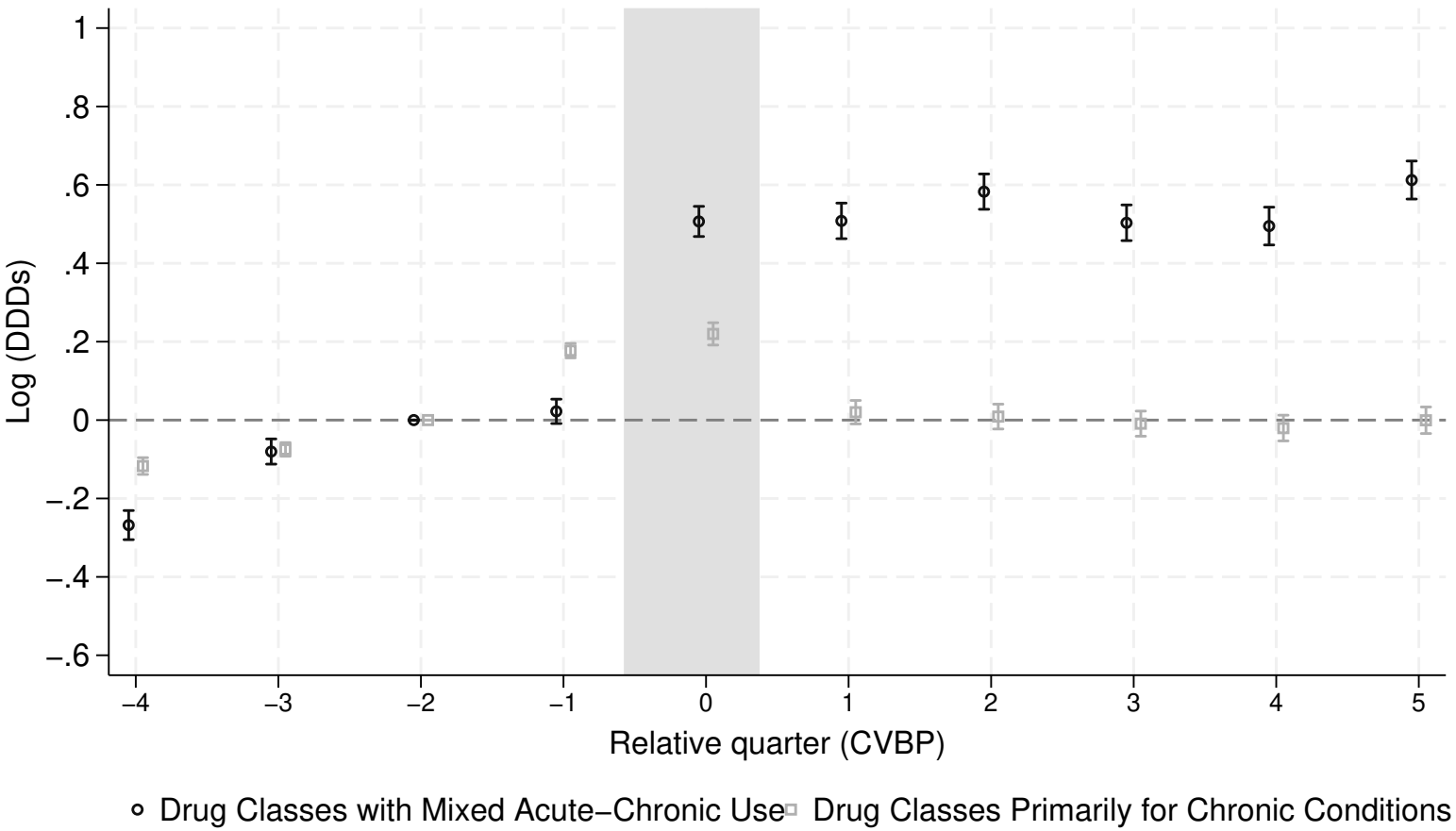

Figure 12: Event Study: Heterogeneous Effects on Drug Utilization by Branded-to-Generic Switch

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Summary Statistics by Branded-to-Generic Switch

	SwitchBG=1	SwitchBG=0	Difference	
	(1)	(2)	(3)	(4)
Variables	Mean (SD)	Mean (SD)	Diff	P-Value
Pre 1Y Total DDDs	31073.70 (109568.70)	21367.57 (81743.95)	9706.13	0.00
Post 1Y- Pre 1Y Total DDDs	10138.22 (96711.95)	8791.84 (83426.42)	1346.38	0.01
Pre 1Y Average Price	6.93 (8.22)	6.72 (17.31)	0.21	0.02
Pre 1Y Share of Branded	0.96 (0.11)	0.01 (0.07)	0.95	0.00
Tertiary Hospitals	0.20 (0.40)	0.09 (0.29)	0.11	0.00
Secondary Hospitals	0.25 (0.43)	0.18 (0.39)	0.07	0.00
Primary Care Institutions	0.55 (0.50)	0.72 (0.45)	-0.18	0.00
Rural Hospitals	0.29 (0.45)	0.66 (0.47)	-0.37	0.00
Wage	104368.60 (37494.82)	82633.32 (24223.10)	21735.29	0.00
Education	10.28 (1.22)	9.45 (0.96)	0.82	0.00
Observations	38,606	143,615		

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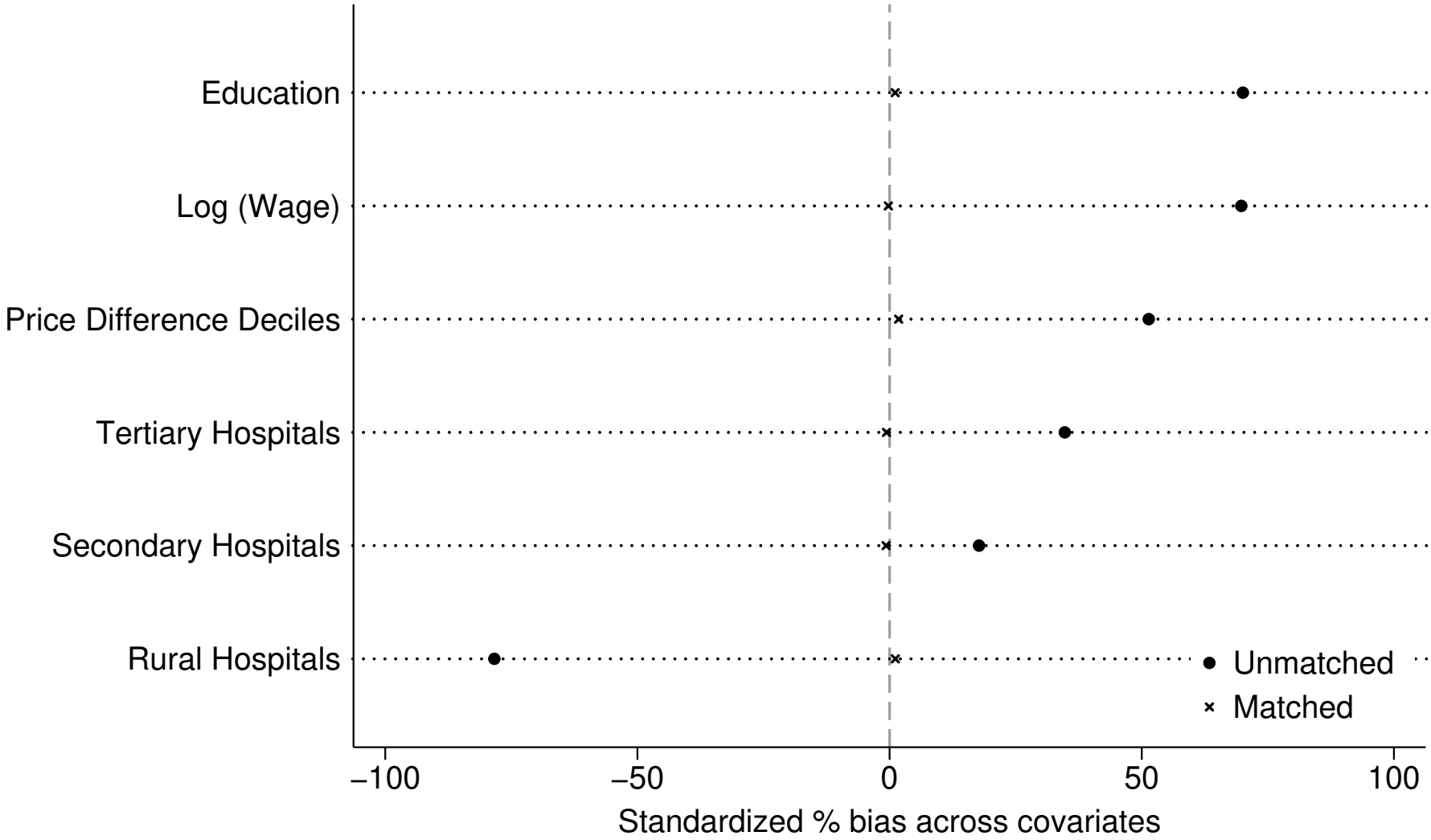
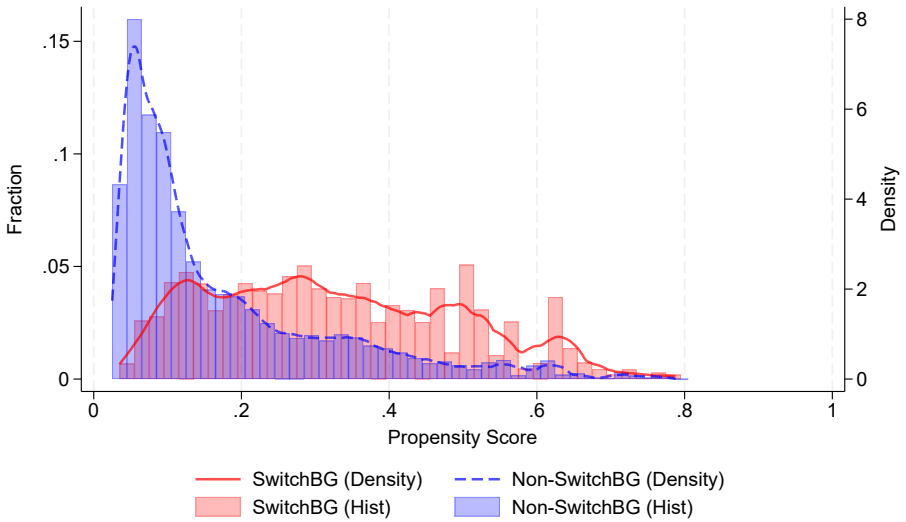


Figure 13: Balance Check before and after Propensity Score Matching

(a) Before Propensity Score Matching



(b) After Propensity Score Matching

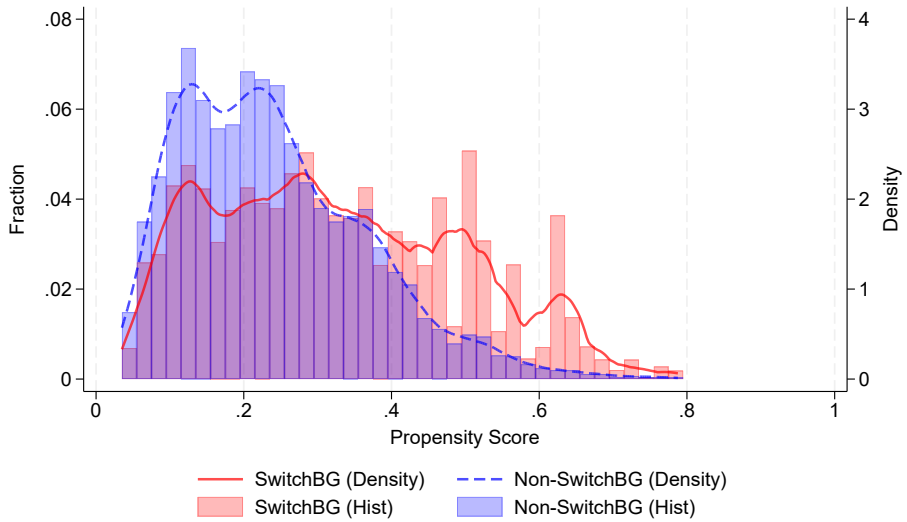


Figure 14: Propensity Score Distribution before and after Matching

Notes: These figures plot the distribution of estimated propensity scores for *SwitchBG*. The bars represent the fraction of observations, and the solid (dashed) lines represent the kernel density for the SwitchBG (Non-SwitchBG) group.

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Table 7: The Effects of MPACs on Selling and Marketing Expenses

	Log(SellingExp)		SellingExp/TA		SellingExp_Adv/TA		SellingExp_wage/TA	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Procured × winMPACs	-0.010		-0.012		-0.006		0.001	
	(0.095)		(0.011)		(0.008)		(0.002)	
Procured × winMPACs (Package)		-0.072		0.009		0.019		0.007**
		(0.109)		(0.015)		(0.014)		(0.003)
Procured × winMPACs (API)		-0.022		-0.020		-0.004		0.000
		(0.090)		(0.014)		(0.010)		(0.002)
Procured × winMPACs (Process)		0.104		0.005		-0.003		-0.004
		(0.107)		(0.012)		(0.008)		(0.003)
Procured	0.036	0.024	0.023	0.021*	0.003	0.012	0.004	0.001
	(0.135)	(0.116)	(0.014)	(0.012)	(0.014)	(0.014)	(0.005)	(0.004)
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Firm Controls	✓	✓	✓	✓	✓	✓	✓	✓
Mean of Y (Before MPAC)	20.08		0.16		0.09		0.02	
# of observations	956	956	956	956	956	956	956	956
R^2	0.91	0.91	0.50	0.50	0.53	0.53	0.46	0.46

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Table 8: Average Effects of CVBP on Other Changes

	(1) Pack Size	(2) Shelf Life	(3) Pharmacopoeia	(4) Package Inserts
Procured	-0.000	-0.003	0.006	0.023***
	(0.005)	(0.005)	(0.004)	(0.007)
Procured × Winning	-0.012	0.002	0.016	-0.008
	(0.015)	(0.014)	(0.011)	(0.015)
Producer × Molecule FE	✓	✓	✓	✓
Quarter FE	✓	✓	✓	✓
Mean of Y (Before CVBP)	0.046	0.024	0.015	0.012
# of observations	8510	8510	8510	8510
R^2	0.11	0.12	0.10	0.23

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Table 9: The Effects of MPACs on Pack Size

	Winning DDDs		Log (Pack Size)	
	(1)	(2)	(3)	(4)
Procured	1.842***	1.852***	0.225***	0.233***
	(0.031)	(0.031)	(0.003)	(0.003)
Procured × winMPACs	0.177***		0.040***	
	(0.020)		(0.002)	
Procured × winMPACs (Package)		0.293***		0.039***
		(0.041)		(0.007)
Procured × winMPACs (API)		0.171***		0.048***
		(0.022)		(0.002)
Procured × winMPACs (Process)		-0.045		-0.006***
		(0.040)		(0.002)
Hospital × Molecule FE	✓	✓	✓	✓
Quarter FE	✓	✓	✓	✓
Mean of Y (Before CVBP)	1068.62		13.42	
# of observations	866666	866666	1356508	1356508
(Pseudo) R^2	0.86	0.86	0.94	0.94

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Table 10: Heterogeneous Effects of MPACs on Drug Utilization by Location

	(1) Urban	(2) Rural
Procured	0.224***	0.313***
	(0.007)	(0.006)
Procured × winMPACs	0.162***	0.182***
	(0.010)	(0.014)
Hospital × Molecule FE	✓	✓
Quarter FE	✓	✓
Mean of Y (Before CVBP)	14613.68	6464.55
# of observations	849959	913850
R^2	0.84	0.78

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Table 11: Effects of MPACs on the Number of Hospital Visit

	Number of Claims			
	(1)	(2)	(3)	(4)
MPACs	0.053***			
	(0.020)			
MPACs (Package)		-0.115***		
		(0.042)		
MPACs (API)			0.088***	
			(0.031)	
MPACs (Process)				0.347***
				(0.072)
Controls	✓	✓	✓	✓
Hospital × Molecule FE	✓	✓	✓	✓
Quarter FE	✓	✓	✓	✓
Mean of Y (Before MPAC)	12.99	22.29	15.39	3.87
# of observations	256,451	193,996	223,852	184,637
Pseudo R^2	0.93	0.94	0.93	0.93

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Table 12: Heterogeneous Effects of MPACs on Drug Utilization

	By Drug Use		By Injection			
	(1) Mixed Use	(2) Chronic	(3) Injection	(4) Non-Injection	(5) Injection	(6) Non-Injection
Procured	0.201***	0.149***	-0.318***	0.298***	-0.262***	0.299***
	(0.008)	(0.006)	(0.025)	(0.005)	(0.024)	(0.005)
Procured × winMPACs	0.175***	0.121***	0.392***	0.147***		
	(0.015)	(0.009)	(0.025)	(0.009)		
Procured × winMPACs (Package)					0.422***	-0.069*
					(0.023)	(0.036)
Procured × winMPACs (API)					-0.050	0.150***
					(0.112)	(0.009)
Procured × winMPACs (Process)					0.312***	0.069***
					(0.037)	(0.021)
Hospital × Molecule FE	✓	✓	✓	✓	✓	✓
Quarter FE	✓	✓	✓	✓	✓	✓
Mean of Y (Before VBP)	9297.87	10717.99	6735.52	10451.46	6735.52	10451.46
Mean of Y (After VBP)	11646.51	16597.61	5558.79	15505.81	5558.79	15505.81
# of observations	1020777	743032	936375	1709447	936375	1709447
R^2	0.81	0.81	0.83	0.81	0.83	0.81

Table 13: Heterogeneous Effects of MPACs on Claim Drug Utilization

	Log (Total Quantity per Claim)				Log (Average Quantity per Day)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MPACs	0.005				-0.016			
	(0.018)				(0.020)			
MPACs × Injection	0.070***				0.087***			
	(0.024)				(0.024)			
MPACs (Package)		-0.008				0.016		
		(0.032)				(0.033)		
MPACs (Package) × Injection		0.209***				0.162***		
		(0.043)				(0.043)		
MPACs (API)			0.007				-0.016	
			(0.018)				(0.020)	
MPACs (API) × Injection			0.024				0.023	
			(0.040)				(0.043)	
MPACs (Process)				-0.020				-0.026
				(0.023)				(0.028)
MPACs (Process) × Injection				0.105***				0.132***
				(0.033)				(0.035)
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Hospital × Molecule FE	✓	✓	✓	✓	✓	✓	✓	✓
Quarter FE	✓	✓	✓	✓	✓	✓	✓	✓
Mean of Y (Before MPAC)	9.25	7.17	9.22	8.45	0.98	0.76	0.97	0.94
# of observations	3732808	3098091	3514659	2688382	3732808	3098091	3514659	2688382
R^2	0.66	0.65	0.67	0.71	0.59	0.56	0.59	0.61

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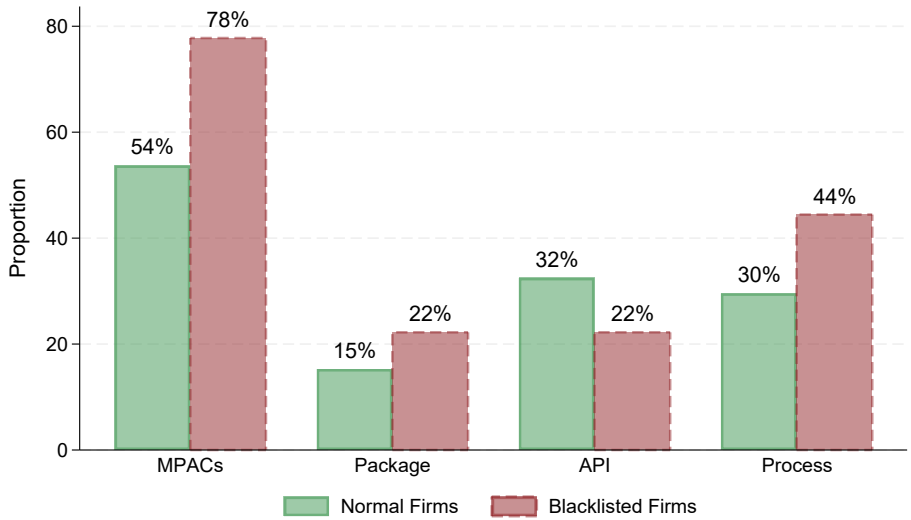
Supplier MPACs and Regulatory Violation

—Suggestive validation from severe quality violations (9 cases)

- **9** winning firms over 10 rounds were placed on the governmental regulatory violation list (blacklist) due to quality issues
  - Quality deterioration:
    - ★ Severe (adverse effects) → blacklist; Mild → reduced potency



- NMPA enforcement records (non-compliance announcements, unannounced inspections, and product recalls) indicate no overlap with our winning firms