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

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# Motivation

- In procurement, **price is contractible** but **quality often isn't**: suppliers adjust along unobserved margins.
- Drug quality is especially hard to verify and consequential:
  - Therapeutic quality (bioavailability, impurities) is hard to observe.
  - Post-award manufacturing changes face minimal oversight.
  - Patients and clinicians respond to perceived efficacy change via **dosage adjustments**.
- China's centralized volume-based procurement (**CVBP**) offers a rare large-scale setting: big, binding price cuts and mandatory purchasing.

# Research Questions

1. How do firms adjust when price and quantity are contractible but post-award quality is not?
2. How does drug utilization reveal otherwise invisible quality changes?
3. And what is the *effective* price of treatment once these adjustments take place?

# Preview of Findings

- **Supply side: winning firms alter manufacturing after award**
  - Manufacturing Post Approval Changes (MPACs) increase 8.5× vs. pre-CVBP, driven by firms with larger revenue losses.
  - Packaging material changes consistent with cost-cutting, not capacity expansion.
- **Demand side: compensatory dosing**
  - Hospitals with packaging-altering suppliers see 24.7% larger utilization increases.
  - Prior branded users resist switching, but dose higher when they do.
  - Strongest for injections and classes where efficacy is salient.
- **Welfare: savings are overstated**
  - Effective price cut is 3–18 pp below the nominal 64%.

# Contributions

- Complete causal chain: procurement → moral hazard → compensatory dosing → overstated savings.
  - Beyond post-award contractual distortions (Bajari and Tadelis 2001; Decarolis 2014; Lewis and Bajari 2014), we document distortions in the *product itself* and their demand-side effects.
- Competition and quality in healthcare: winners cut costs along less observable margins.
  - We show firm-side moral hazard, complementing adverse selection in U.S. Medicare DME procurement (Gaynor et al. 2013; Currie et al. 2023; Jansen and Zhang 2023; Diwan et al. 2026).
- Regulation and procurement design: packaging-related MPACs predict quality deterioration.
  - MPAC records can feed scoring auctions (Che 1993; Lewis and Bajari 2011).

# Institutional Background

## China's Pharmaceutical Market

- Public hospitals dominate; **Hospital pharmacies ∼85% of prescription drugs**.
- 3,000+ firms, mostly generics; 2016 bioequivalence reform addressed quality concerns.
- Near-universal insurance, but copays for drugs

## Centralized Volume-Based Procurement (CVBP)

- Nationwide from Dec 2019; 11 rounds, 16–62 molecules each. Timeline
- Lowest bid wins, guaranteed 50–80% of demand. **Avg. price cuts >50%.**

## Post-Approval Changes (PACs)

- Major (NMPA approval) / **Moderate: packaging, APIs, process** / Minor.
- We focus on quality-relevant **manufacturing PACs (MPACs)**.

# Data Overview

1. **National Drug Procurement Data** (2019.01–2023.06)
   - Universe of all prescription drug transactions (hospital level): date, volume, price, product identity, hospital, firm, strength, formulation
   - Includes both procured and non-procured molecules.
   - We focus on five representative therapeutic classes: PPI, ACE inhibitors, HMG (statins), SSRIs, SABA inhalers

Sample Construction

2. **Post-Approval Changes**
   - MPACs: package material, APIs, production process
   - Other PACs: changes in the number of tablets, shelf life, *Chinese Pharmacopoeia*, package inserts
3. **Complementary Data Sources**
   - Hospital characteristics: tier, location
   - Drug attributes: branded vs. generic, bidding outcomes, supplying provinces
   - Firm attributes: location, top 100, listed firms' financial statement.

Summary Statistics

# 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).
- MPACs between winning and non-winning firms:

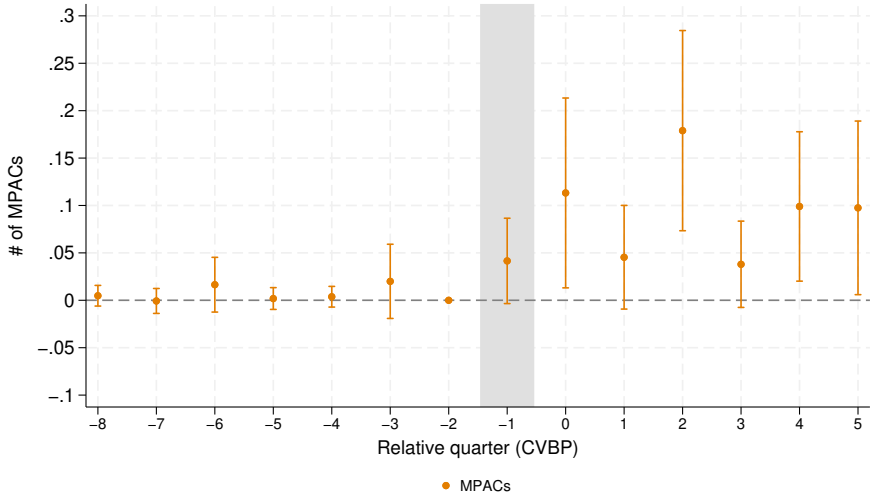
$$MPAC_{fdt} = \beta_0 + \beta_1 \textit{procured}_{dt} + \beta_2 \textit{procured}_{dt} * Win_{fd} + \alpha_{fd} + \mu_t + \epsilon_{fdt}$$

The MPACs involve the following three types:

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

▸ Details and Examples

(a) All MPACs




(b) MPACs by Type

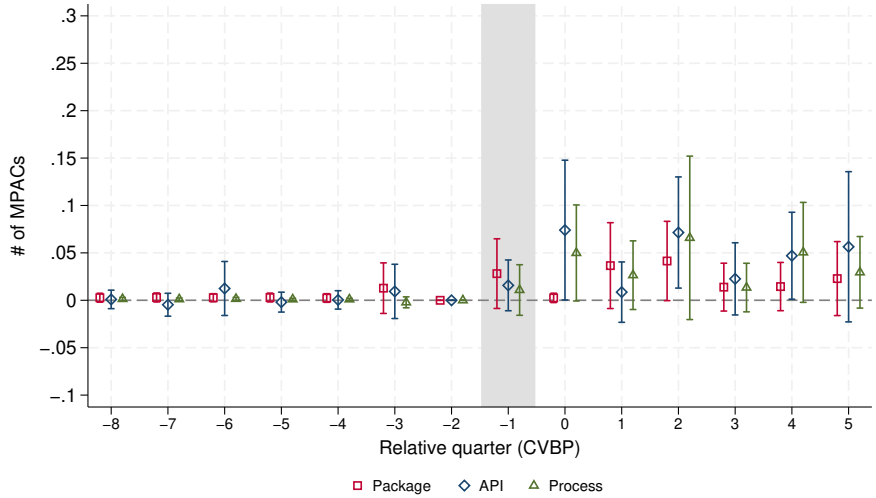



Figure 1: Event Study: Effects of CVBP on Winning Firms' MPACs

Winning firms post-CVBP: 8.5 × baseline

# Supplier Behavior: Motives for MPACs

Table 1: 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) |

Demand side factors don't predict MPACs | Regulatory Violation

# Demand-side Response (1): MPACs on Drug Utilization

Baseline Results

- **Do MPACs affect drug utilization?**

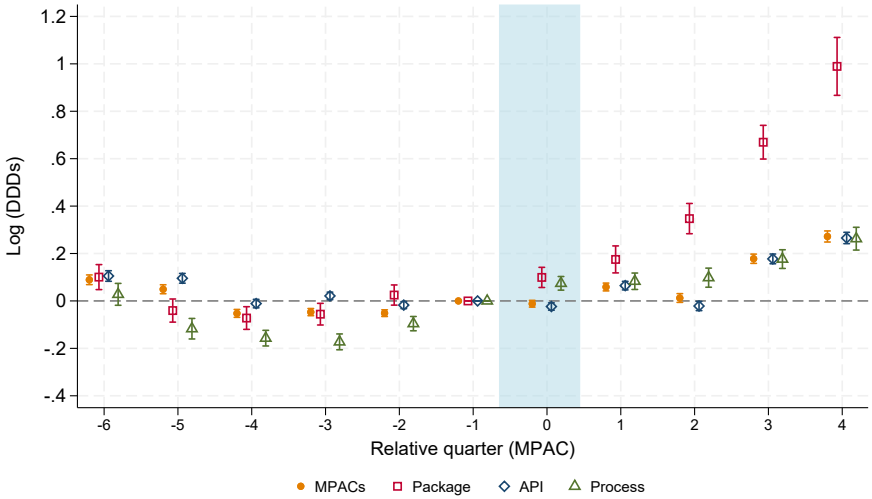
$$ln(Q_{idt}) = \beta_0 + \beta_1 procured_{dt} + \beta_2 procured_{dt} \cdot winMPAC_{idt} + \beta_3 procured_{dt} \cdot winMPAC_{id} + \alpha_{id} + \mu_t + \epsilon_{idt},$$

  - $\beta_2$: differential utilization change after a winning firm's MPAC.
  - $procured_{dt} = 1$ when $t \geq t_d^*$; $winMPAC_{idt} = 1$ when $t \geq t'_{id}$.
- **Event study** (procured molecules only):

$$ln(Q_{idt}) = \beta_0 + \sum_{n=-6, n\neq -1}^{n=4} \beta_n MPAC_{idt}^n + \alpha_{id} + \mu_t + \epsilon_{idt},$$

  - Assumption: absent the MPAC, drug utilization would have trended similarly across hospitals supplied by MPAC and non-MPAC winning firms.

(a) Full Sample




(b) Excluding MPACs Concurrent with CVBP Implementation

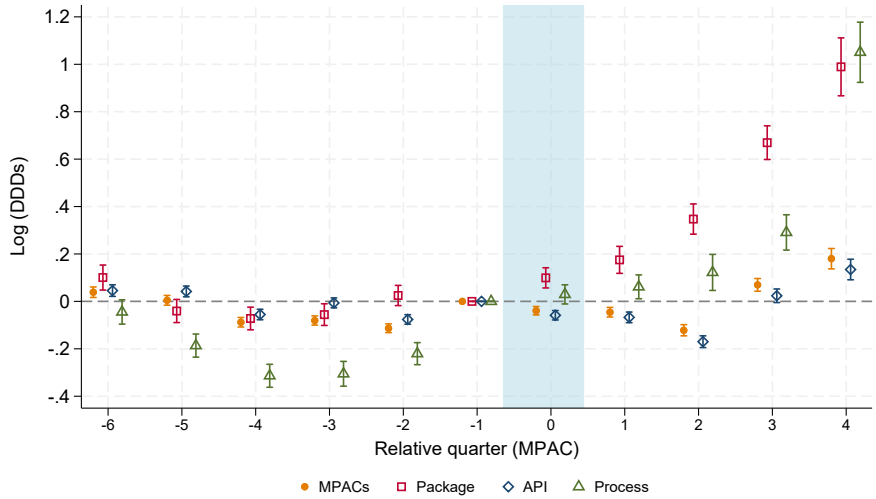



Figure 2: Event Study: Effects of MPACs on Drug Utilization

# Table 2: 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 |

Heterogeneous Effects

# Ruling Out Alternative Mechanisms

- Aggressive marketing effort ▸ Result
- Correlation with pack size ▸ Result ▸ Result
- Unmet medical need rather than compensatory dosing ▸ Result
- Patient awareness of higher quality
  - Post-award quality upgrades are incentive-incompatible under the severe cost pressures.

# 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).

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

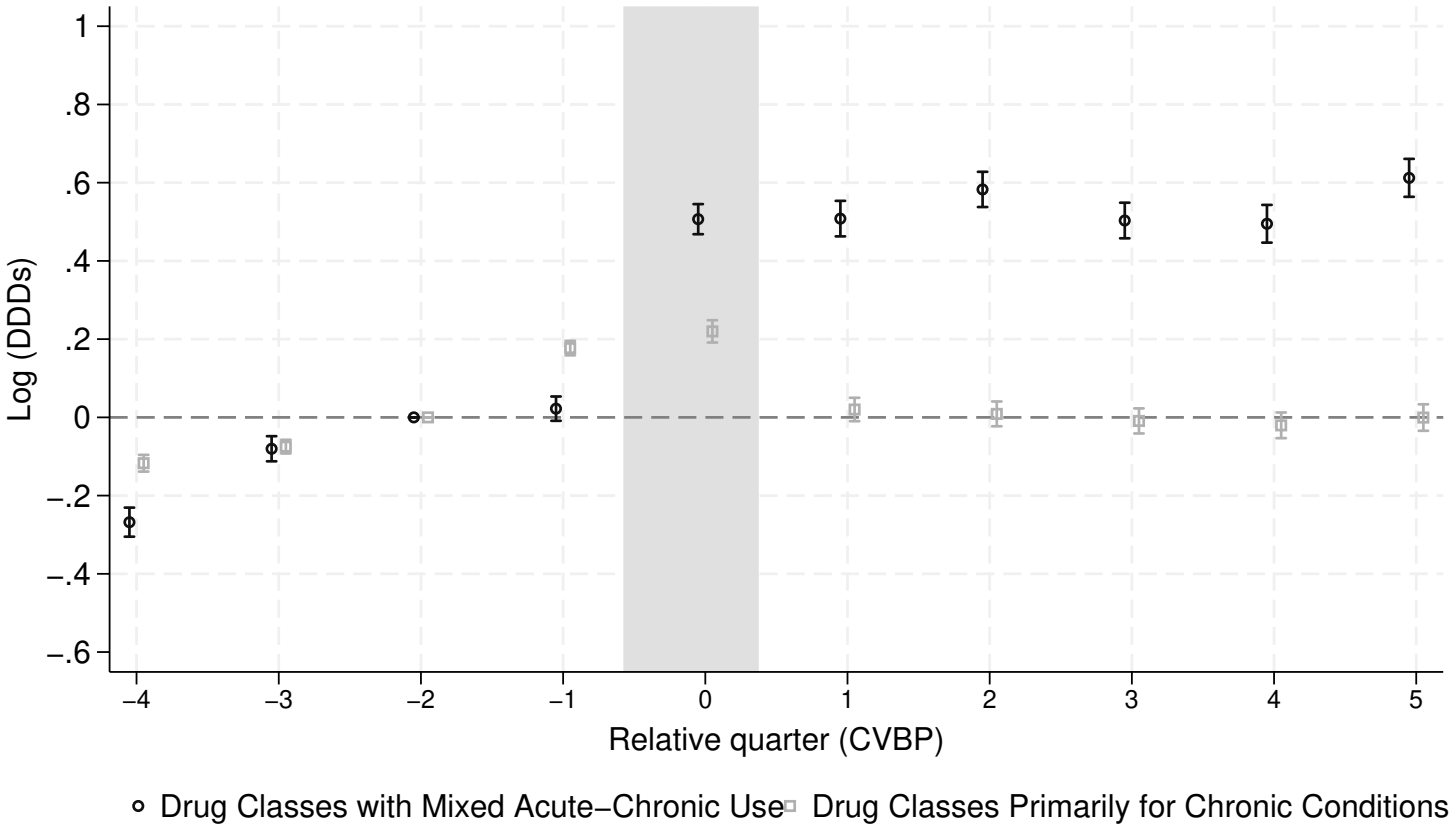



Figure 3: Event Study: Heterogeneous Effects on Drug Utilization by Branded-to-Generic Switch

▸ Summary Statistics ▸ Baseline Result

# Welfare: Effective Price Reduction

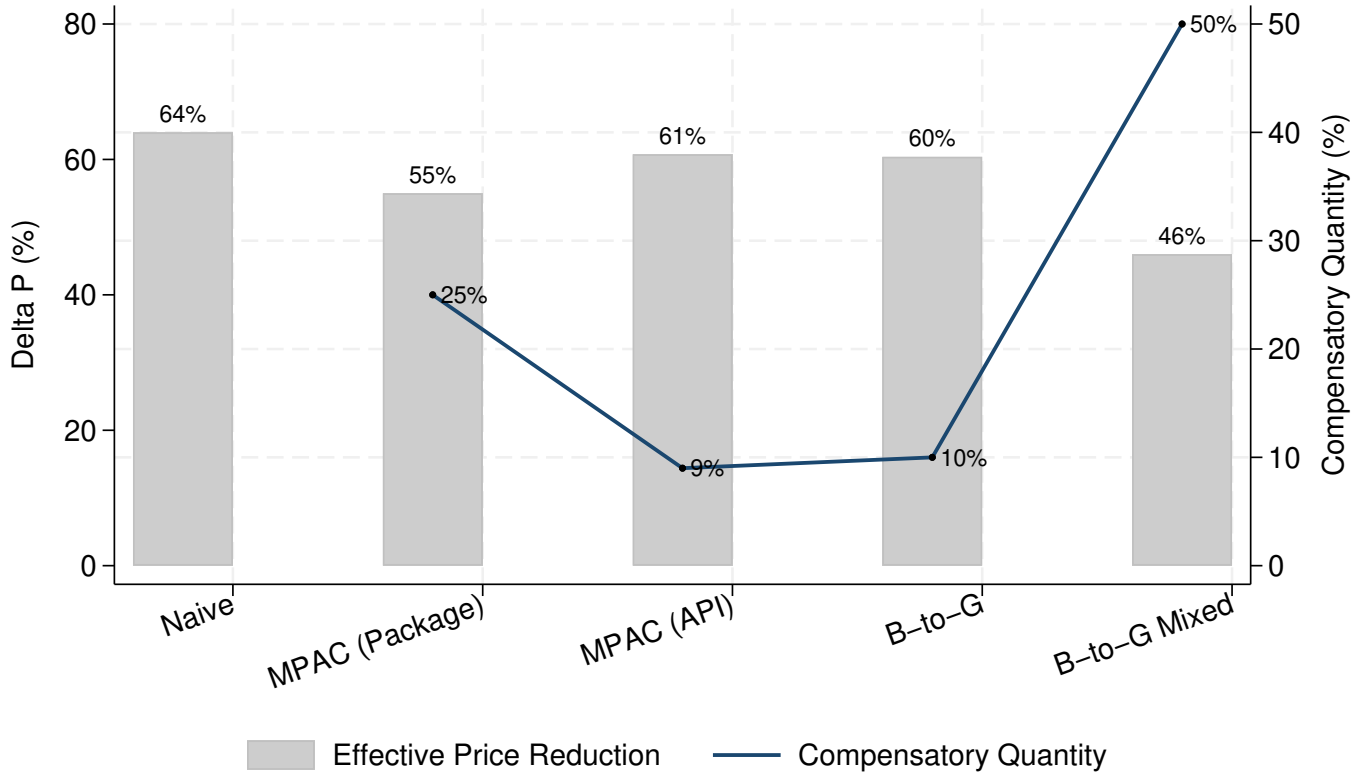



Figure 4: Effective Price Reduction Accounting for Compensatory Dosing

Notes: The $\Delta P$ is calculated by: $\Delta P = 1 - (1 - 64\%) * (1 + \Delta Q)$.

# Conclusion

- Centralized procurement achieves large price reductions, but **price-only contracts create post-award moral hazard**.
- Winning firms alter manufacturing processes after award, especially those with lower bids.
- Compensatory dosing partially offsets savings: effective price reduction is $46\%$–$61\%$, not $64\%$.

- **Policy implications:**
  - Evaluating procurement savings should account for utilization responses, not just unit prices.
  - Scoring auction can incorporate past post-award MPACs on packaging related materials.

- Thank you for your time and comments!
- Contact: Xuan Zhang, xuanzhang@smu.edu.sg

# Timeline of CVBP for Prescription Drugs

Table 3: Timeline of CVBP

| Round | No. of molecules | Competitive bidding time | Implementation time |
|---|---|---|---|
| 0 (4+7 pilot) | 25 | 2018.12 | 2019.3 |
| 1 (The rest of China) | 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.

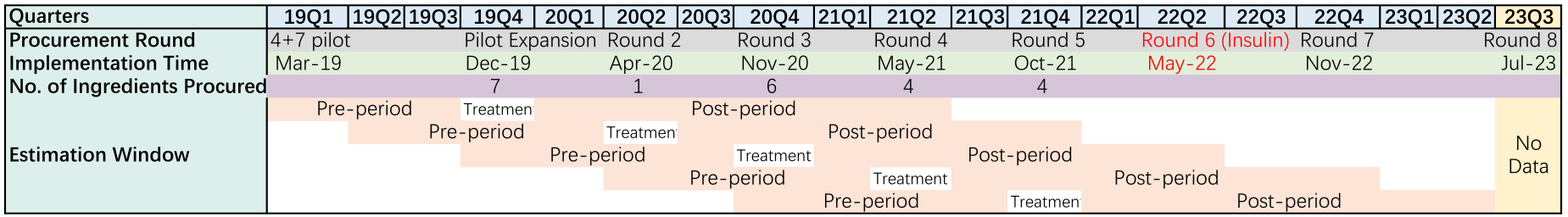


Figure 5: Data Structure for Analysis

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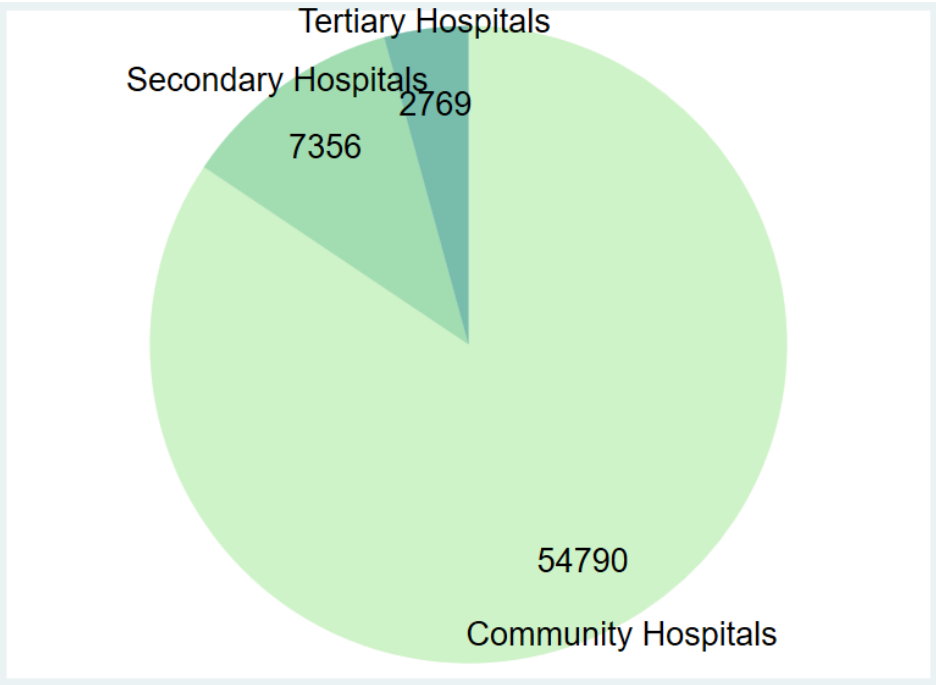
# Robustness Checks for Average Effects

- 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

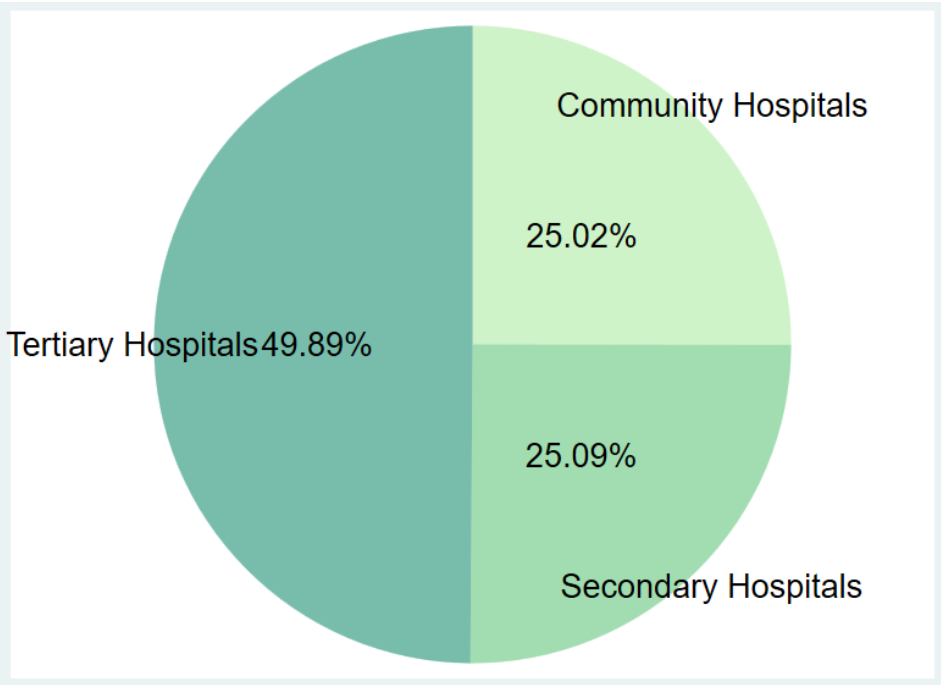



Figure 6: Summary of hospitals in our sample

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.

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

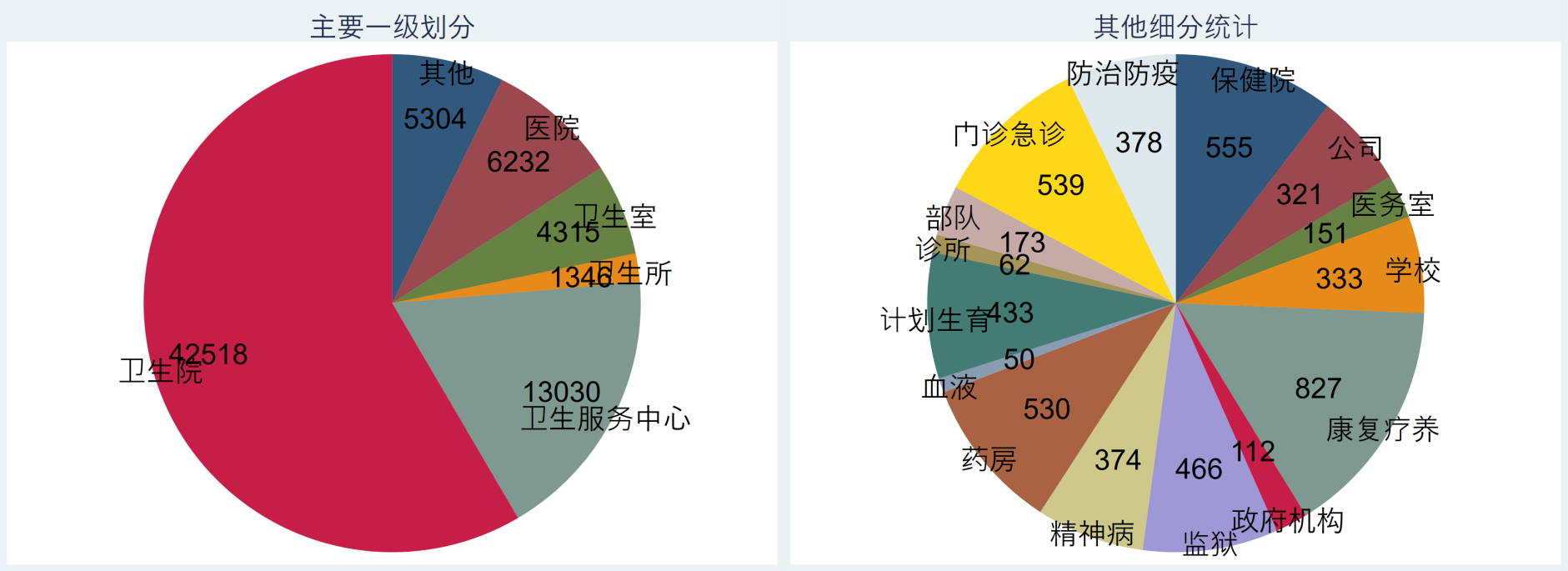


Figure 7: Summary of community hospitals in our sample

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

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# Summary Statistics

| | 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) |
| Community Hospitals | 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 |

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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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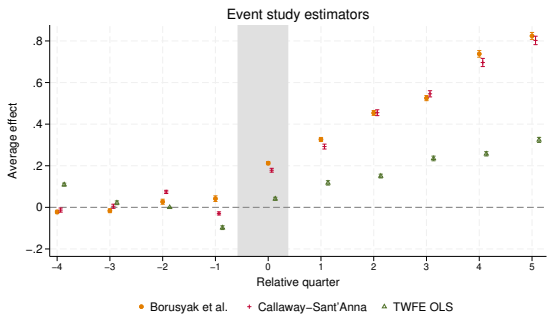
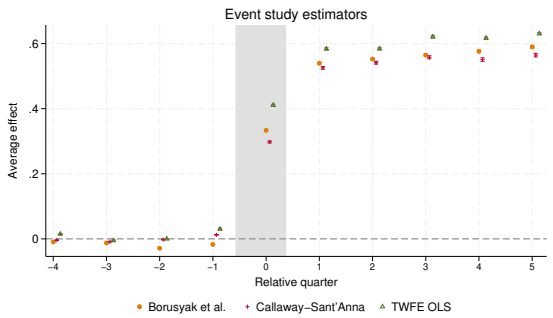
# Event Study without the Control Group

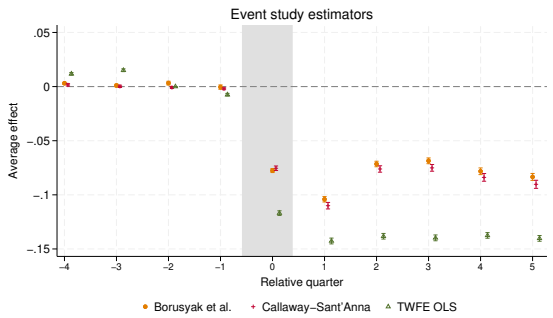
(a) Log (Total DDDs)




(b) Share of Winning




(c) Share of Banded

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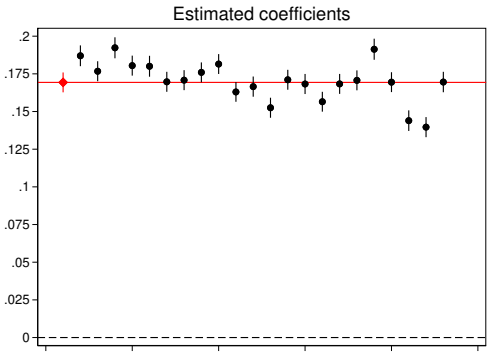
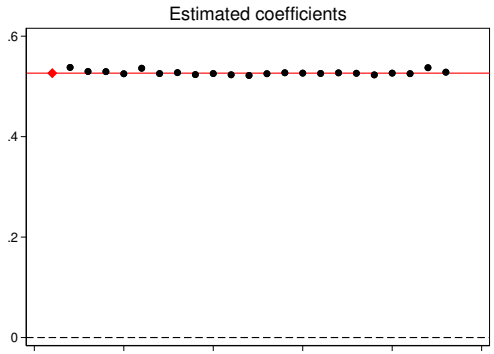
# Dropping One Particular Molecule

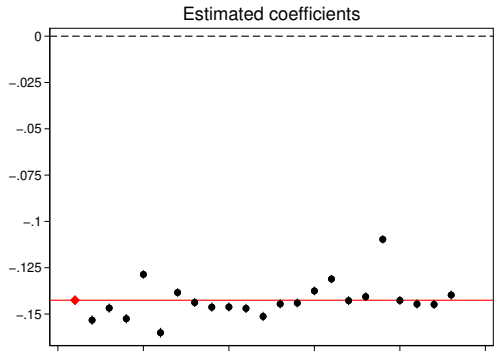
(a) Log (Total DDDs)




(b) Share of Winning




(c) Share of Banded

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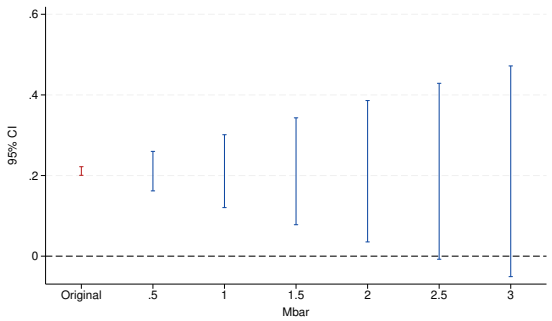
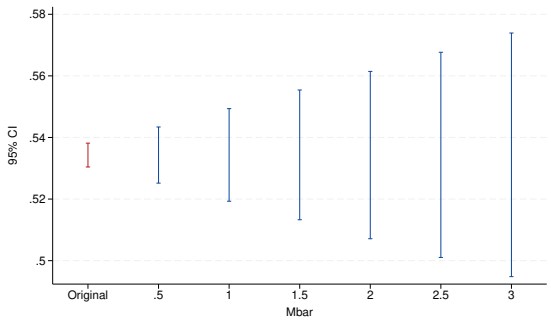
# Sensitivity Analysis

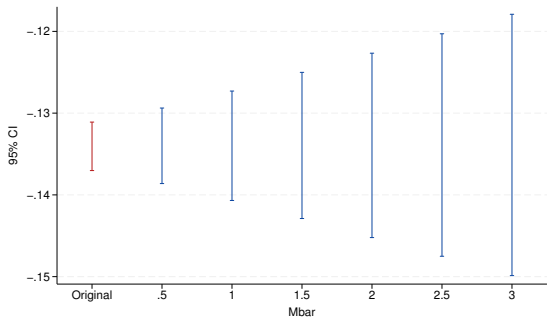
(a) Log (Total DDDs)




(b) Share of Winning




(c) Share of Banded

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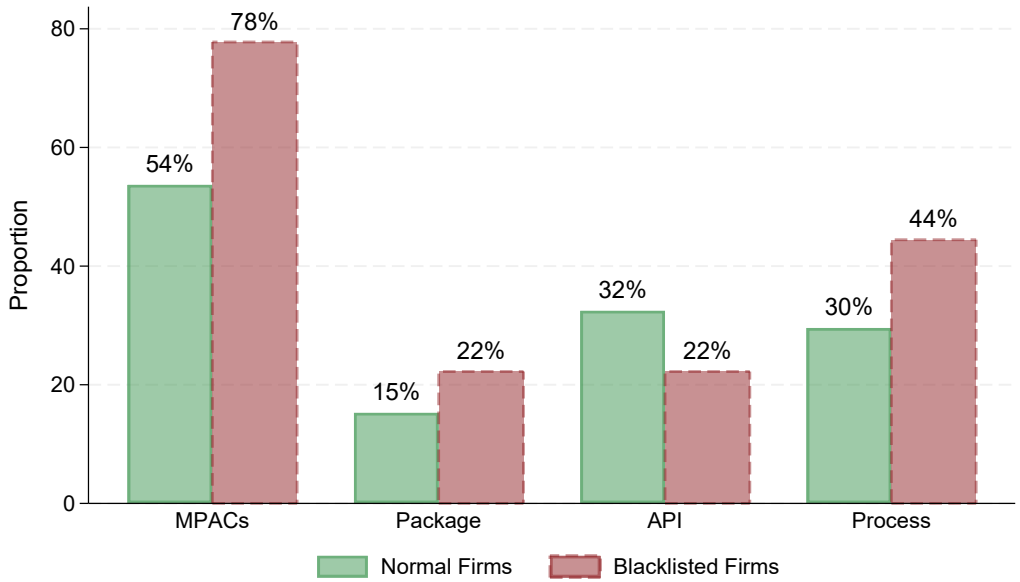
# Supplier MPACs and Regulatory Violation

- Through the first 10 CVBP rounds, **9** winning firms were placed on the governmental regulatory violation list (blacklist) due to quality issues for a specific molecule
  - Quality deterioration:
    - ★ Severe (adverse effects) → blacklist; Mild → reduced potency
  - MPAC among blacklisted (red, <0.5%) vs. non-blacklisted (green) winning firm-molecule pairs.

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# Baseline Effects: CVBP on Drug Utilization

- CVBP increases the total utilization of drugs, shifts the market towards winning generics.

$$y_{idt} = \beta_0 + \sum_{k=-4, k\neq -2}^{k=5} \beta_k D_{dt}^k + \alpha_{id} + \mu_t + \epsilon_{idt},$$

- $y_{idt}$: quantity (number of Defined Daily Doses [DDDs]), share of winning drugs, and share of branded drugs of molecule $d$ in hospital $i$ in relative quarter $t$;
- $\alpha_{id}$ : Hospital-molecule FE, $\mu_t$ : Quarter FE; Clustered at hospital level;
- Robust estimates: Callaway-Sant'Anna (2021); Sun-Abraham (2021); Borusyak et al.(2024).

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# Baseline Effects: CVBP on Drug Utilization

Table 4: Average Effects of CVBP on Drug Utilization

| | (1) Log (DDDs) | (2) Share of Winning | (3) Share of Branded Drugs |
|---|---|---|---|
| Procured | 0.214*** | 0.601*** | -0.157*** |
| | (0.004) | (0.002) | (0.001) |
| Hospital × Molecule FE | ✓ | ✓ | ✓ |
| Quarter FE | ✓ | ✓ | ✓ |
| Mean of Y (Before CVBP) | 9037.47 | 0.10 | 0.24 |
| Percentage Change | 23.82 | | |
| # of observations | 1923491 | 1923491 | 1923491 |
| $R^2$ | 0.81 | 0.80 | 0.86 |

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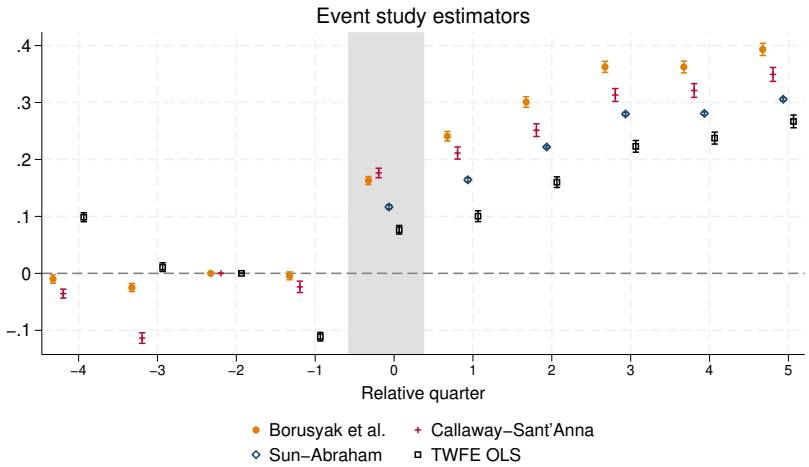
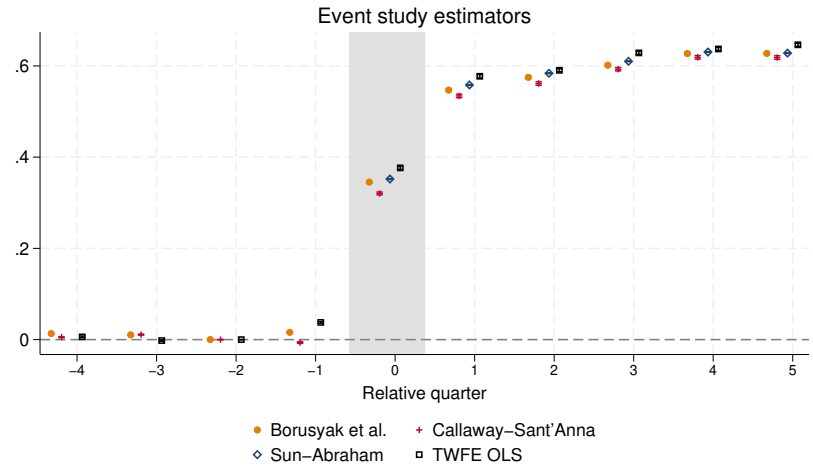
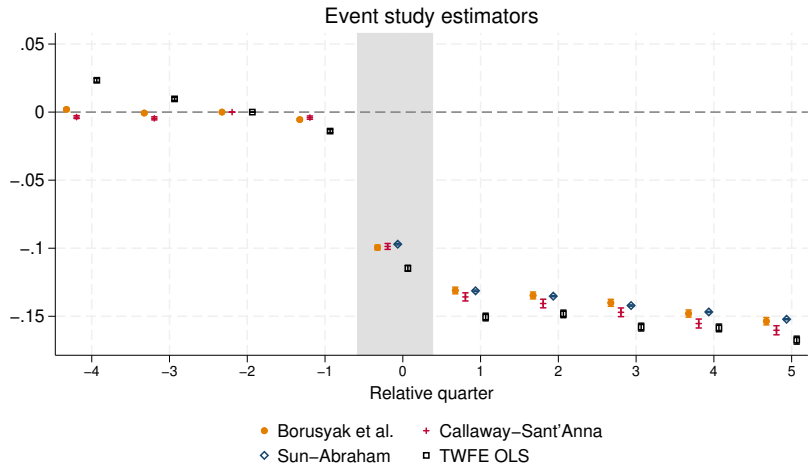
## (a) Log (DDDs)




## (b) Share of Winning Drugs




## (c) Share of Banded Drugs

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## Table 5: 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 |

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# Continued

| | (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 |

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# Heterogeneous Effects of MPACs on Drug Utilization

## Table 6: Heterogeneous Effects of MPACs on Drug Utilization

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| | 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 CVBP) | 9297.87 | 10717.99 | 6735.52 | 10451.46 | 6735.52 | 10451.46 |
| # of observations | 1020777 | 743032 | 936375 | 1709447 | 936375 | 1709447 |
| $R^2$ | 0.81 | 0.81 | 0.83 | 0.81 | 0.83 | 0.81 |

# 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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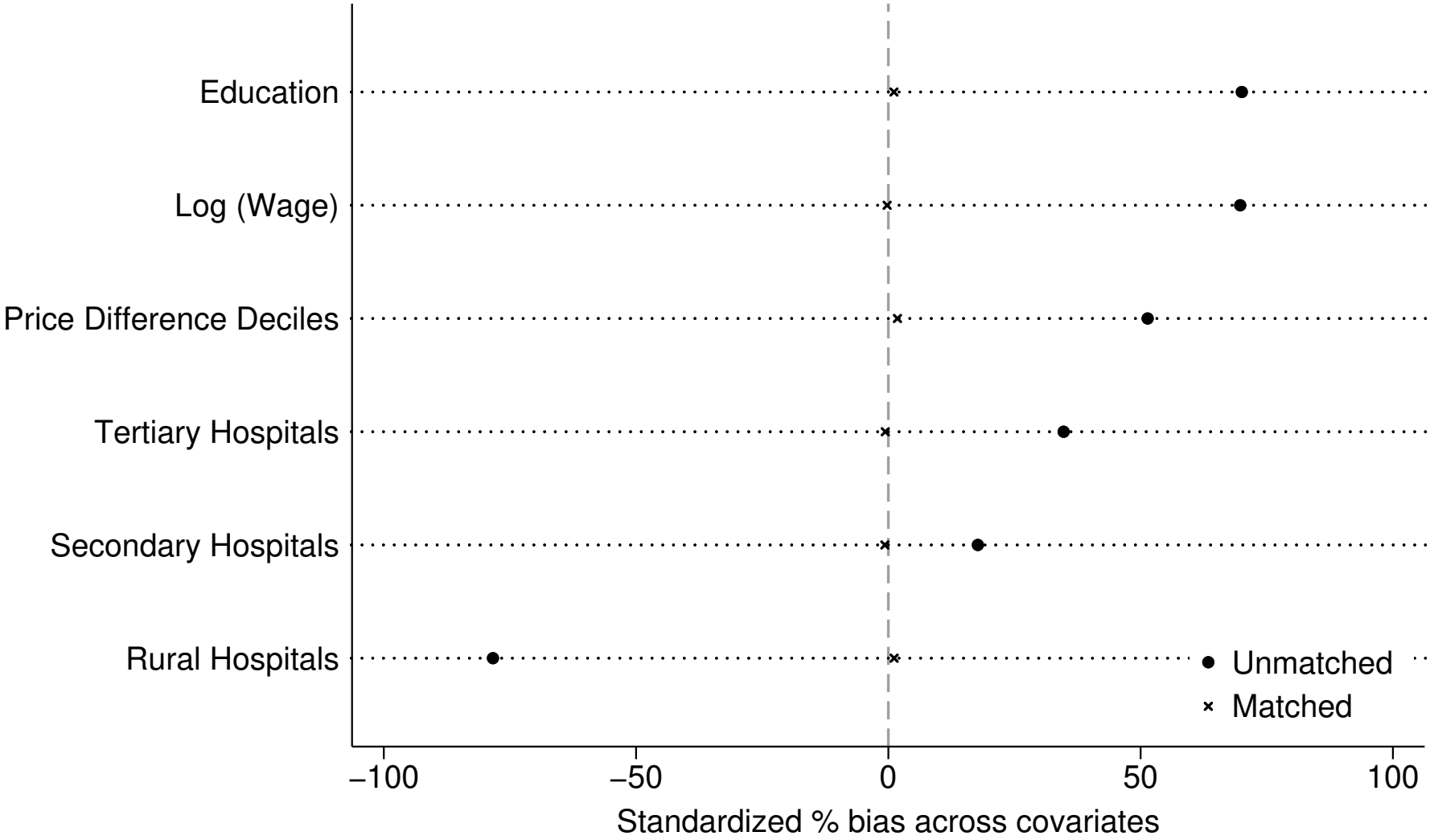


Figure 12: Balance Check before and after Propensity Score Matching

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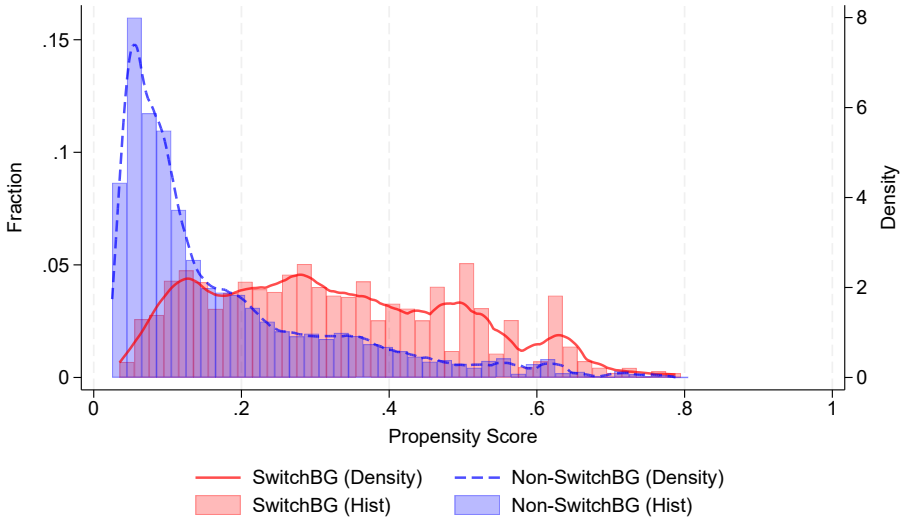
(a) Before Propensity Score Matching




(b) After Propensity Score Matching

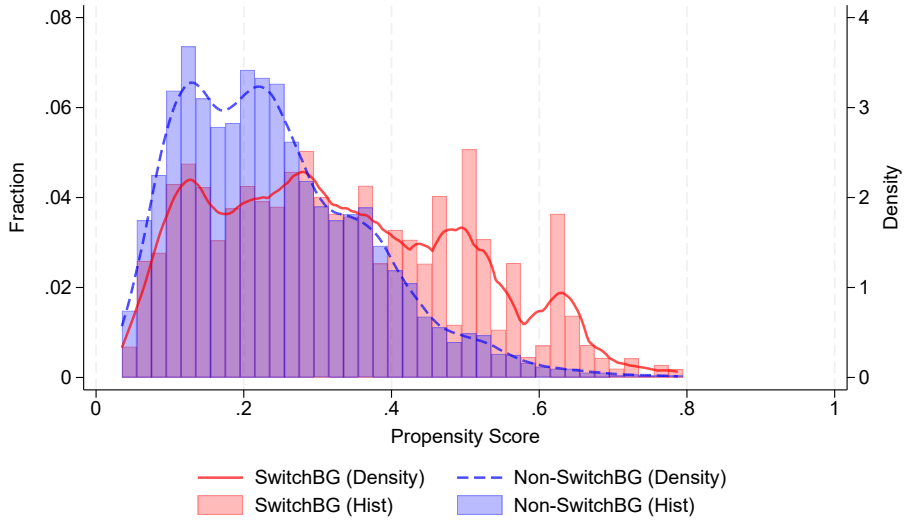



Figure 13: Propensity Score Distribution before and after Matching

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

Table 7: Effects of Branded-to-Generic Switch on Drug Utilization

| | 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 |

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# Table 8: 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) |
| winMPACs | 0.175 | | 0.002 | | -0.001 | | 0.010 | |
| | (0.160) | | (0.019) | | (0.019) | | (0.006) | |
| winMPACs (Package) | | 0.087 | | -0.041 | | 0.016 | | 0.008 |
| | | (0.243) | | (0.040) | | (0.037) | | (0.009) |
| winMPACs (API) | | -0.012 | | 0.031 | | 0.001 | | 0.013* |
| | | (0.158) | | (0.019) | | (0.019) | | (0.007) |
| winMPACs (Process) | | 0.193* | | 0.020 | | 0.003 | | 0.001 |
| | | (0.104) | | (0.019) | | (0.017) | | (0.006) |
| Firm FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Year FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Firm Controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Mean of Y (Before MPAC) | 21.62 | | 0.23 | | 0.05 | | 0.04 | |
| # of observations | 191 | 191 | 191 | 191 | 191 | 191 | 191 | 191 |
| $R^2$ | 0.87 | 0.87 | 0.79 | 0.79 | 0.75 | 0.75 | 0.84 | 0.85 |

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## Table 9: 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 10: 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 11: 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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