A Double Dose of Reform: Insurance and Centralized Negotiation in Drug Markets

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Motivation

- A global challenge: how to make innovative drugs affordable to patients?
- Verzenio (abemaciclib) costs \$180k per year in the U.S. and ¥66,000 (\$9,430) in China

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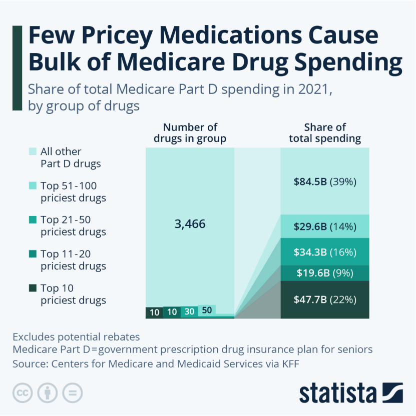

Cancer drugs price rise 'costing NHS millions' BBC

Motivation

- A global challenge: how to make innovative drugs affordable to patients?
- Insurance improves affordability, but high drug prices strain government budgets
- Various other remedies:
  - Administrative prices (hard to get right)
  - Auctions (competition not guaranteed)
  - Negotiation

Press Releases Jan 17, 2025

HHS Announces 15 Additional Drugs Selected for Medicare Drug Price Negotiations in Continued Effort to Lower Prescription Drug Costs for Seniors

Inflation Reduction Act

EUROPARL.EUROPA.EU

Parliament adopts its position on EU pharmaceutical reform | News | European Parliament

Research Question and Contributions

This paper studies China's ongoing National Reimbursement Drug List (NRDL) Reform

- Universal insurance $\rightarrow$ affecting 1.4 billion people
- Centralized negotiation over universal health insurance formulary
- Staggered roll-out across drugs $\rightarrow$ direct evidence on the role of negotiation
- 25% of negotiations fail $\rightarrow$ insight into government's objectives
- Regressive provincial coinsurance rates $\rightarrow$ additional variation

Research Question and Contributions

1. How does the NRDL Reform affect drug prices, quantities, welfare, and survival?
   - Large effects, high-stakes setting
   - Decompose contributions of negotiation and insurance expansion
2. New evidence on policy design:
   - Negotiation for formulary placement vs. market access
   - Centralized (China) vs. decentralized negotiation (US, EU, etc.)
   - Optimal income-based coinsurance schedule: level and progressivity

Policy determines tradeoffs: extensive vs. intensive margin, winners and losers by geography, equity vs. efficiency

Institutional Background

Policy Background

- China has a universal healthcare system covering 1.4 billion people
  - $> 95\%$ enrollment, low premium (\$50), little commercial insurance ($< 7\%$)
- Prior to 2016, the NRDL (formulary) did not cover innovative drugs

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Policy Background

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- Prior to 2016, the NRDL (formulary) did not cover innovative drugs
- Public backlash leads to reform: NRDL covers innovative drugs at a negotiated price

Round	2016	2017	2018	2019	2020	2021	2022	All
#Negotiated Products	5	44	18	150	162	117	147	643
#Successful Negotiations	3	36	17	97	119	94	121	487

Data source: NHSA website. Overall success rate: 75.7%.

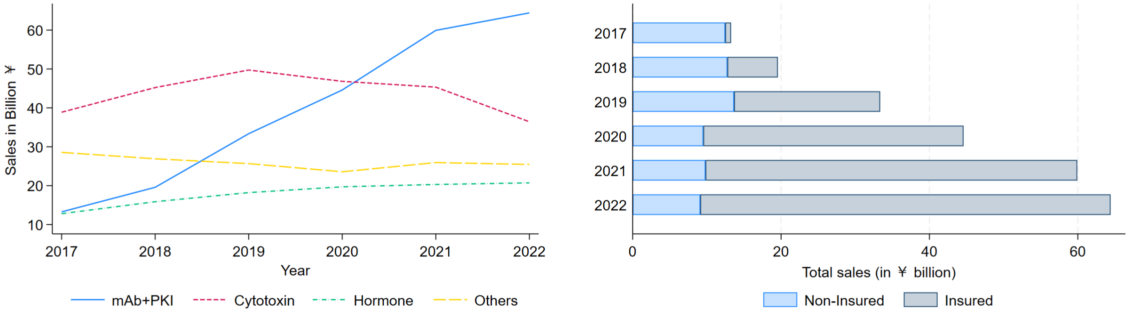
Bargaining process

Cancer Drugs

- Main dataset: comprehensive drug sales data from SinoHealth
    - 2017Q1-2023Q2
    - Sales, quantity (yearly doses), prices (*brand-province-quarter level*)
- Today's presentation focuses on the cancer drug market
    - Huge market (0.1% of GDP; $> 60\%$ of sales among all successfully negotiated drugs)
    - Millions of lives at stake in China alone: 23% of global incidence and 30% of mortality
- NRDL Reform outcomes:
    - 89 negotiations with 70 cancer drugs through 2022; 57 were successful

Expansion of Innovative Cancer Drug Market

- Innovative cancer drugs include monoclonal antibodies (mAbs) and protein kinase inhibitors (PKIs)
- Rapid growth in insurance coverage and sales

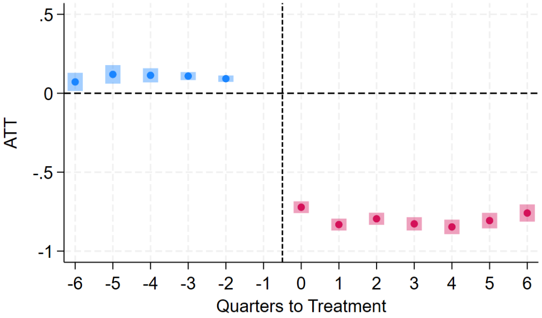


(a) Cancer Drug Market Sales

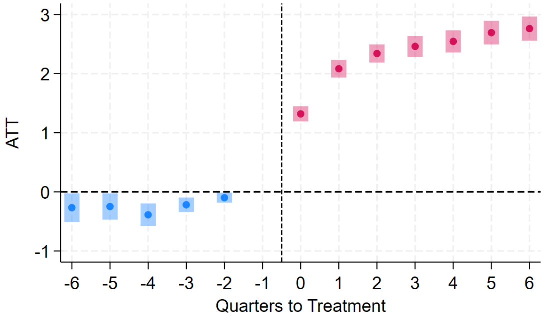
(b) Innovative Drugs (mAb+ PKI)

Average Treatment Effects for Cancer Drugs Raw Data: Q Raw Data: P Rival

- Successfully negotiated vs. not-yet-negotiated/failed (Callaway and Sant'Anna, 2021)
- Retail price ↓ 57%, out-of-pocket price ↓ 86%, quantity ↑ 930%



(a) Log(Retail Price)



(b) Log(Quantity)

Model

Step 1:

Ineligible firms set prices $(\mathbf{p}^{BN})$ given $(\alpha, \delta, \xi, \mathbf{mc})$

Eligible firms negot. with gov't $(\mathbf{p}, \mathcal{G})$ given $(\alpha, \delta, \xi, \mathbf{mc}, \boldsymbol{\tau}, \boldsymbol{\beta})$

$\longrightarrow$

Step 2:

Patients choose treatments given $(\alpha, \delta, \xi, \mathbf{p}^{BN}, \mathbf{p}, \mathcal{G})$

Supply Overview

- Model primitives $\rightarrow$ negotiation outcomes (success/failure, and price)
- Bertrand-Nash pricing pre-reform and for ineligible drugs
  - Use pre-inclusion prices to infer mc_{jm}
- Nash-in-Nash bargaining over retail price p_j between the central government and eligible innovative drug producers
  - If the negotiation succeeds, the drug is sold at negotiated retail price p_j with insurance ($j \in \mathcal{G}$)
  - If the negotiation fails, the drug is sold at Bertrand-Nash price p_j^{BN} (atypical!)

Firm Objective*

- Firm j's profit under a successful negotiation at retail price p_j and formulary $\mathcal{G}$:

$$\pi_j(p_j; \mathbf{p}_{-j}, \mathcal{G}) = \sum_m (p_j - mc_{jm})\, q_{jm}\,(p_j; \mathbf{p}_{-j}, \mathcal{G})$$

- Firm j's profit under a failed negotiation or not participating in the program:

$$\pi_j^{dev}(\mathbf{p}_j^{BN}; \mathbf{p}_{-j}, \mathcal{G}) \quad = \quad \max_{\tilde{\mathbf{p}}_j} \sum_m (\tilde{p}_{jm} - mc_{jm})\, q_{jm}(\tilde{p}_{jm}; \mathbf{p}_{-j}, \mathcal{G}/\{j\})$$

- Define firm j's gains from trade at price p_j:

$$\Delta\pi_j(p_j; \mathbf{p_{-j}}, \mathcal{G}) \equiv \pi_j(p_j; \mathbf{p}_{-j}, \mathcal{G}) - \pi_j^{dev}(\mathbf{p}_j^{BN}; \mathbf{p}_{-j}, \mathcal{G})$$

*We assume single-product firms for notational simplicity.

Government Objective

- Government objective function includes consumer surplus and insurance expenditure:

$$V(\mathbf{p}, \mathcal{G}) = CS(\mathbf{p}, \mathcal{G}) - \beta TC(\mathbf{p}, \mathcal{G})$$

- β is the shadow cost of government expenditures
- The government gains from trade of covering drug j at price p_j:

$$\Delta V_j(p_j; \mathbf{p_{-j}}, \mathcal{G}) = \Delta CS(p_j; \mathbf{p_{-j}}, \mathcal{G}) - \beta \Delta TC(p_j; \mathbf{p_{-j}}, \mathcal{G})$$

Admissible Sets and Negotiation Outcomes

- Novel element: model must account for 25% negotiation **failure**
- Negotiation for drug j is **successful** if:
  - $\exists$ *admissible* prices such that gains from trade are positive for both sides (note: no lump sum transfers)

$$\mathcal{P}_j \equiv \{p_j : \Delta V_j\left(p_j; \mathbf{p_{-j}}, \mathcal{G}\right) \geq 0 \text{ and } \Delta \pi_j\left(p_j; \mathbf{p_{-j}}, \mathcal{G}\right) \geq 0\}$$

- Negotiation **fails** if this admissible set is empty:

$$\mathcal{P} = \emptyset$$

Nash-in-Nash FOC

- If a negotiation succeeds, the price is determined by the bargaining FOC

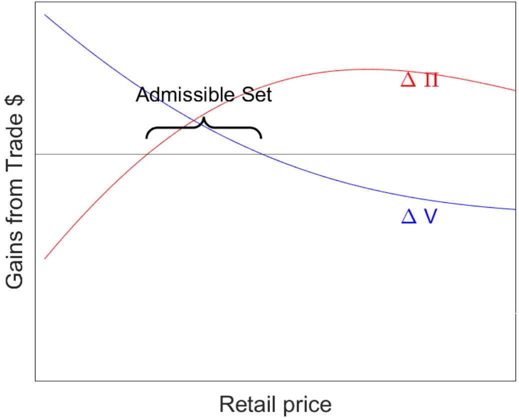
$$p_j = \arg\max_{p_j} \left(\Delta\pi_j\left(p_j; \mathbf{p_{-j}}, \mathcal{G}\right)\right)^{\tau_j} \left(\Delta V\left(p_j; \mathbf{p_{-j}}, \mathcal{G}\right)\right)^{1-\tau_j}, \forall j \in \mathcal{G}$$

- The markup equation is then:

$$\sum_m \underbrace{(p_j - mc_{jm})}_{\text{retail margin}} \frac{\partial q_{jm}}{\partial OOP_{jm}} = -\sum_m \underbrace{\frac{q_{jm}}{\text{Coins}_m}}_{\text{expansion effect}} + \left(\underbrace{\frac{1-\tau_j}{\tau_j} \times \frac{\Delta\pi_j}{\Delta V_j} \frac{d\Delta V_j}{dp_j} \frac{1}{\text{Coins}_m}}_{\text{bargaining effect}}\right), \forall j \in \mathcal{G}$$

Identification Intuition Estimation

- β denotes (random) shadow cost of gov't spending in $V = CS - \beta TC$
- τ_j denotes the firm's relative bargaining power in the negotiation over j
- Estimate via MLE, using all (successful and failed) negotiations



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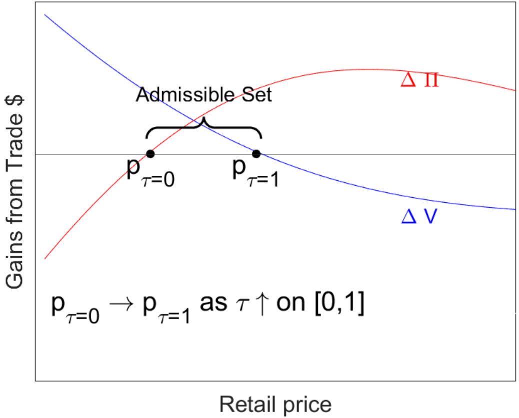

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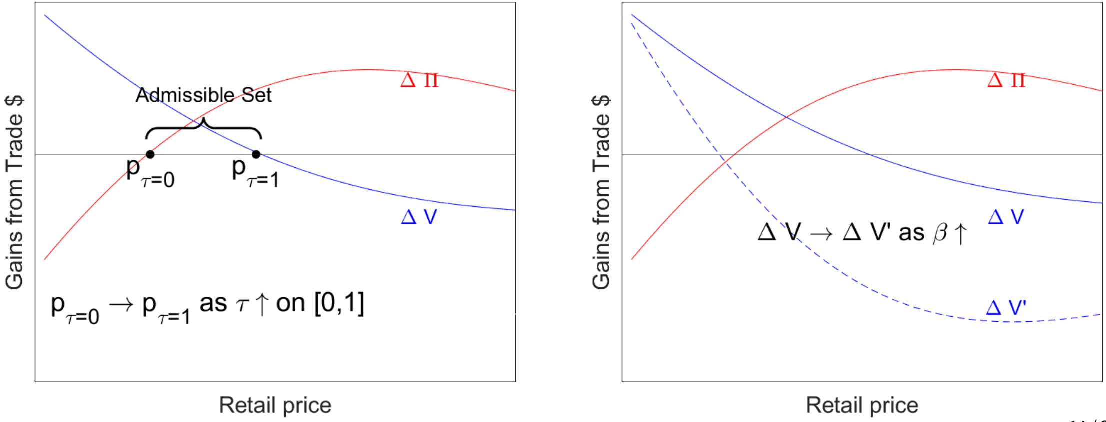


Estimation Results

- Inter-quartile of demand elasticity: [-1.76, -1.31]
  - Consistent with Dubois et al 2022 and robust across IVs and nesting structure
- The government budget constraint β:
  - Mean $\beta = 0.88$, median $\beta = 1.09$;
  - Relaxes for more effective drugs: 1 s.d (6 months) $\uparrow OS \Rightarrow \beta \downarrow .17$
- Firm bargaining power $\tau = 0.66$; domestic firms modestly higher bargaining power

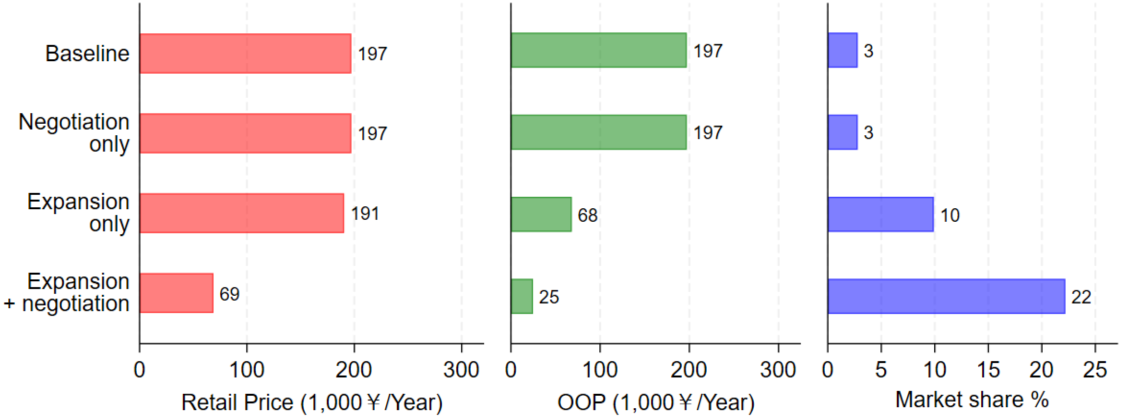
Welfare Decomposition of Insurance and Negotiation

Simulation Design

- We focus on the 2023Q2 market and the 57 brands that were covered via the NRDL reform
- All simulated outcomes are relative to the **baseline scenario** where the program does not exist
- Revisit all drugs (including 13 failed drugs) when analyzing policy designs

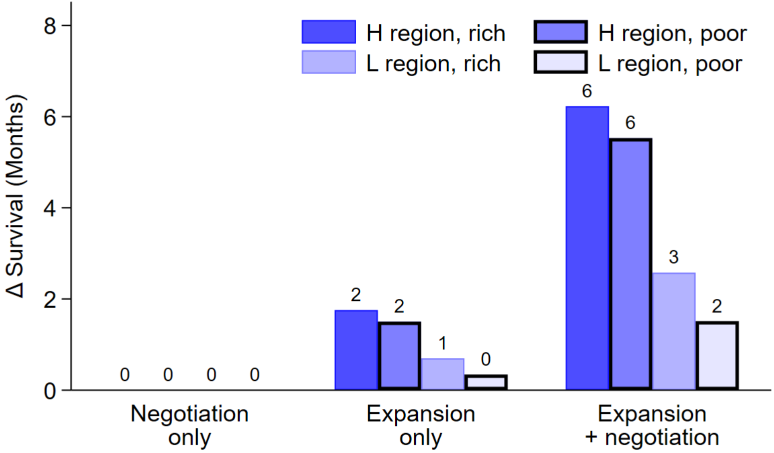
Decomposition: Prices and Quantities

- Expansion + negotiation achieves the highest price reduction and quantity expansion



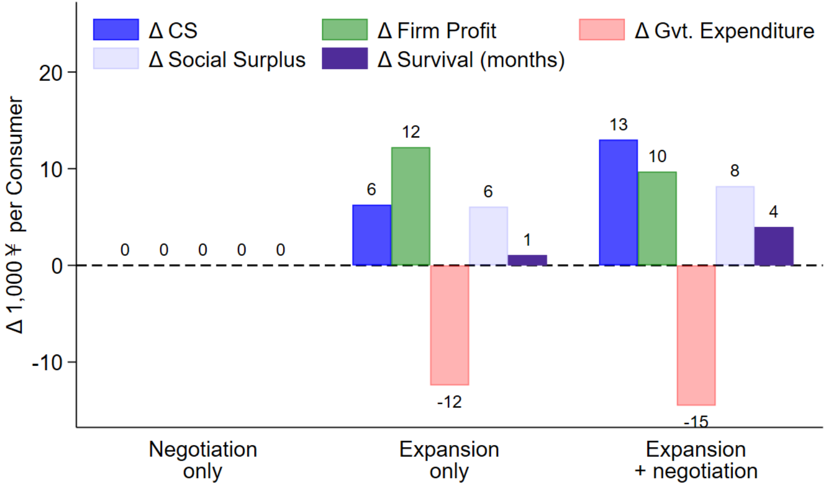
Decomposition: Survival

- OS from innovative drugs ↑ 846% under NRDL relative to the Baseline
- Rich patient and wealthy regions benefit more



Decomposition: Welfare

- Annual CS ↑ ¥37 billion, SS ↑ ¥25 billion under NRDL



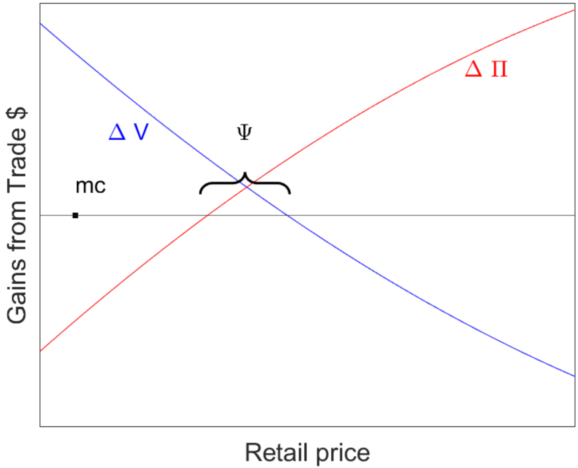
Policy Simulations

Counterfactuals

1. **Market-access negotiation** Assume the government negotiates drug prices with firms for market access (with or without insurance coverage)
   - Threat point is exclusion from the Chinese market
2. **Decentralized negotiation** Let each provincial government negotiate drug prices
   - For the sake of comparison, set uniform coinsurance across provinces (nat'l avg. $= 0.37$)
3. **Income-based coinsurance** Consider a range of coinsurance schedules based on individual income, rather than province

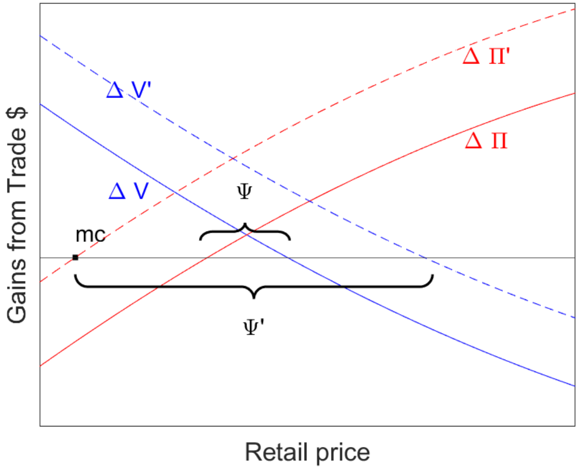
Market Access Bargaining + Insurance: Intuition

- $\Delta\Pi$ and ΔV under NRDL



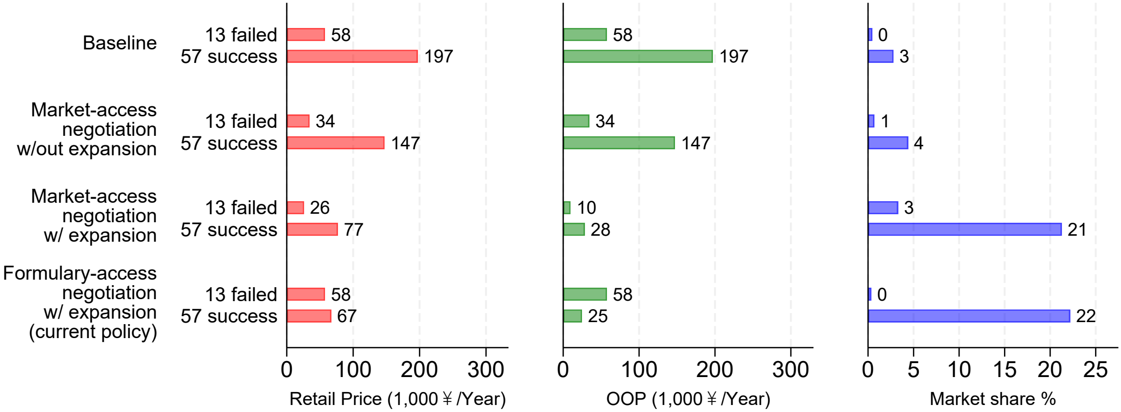
Market Access Bargaining + Insurance: Intuition

- Intuition: $\Delta\Pi' > \Delta\Pi$ and $\Delta V' > \Delta V \Rightarrow$ new admissible set $\Psi' \supset \Psi$
- More coverage than NRDL, but ambiguous effect on negotiated price



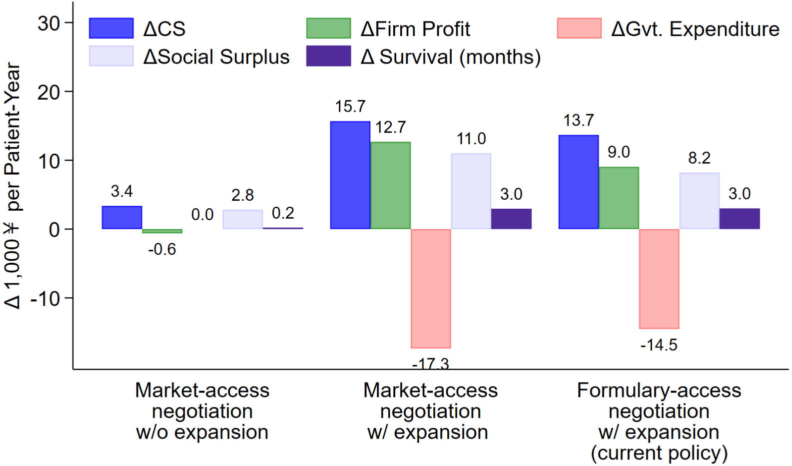
Effects of Market-access Bargaining + Insurance

- We report the effect of each policy on 57 drugs that were successful under the current policy, and 13 drugs that failed



Effects of Market Access Bargaining + Insurance

- **Tradeoff:** Combining market access with insurance expansion increases coverage breadth (extensive margin), but slightly decreases coverage depth (intensive margin)



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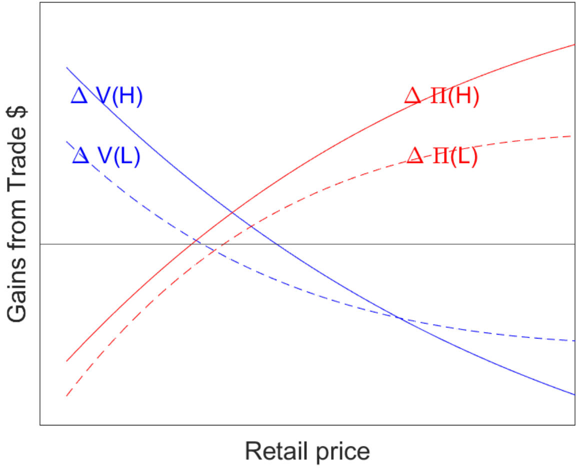
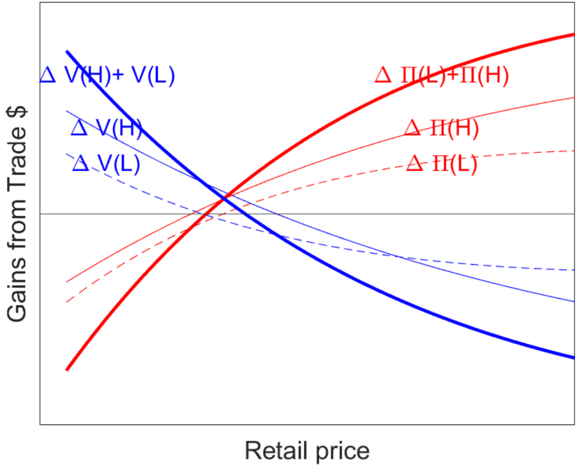
Decentralized Bargaining: Intuition

- Lower GFT for low-income regions → more failures



Decentralized Bargaining: Intuition

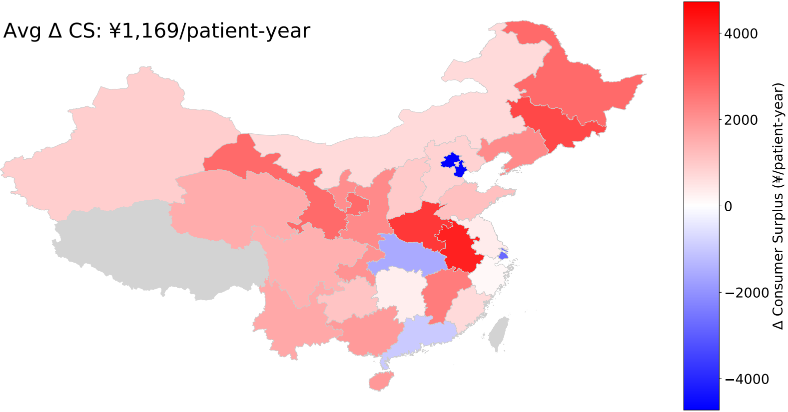
- Higher GFT under central negotiations → more successes



Effects of Centralization

- Extensive margin: 13.8 (19%) more bargains would succeed $\rightarrow$ more coverage
- Intensive margin: For successful negotiations, the average price cut is larger (25%)

$\Rightarrow$ **Tradeoff:** Centralization creates winners and losers, but the majority of regions benefit



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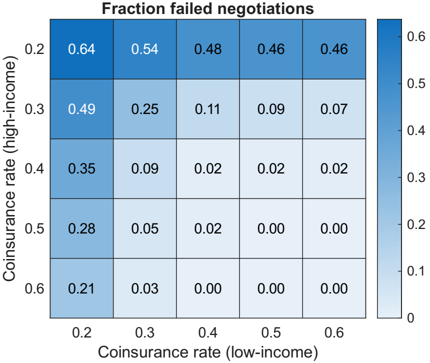
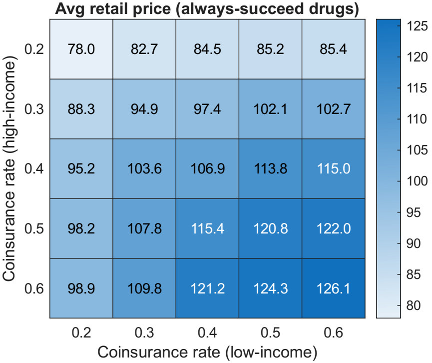
Optimal Income-Based Coinsurance Rate Design

- The effect of coinsurance is nuanced
- **Level** Pros and cons of low coinsurance rates:
  - $\downarrow$ consumer spending $\rightarrow$ increase consumer surplus and demand
  - $\uparrow$ government expenditure
  - $\uparrow$ firm's gains from trade $\rightarrow$ $\uparrow$ gvt. bargaining leverage $\rightarrow$ deeper price cuts
  - $\uparrow$ bargaining failures
- **Income heterogeneity** progressive vs. regressive
- We focus on a two-group income-based coinsurance system $(Coins_H, Coins_L)$

Effects of Coinsurance: Extensive and Intensive Margins

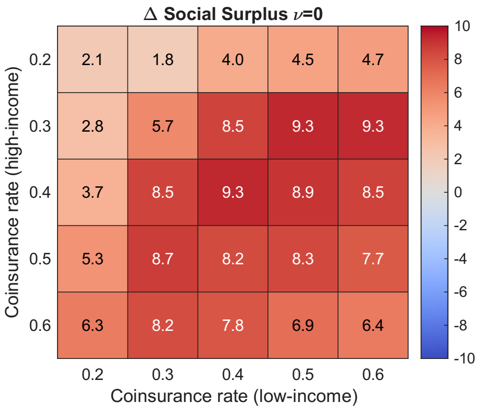
- More generous coinsurance: more bargaining failures but lower prices





Effects of Coinsurance Rate: Welfare

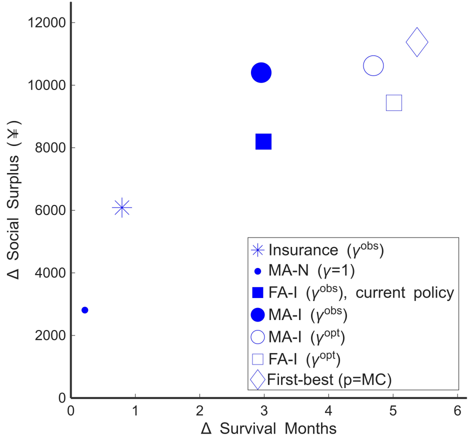
- Moderate level of regressivity (H:0.32, L:0.46) is optimal for social surplus



Summary of Policy Simulations

- Market-access (MA) negotiation with insurance expansion (at optimal coinsurance rate) balances efficiency, access, and equity

$\Rightarrow$ 29% gain in SS over observed NRDL, 93% of SS of $OOP = MC$



Conclusion

- We document the effects of an important and large-scale policy reform
  - Insurance expansion + negotiation expand access to innovative drugs and improve welfare
  - CS gains of ¥37 billion per year and OS gains of 1.1 million life-years

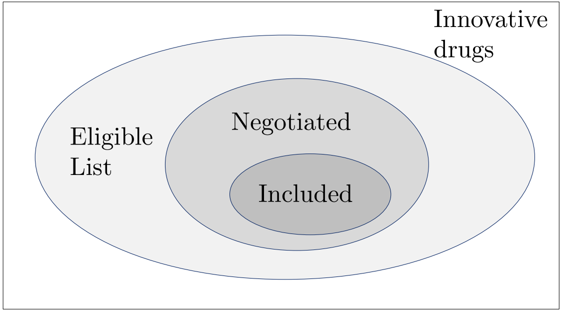
- We provide new empirical evidence on how policy shapes gains from trade
  - Harsher threat point increases drug coverage, but can have ambiguous effects on prices of inframarginal, higher-quality drugs
  - Centralized negotiation helps most provinces, at some cost to the richest provinces
  - Income-based coinsurance schedules can use high-income patients for leverage, but may raise concerns about equity

- Policy recommendation: MA + I

  Robust, efficient, and more equitable ($>$ FA, FA+I, MA+I)

Thank you!

The Negotiation Back



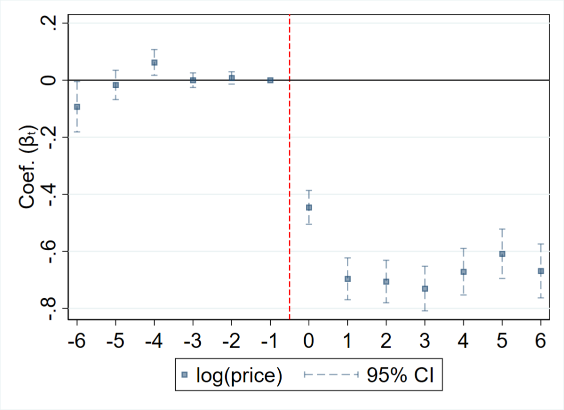
- Extensive pre-negotiation information exchange
- The government emphasizes patient benefits and its expenditure
- Each drug is negotiated independently $\Rightarrow$ a true Nash-in-Nash setting!

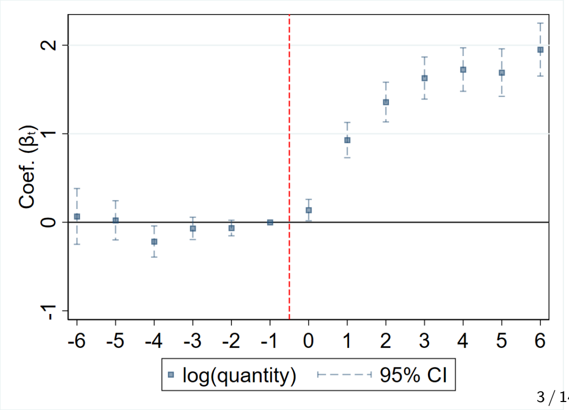
TWFE Event Study Back

- Price/quantity of brand j in province m in quarter t:

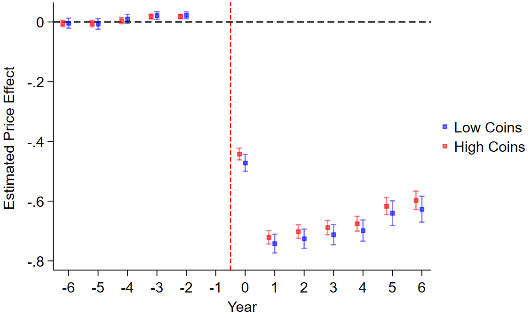
$$y_{jmt} = \sum_{\tau \neq -1} \beta_\tau 1\{\text{Insured}_j\} \times 1\{t - t_j = \tau\} + \eta_{jm} + \eta_{mt} + \epsilon_{jmt}$$

- (Retail) price decreases by 50%, quantity increases by 400%.

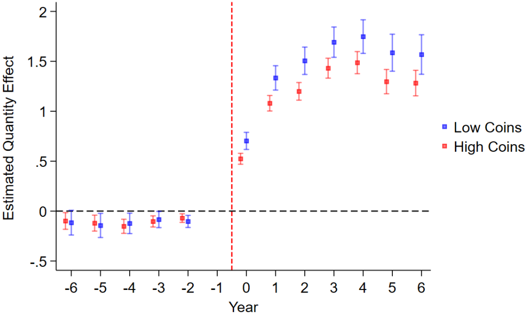




Average Treatment Effects for High vs. Low Coinsurance Back

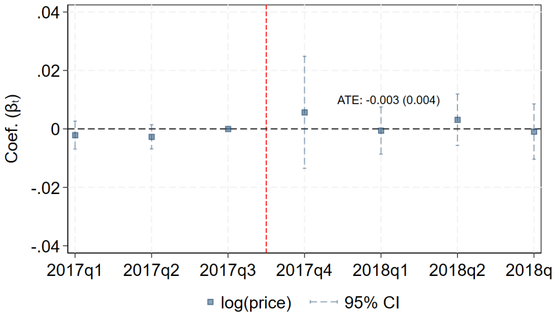


(a) Log(Retail Price)

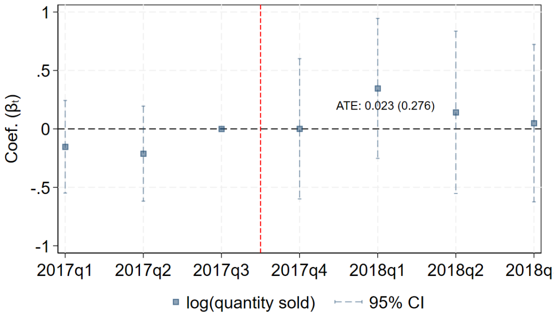


(b) Log(Quantity)

Spillover Effects of the Negotiation on Competing Drugs Back

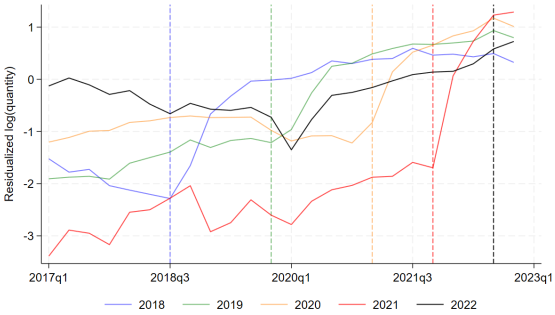


(a) log(Retail Price)

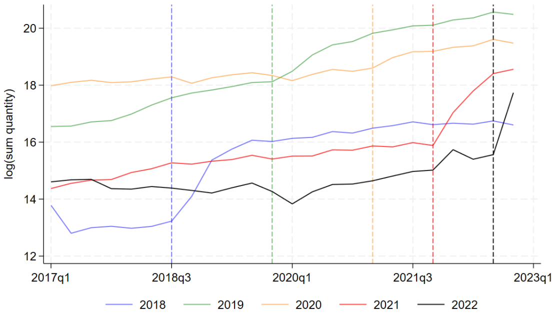


(b) log(Quantity)

Raw Data: Quantities Back



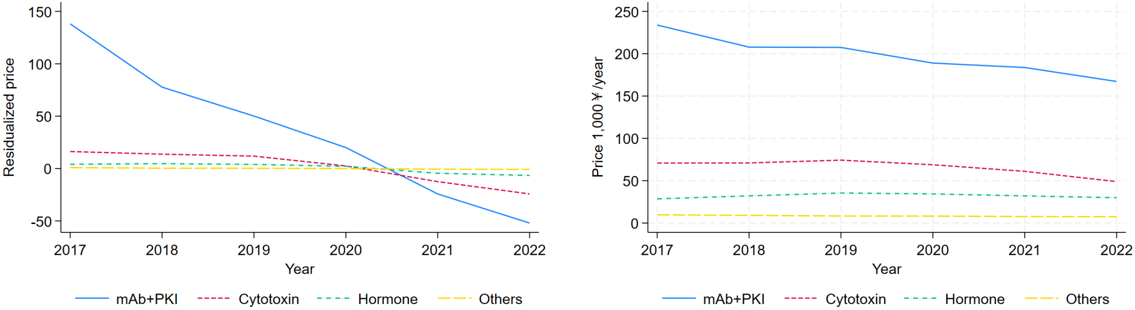
(a) Residualized Log(Quantity)



(b) Raw Log(Quantity)

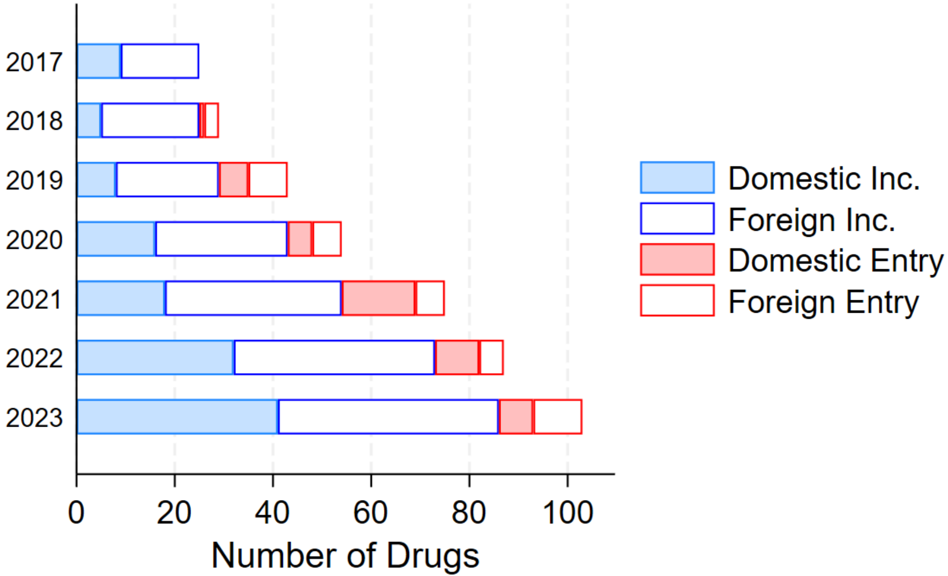
Raw Data: Prices

Back



(a) Residualized Log(Price) (b) Raw Log(Price)

Domestic and Foreign Entry Back



Income Gradients Back

Figure: (Raw data) Local income and innovative drug share

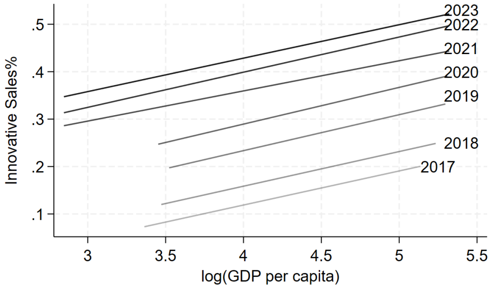
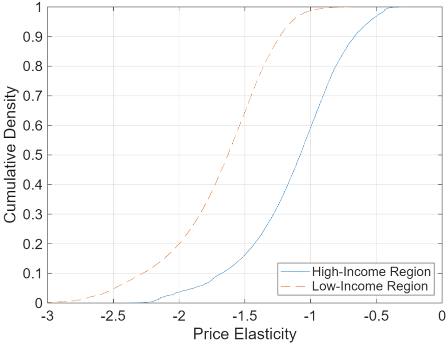


Figure: (Estimates) CDF of price elasticity across income



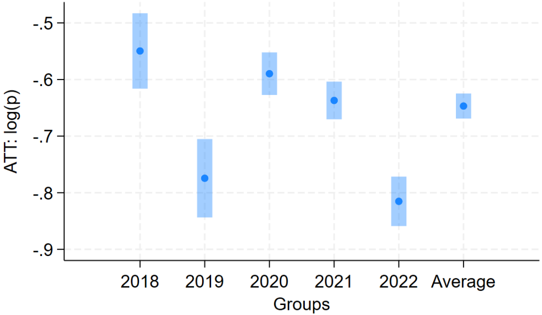
Demand Robustness Back

	Local IV	ATC4 nest	No GH IV	Neg. IV	+Price RC
	(1)	(2)	(3)	(4)	(5)
log(OOP)	-1.196***	-3.887***	-2.999***	-3.150***	-3.215***
	(0.074)	(0.182)	(0.154)	(0.165)	(0.450)
log(OOP) $\times$ log(income)		0.586***	0.453***	0.486***	0.430***
		(0.038)	(0.030)	(0.032)	(0.033)
log(OOP) $\times$ ν					0.354
					(0.288)
λ (nesting para.)		0.010	0.289***	0.207***	0.312***
		(0.033)	(0.029)	(0.034)	(0.033)
γ^* (combo scale)		0.017***	0.014***	0.024***	0.011***
		(0.005)	(0.003)	(0.005)	(0.003)
Median elasticity	-1.20	-1.53	-1.60	-1.47	-2.09
Nesting level		ATC4	Primary	Primary	Primary
Combo products		Yes	Yes	Yes	Yes
Product FE		Yes	Yes	Yes	Yes
Product$\times$Time FE	Yes				
Province$\times$Time FE	Yes	Yes	Yes	Yes	Yes
Controls (cols. 2–5): indication dummies (lung, breast, colon, stomach), log(#indications), years since entry$\geq$1					

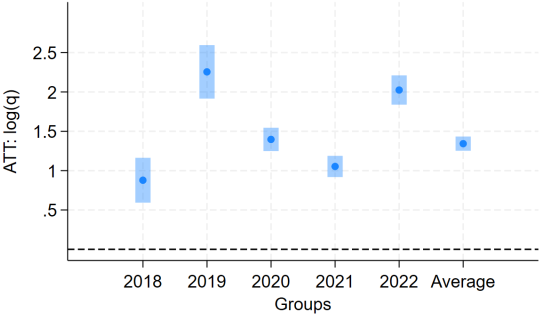
IV for Col (1): negotiation dummy $\times$ local coinsurance. IV for Col (2)-(5) same as main table, except (3) drops GHIV and (4) use observed negotiation success instead of predicted success probability.

Treatment Effects by Negotiation Round

Back



(a) Log(Retail Price)



(b) Log(Quantity)

Counterfactual Algorithm Back

For each vector of $\{\gamma, \beta, \tau\}$:

1. **Outer loop:** In iteration t, start with the old equilibrium price $\mathbf{p}^t = \mathbf{p}^{t-1}$ (or an initial price vector if $t = 0$) and the formulary $\mathcal{G}^t = \mathcal{G}^{t-1}$
2. **Inner loop:** For product $j = 1, ..., J$ (descending by quantity sold):
   2.1 If the price of drug j is negotiated:
      - Calculate the deviation price $\mathbf{p}_j^{BN}$ as the firm's best-response price $\mathbf{p}_j^{BN} = BR_j(\mathbf{p}_{-j}^t, \mathcal{G}^t/\{j\})$
      - Given the deviation price $\mathbf{p}_j^{BN}$, calculate the admissible set: $[p_j^l, p_j^u]$, where p_j^l denotes the lower bound ($\Delta\Pi(p_j^l, \mathbf{p}_{-j}^t) = 0$) and p_j^u denotes the upper bound ($\Delta V(p_j^u, \mathbf{p}_{-j}^t) = 0$)
      - If the admissible set is empty, the negotiation fails, and we move to step 2.2
      - If the admissible set is non-empty, solve for the negotiated outcome given τ: $p_j^*(\tau)$ according to the FOC and update the formulary $\mathcal{G}^* = \mathcal{G}^* \cup j$

   2.2 If drug j is not negotiated, or if the negotiation fails, then $p_j^* = \mathbf{p}_j^{BN}$
3. The algorithm converges to the equilibrium formulary and price if $|\mathbf{p}^* - \mathbf{p}^t| < \epsilon$ and $\mathcal{G}^t = \mathcal{G}^*$, otherwise reset $\mathbf{p}^t = \mathbf{p}^*$ and $\mathcal{G}^t = \mathcal{G}^*$ and return to step 1

Supply Estimation (1) Back

1. Recover $\mathbf{mc}$ in each province using demand parameter estimates and the observed prices and market shares during the quarter before the negotiation, assuming Bertrand-Nash competition among all firm-market pairs
   - Assume unchanged from pre-negotiation levels

2. Parameterize β and τ:
   - Government's relative weight on expenditure β follows a T1EV distribution: $\exp(\beta) \sim Exp(X_{\beta j}; \theta_\beta)$
   - Allow θ_β to be a function of drug attributes $X_{\beta j}$ such as clinical effectiveness
   - Firm's bargaining power depends on its attributes (such as nationality): $\tau_j = f(X_{\tau j})$

Supply Estimation (2) Back

3. Construct the sample log-likelihood function for parameters $\theta = \{\theta_\beta, \tau\}$, using the observed negotiation outcomes $\{\mathcal{G}_j \in \{0,1\}, \forall j\}$ and negotiated prices $\{p_j\}$ for all successful cases $\mathcal{G}_j = 1$

   - For failed negotiations, we define $\underline{\beta_j}$ as the value of β such that $\Delta V = 0$ at the lowest price acceptable to the firm (i.e., the bargain barely succeeds)
   - For successful negotiations ($\mathcal{G}_j = 1$), β_j can be inverted from the Nash-in-Nash FOC

4. The joint log-likelihood function is:

$$log\mathcal{L}(\theta) = \sum_j \underbrace{\mathbb{1}(\mathcal{G}_j = 1) log \left(\frac{\partial \beta_j}{\partial p_j} f_\beta(\beta_j; \theta_\beta) \right)}_{\text{successful negotiations}} + \underbrace{\mathbb{1}(\mathcal{G}_j = 0) log \left(1 - F_\beta(\underline{\beta_j}; \theta_\beta) \right)}_{\text{failed negotiations}}.$$

Estimated via maximum likelihood