Optimal Payment Levels for Reference-Dependent Physicians

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Motivation: Prospectively Fixed Payment Policies

Over- or under-supply of goods or services due to market frictions (e.g., information asymmetry and market power)

Prospectively fixed payment policies eliminate marginal incentives for over- or under-supply:

- **Healthcare**: diagnosis-based payment schemes for providers
- **Education**: funding for schools based on student enrollment
- **Ride-sharing platforms**: predetermined rates for drivers

Motivation: Prospectively Fixed Payment Policies

The level of fixed payment shapes policy outcomes

Individuals have **reference-dependent preferences** (Kahneman & Tversky, 1979)

- Assess outcomes relative to a reference point (e.g., familiar preexisting payment)
- Fixed payment − reference point ⇒ perceived gains/losses
- Loss aversion: stronger response to perceived losses

This study

Focus on prospective payment scheme (PPS) in healthcare markets

- Widely adopted over the world to curb healthcare overprovision (e.g., diagnosis-based payment)

Research goals:

1. Provide evidence for physicians' reference-dependent preferences
2. Develop and estimate a model of medical decision-making
   - Patients and physicians jointly make decisions
   - Physicians have reference-dependent preferences
3. Determine the optimal payment level under PPS

Institutional Background

- **Healthcare Supply in China**
- **Urban Employee Basic Medical Insurance (UEBMI)**
- **Rehabilitation Care**
- **The 2015 Reform**

Healthcare Supply in China

Public hospitals provide a dominant share of healthcare services

- 87.3% outpatient, 89.1% inpatient (Tier-3 $>$ Tier-2 $>$ Tier-1)

Public hospitals have strong financial incentives

- Before 1980s, government subsidies $\approx$ 60% hospital revenue
- After 1980s, subsidies $\downarrow$ + regulated prices

Hospital revenue:

- **Payments from public insurances (54%)**, out-of-pocket expenses (39%), government subsidies (7%)

Hospitals and physicians: same incentives

- Training: physician strategies align with hospital interests
- Physician income: low salary + high bonus (1:3)

Public Health Insurances in China

Two public health insurances:

1. The urban and rural residents basic medical insurance
2. The urban employee basic medical insurance (UEBMI)

The UEBMI:

- Mandatory for urban employees and retirees (& family members)
- Financed and managed by local governments
- Cover inpatient and outpatient care

Rehabilitation Care

Rehabilitation: improve functioning and reduce disability (WHO, 2017)

- Neurological disorder; musculoskeletal disorder; sensory impairments; mental disorder; cardiovascular diseases...

Distinct features:

1. Intensive patient-physician cooperation (Dibbelt et al., 2010)
2. Active patient involvement (Baker et al., 2011)
3. Higher price elasticity of demand (Ziebarth, 2010)

Unmet need for rehabilitation in China

1. Demand: lack awareness, undervalue benefit
2. Supply: under-resourced, unevenly distributed, no referral system

A Reform in Changsha in 2015[1]

The urban employee basic medical insurance (UEBMI) changed **hospital payment schemes** & **patient reimbursement structures** for rehabilitation care in **7 hospitals**.

- **5 categories (110 diagnoses)**:
    1. Stroke (44)
    2. Spinal cord injury (29)
    3. Traumatic brain injury (28)
    4. Recovery from brain tumor surgery (6)
    5. Recovery from hip/knee replacement (3)

- **Rehabilitation care**: improve functioning and reduce disability (WHO, 2017)

1. Changsha: Capital city of Hunan province (population: 8.13 million; GDP per capita: 15,056 USD)

The 2015 Reform

For an admission with diagnosis d in category g,

Hospital Payment Schemes

- Before: $R = E$ (fee-for-service)
  - R: hospital revenue; E: medical expense
- After: $R = P_g$ (diagnosis-based scheme)
  - P_g: fixed price for category g

Patient Reimbursement Structure

- Before: $p = \begin{cases} E - (Clm - Dud) \cdot re & \text{if } Clm \geq Dud, \\ E & \text{if } Clm < Dud. \end{cases}$
  - p: out-of-pocket (OOP) expense; Dud: deductible; Clm: claimable expense; re: reimbursement rate
- After: $p = \delta \cdot P_g$
  - $\delta = 15\%$ for employees; $\delta = 10\%$ for retirees

The 2015 Reform: An Ideal Context

1. Eliminate physician's marginal revenue + patient's marginal OOP → physicians provide less + patients demand more (**Incentive compatibility in collective decisions**)

2. Varying changes in average physician revenue per admission across diagnoses and hospitals → perceived gains/losses for physicians (**Reference-dependence preferences of physicians**) Example

Diagnoses in stroke rehabilitation	Before Tier-2 hospitals	Before Tier-3 hospitals	After Fixed price
Cerebral arteritis	5,589	8,075	18,000
Subarachnoid hemorrhage following cerebral infarction	9,396	20,978	18,000
Intracerebral hemorrhage in hemisphere	20,063	32,963	18,000

Data

Two datasets from Changsha UEBMI (2013–2015):

1. **Claim data**
   - Admission and discharge dates
   - Diagnostic codes (ICD-10)
   - Detailed expense related information
   - Basic hospital information (e.g., name, tier, type, and number of beds)
2. **Enrollment data**
   - Age, gender, monthly salary (pension) of employees (retirees)

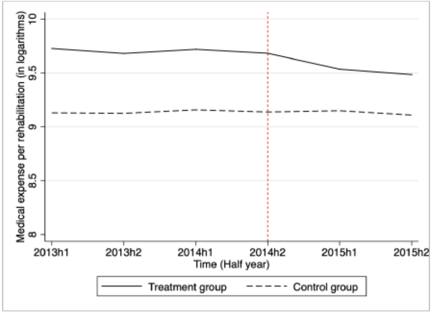
Estimation Sample:

- 31,158 admissions in 29 hospitals
  - **Treatment group**: 9,174 admissions in 7 hospitals
  - **Control group**: 21,984 admissions in 22 hospitals (same tier; similar size: ≥ 50 admissions per year)

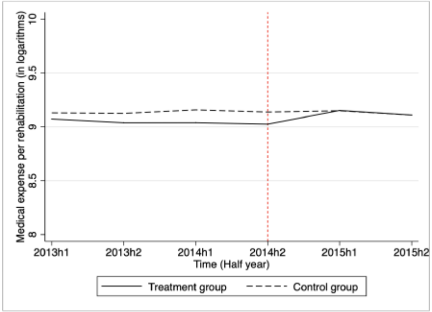
Change in Medical Expense Across Time

For an admission with diagnosis d in hospital j,

- **Medical expense** measures the amount of healthcare Summary Statistics
- **Change in average hospital revenue (ΔP_{dj})**: $\Delta P_{dj} = \frac{P_g - E_{dj0}}{E_{dj0}}$
  - $\Delta P_{dj} = 0$ for control group



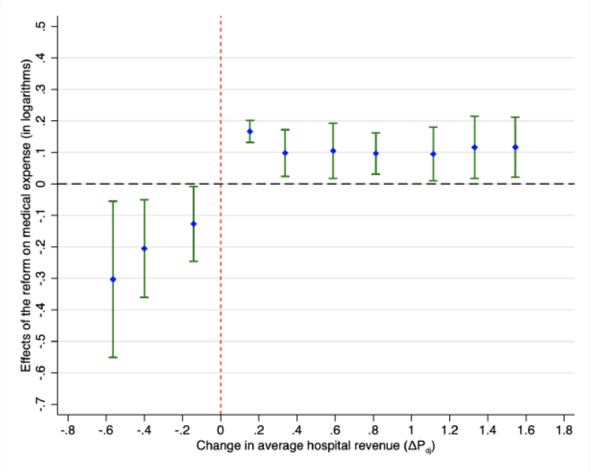
(a) $\Delta P_{dj} < 0$



(b) $\Delta P_{dj} > 0$

Impacts of the Reform

- **Heterogeneous impacts by ΔP_{dj}** DID Specification



- No heterogeneous impacts by change in average OOP expense Results

Plausible Interpretations

1. **Hospital selection**
   a. Based on diagnoses Results
   b. Based on patient severity Results
2. **Mean reversion** Results
   - $\Delta P_{dj} < 0$: high pre-reform medical expense, decrease across time
   - $\Delta P_{dj} > 0$: low pre-reform medical expense, increase across time
3. **Anchoring effects** Results
   - Physicians interpret P_g as an implicit suggestion by the government and regard it as a psychological "anchor" in decision-making.
4. **Heterogeneous treatment effects**
   a. Variation in financial incentives across hospitals Results
   b. Heterogeneity in price sensitivity across patients Results
   c. Differences in patient involvement across diagnoses Results
   d. Variation in pre-reform cost-sharing rates across admissions Results
   e. Heterogeneous marginal cost across admissions Results1 Results2

Model

A model of medical decisions with two important features:

1. **Collective decision** by patient and physician $\rightarrow$ both $\uparrow$ and $\downarrow$ in medical expenses due to the reform
   - Patient: demand $\uparrow$
   - Physician: supply $\downarrow$
2. **Reference dependence** of physicians $\rightarrow$ heterogeneous impacts based on whether $\Delta P_{dj} < 0$ or $\Delta P_{dj} > 0$

A representative patient is treated by a representative physician, receiving the amount of healthcare E (measured by medical expense)

Patient utility (Einav et al., 2013; Finkelstein et al., 2016):

$$u(E) = \frac{1}{\alpha} h(E, \omega) - p \tag{1}$$

- ω: patient health conditions
- $h(E, \omega)$: health benefit

  (i) $\frac{\partial h}{\partial E}|_{E=0} > T$; (ii) $\frac{\partial^2 h}{\partial E^2} \leq 0$; (iii) $\frac{\partial h}{\partial E}|_{E=\infty} < 0$.
- α: patient's price sensitivity
- p: OOP expense (**affected by the reform!**)

Model Setup

Physician Utility

Physician's profit for providing healthcare E: $\pi(E) = R(E) - C(E)$

- $R(E)$: revenue (**affected by the reform!**)
- $C(E)$: cost (linear function: $C(E) = c \cdot E$)

Utility of the reference-dependent physician (Koszegi & Rabin, 2006):

$$v(E|r) = \begin{cases} \frac{1}{1+\eta}\pi(E) + \frac{\eta}{1+\eta}(\pi(E) - \pi(r)), & \text{if } \pi(E) \geq \pi(r) \\ \frac{1}{1+\eta}\pi(E) + \lambda\frac{\eta}{1+\eta}(\pi(E) - \pi(r)), & \text{if } \pi(E) < \pi(r) \end{cases} \tag{2}$$

- η: weight on gain-loss utility
- $\lambda > 1$: degree of loss aversion
- $\pi(r)$: reference point
- r: critical amount of care for the physician to achieve a profit at $\pi(r)$

Optimal amount of care (E^*) is chosen to maximize the collective utility (Chiaporri, 1992; Browning et al., 2014; Cherchye et al., 2015):

$$\mathbb{U}(E|r) = \theta \cdot u(E) + (1-\theta) \cdot v\left(E \mid r\right). \tag{3}$$

- θ $(1-\theta)$: bargaining weight of the patient (physician)

Determinants of E^*:

1. Incentives of patient and physician
2. Bargaining weights
3. Physician's reference point ($\pi(r)$)

Optimal Amount of Care

Assumption 1

The physician sets a reference point for an admission based on her past experience from admissions with the same diagnosis.

Before the reform: optimal amount of care (E_0^*) is in the steady state:

$$\pi^0(r_0) = \pi^0(E_0^*) \Rightarrow r_0 = E_0^*.$$

After the reform:

- **physician's reference point**: $\pi_1(r_1) = \pi^0(E_0^*)$

$$r_1 = \frac{P - E_0^*}{c} + E_0^* \tag{4}$$

- $P - E_0^*$ influences optimal amount of care (E_1^*) by affecting r_1.

Impacts of the Reform on the Amount of Care

Eliminate marginal OOP expense $\Rightarrow E \uparrow$

- Marginal collective utility: $\theta\delta_0 \uparrow$

Eliminate marginal physician revenue $\Rightarrow E \downarrow$

- Marginal collective utility (gains): $(1-\theta) \downarrow$
- Marginal collective utility (losses): $(1-\theta)(1+\frac{(\lambda-1)\eta}{1+\eta}c) \downarrow$

Impact of the reform on E^***:**

Proposition 1

i. *If* $\theta_{ij}\delta^0_{ij} \leq (1-\theta_{ij})$, *the reform decreases* E^*;

ii. *If* $\theta_{ij}\delta^0_{ij} \geq (1-\theta_{ij})(1+\frac{(\lambda-1)\eta}{1+\eta}c_j)$, *the reform increases* E^*;

iii. *If* $(1-\theta_{ij}) < \theta_{ij}\delta^0_{ij} < (1-\theta_{ij})(1+\frac{(\lambda-1)\eta}{1+\eta}c_j)$, *the reform decreases* E^* *when* $(P-E^*_0) < 0$, *but increases* E^* *when* $(P-E^*_0) > 0$.

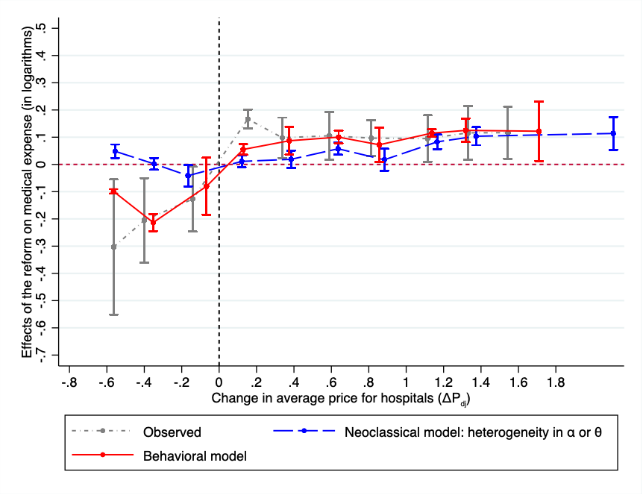
Structural Estimation

- Parameterization Details
- Maximum Likelihood Estimation Details
- Identification Details
  - Policy change + structural model: identify key parameters (α, c, θ, λ)

Parameter Estimates

	(1) Behavioral model	(2) Neoclassical model
Physician's marginal cost c	0.719	0.719
	(0.252)	–
Patient's price sensitivity α	37.203	*Rich*
	(1.121)	*Heterogeneity*
Patient's bargaining weight θ	0.871	0.871
	(0.003)	–
Loss aversion λ	3.529	–
	(1.596)	–
Health conditions		
Age / 10	-2.260	-1.885
	(0.214)	(0.192)
Age^2 / 100	0.168	0.146
	(0.016)	(0.014)
Female	-0.418	-0.449
	(0.048)	(0.049)
Income (log)	0.112	0.029
	(0.058)	(0.033)
Civil servant	-2.037	-1.332
	(0.146)	(0.094)
Diagnosis fixed effects	Yes	Yes
Hospital fixed effects	Yes	Yes
Year-month fixed effects	Yes	Yes
Log-likelihood	-95,295	-95,354
Number of observations	31,158	31,158

Model Fit

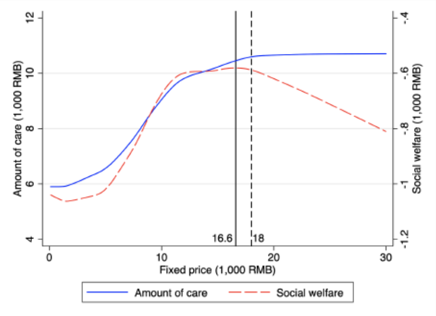


Impacts of the reform
Impacts of loss aversion

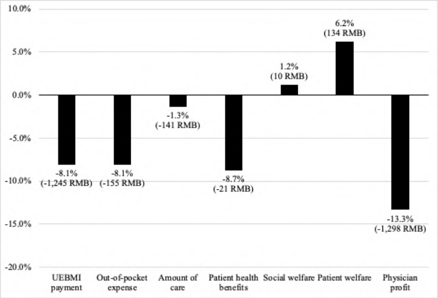
The social planner's problem:

$$\max_P \frac{1}{\alpha_s} h(E_1^*, \omega) - P$$

$$s.t.\ E_1^* = arg \max_E \ \theta u_1(E) + (1-\theta) v_1(E|r_1)$$



(a) A uniform optimal price



(b) Observed price vs. optimal price

Contributions and Future Extensions

Contributions:

1. **Behavioral economics literature** on reference dependence
   - First to study reference dependence in collective decisions
   - Among the first to explore welfare implications of reference dependence (O'Donoghue & Sprenger, 2018)
   - Add to field evidence and structural estimates of loss aversion (Crawford & Meng, 2011; Rees-Jones, 2018; DellaVigna et al., 2017; Andersen et al., 2022; Brown et al., 2024)
2. **Health economics literature** on PPS (see Rosenberg & Browne, 2001; Tan & Melendez-Torres, 2018 for reviews)
   - Investigate the optimal payment level

Future extensions:

1. Reference-dependent preferences of both physicians and patients
2. Dynamic evolution of reference points in the long run

Backup Slides

An Example: Changes in Average Physician Revenue

The 20 most common diagnoses in stroke	Before		After
	Tier-2	Tier-3	Fixed price
Cerebral arteritis	5,589	8,075	18,000
Moyamoya disease	5,882	12,506	
Hemiplegia and hemiparesis following cerebral infarction affecting right non-dominant side	6,307	9,598	
Cerebral infarction due to unspecified occlusion or stenosis of precerebral arteries	6,411	11,017	
Cerebral artery dissection, traumatic	6,511	7,960	
Cerebral infarction due to embolism of cerebral arteries	6,529	8,799	
Hemiplegia and hemiparesis following cerebral infarction affecting right dominant side	7,578	10,995	
Subarachnoid hemorrhage following cerebral infarction	9,396	20,978	
Hemiplegia and hemiparesis following cerebral infarction affecting left non-dominant side	9,702	10,356	
Cerebral infarction due to embolism of unspecified cerebral artery	9,946	23,390	
Hemiplegia and hemiparesis following cerebral infarction affecting left dominant side	10,214	12,666	
Basal ganglia hemorrhage	10,946	28,187	
Cerebrovascular accident	11,056	16,882	
Cerebral infarction due to embolism of precerebral arteries	11,183	16,020	
Subarachnoid hemorrhage following unspecified cerebral infarction	12,912	34,661	
Intracerebral hemorrhage in hemisphere	20,063	32,963	
Cerebral infarction due to thrombosis of precerebral arteries	--	22,645	
Occlusion and stenosis of unspecified cerebral artery	--	21,022	
Cerebral artery dissection, non-traumatic	--	32,398	
Cerebral artery occlusion	--	25,158	

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Summary Statistics

	Full sample		Treatment group		Control group	
	(1)	(2)	(3)	(4)	(5)	(6)
	Mean	SD	Mean	SD	Mean	SD
Medical expense (RMB)	12,690.561	14,338.403	12,515.497	13,476.209	12,763.616	14,682.915
Length of stay (days)	14.226	14.842	14.687	13.566	14.034	15.339
Daily expense on drugs	502.522	537.737	449.874	556.904	524.492	527.996
Daily expense on diagnostic tests	313.742	397.728	334.607	451.351	305.035	372.744
Daily expense on general routine care	169.577	454.108	193.522	540.793	159.584	412.186
Change in average price received by hospitals (ΔP_{dgj})	0.144	0.392	0.490	0.595	0	0
Change in average price paid by patients (Δp_{wdgj})	-0.028	0.218	-0.096	0.393	0	0
Charlson comorbidity index	1.365	0.640	1.360	0.651	1.367	0.636
Number of chronic conditions	2.091	1.582	2.118	1.607	2.080	1.571
Female	0.472	0.499	0.456	0.498	0.479	0.500
Age	67.959	12.088	68.089	12.008	67.905	12.121
Monthly income	2,640.805	1,046.591	2,629.504	944.599	2,645.522	1,086.311
Number of patients	23,097		7,473		16,857	
Observations	31,158		9,174		21,984	

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Difference-in-Differences (DID) Specification

Divide admissions in treatment group into 10 classes:

- Class 1-3: $\Delta P_{dgj} < 0$; Class 4-10: $\Delta P_{dgj} > 0$

$$\ln\left(E_{idjt}\right) = \beta_0 + \sum_{k=1}^{K} \beta_1^k \mathbf{1}\{class = k\} \times \text{Post}_t + \sum_{k=1}^{K} \beta_2^k \mathbf{1}\{class = k\} + \boldsymbol{X}_{it}\gamma + \mu_t + \mu_j + \mu_d + \epsilon_{idjt}$$

- i: patient; d: diagnosis; j: hospital; t: year
- $\mathbf{1}\{class = k\}$: the admission in class k.
- Post_t: $t \geq 2015$.
- $\boldsymbol{X}_{it}$: Patient characteristics.
- μ_t: year-by-month FE; μ_j: hospital FE; μ_d: diagnosis FE.
- Standard errors clustered at hospital-by-diagnosis level.

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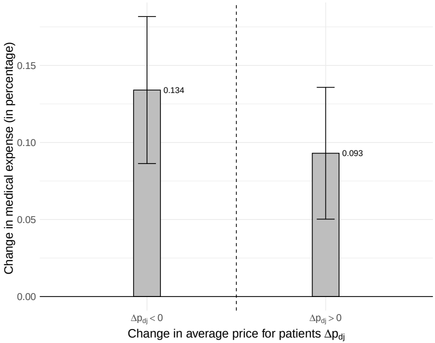
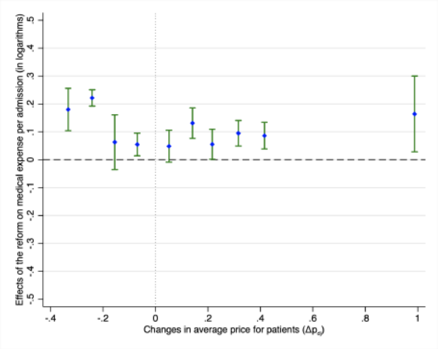
Impacts the Reform by Change in Average OOP Expense

Change in Average OOP Expense: $\Delta p_{dj} = \frac{\delta P_g - p_{dj0}}{p_{dj0}}$



(a) $K = 2$



(b) $K = 10$

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Alternative Interpretation

Selection on Diagnoses

$$\ln(N_{djt}) = \partial_0 + \partial_1^- \mathbf{1}\{\Delta P_{dj} < 0\} \times \text{Post}_t + \partial_1^+ \mathbf{1}\{\Delta P_{dj} > 0\} \times \text{Post}_t + \partial_2^- \mathbf{1}\{\Delta P_{dj} < 0\} + \partial_2^+ \mathbf{1}\{\Delta P_{dj} > 0\} + \zeta_t + \zeta_j + \zeta_d + \varepsilon_{djt}$$

	Number of admissions (in logarithm)		
	(1)	(2)	(3)
$\mathbb{I}\{\Delta P_{dj} < 0\} \times Post$	-0.049	-0.005	-0.004
	(0.061)	(0.060)	(0.056)
$\mathbb{I}\{\Delta P_{dj} > 0\} \times Post$	-0.007	0.030	0.014
	(0.059)	(0.057)	(0.057)
Individual controls	Yes	Yes	Yes
Year-month FE	Yes	Yes	Yes
Hospital FE	Yes	Yes	No
Diagnosis FE	Yes	No	No
Hospital-by-diagnosis FE	No	Yes	Yes
Diagnosis-by-year FE	No	No	Yes
Observations	9,056	9,044	8,972
R-squared	0.449	0.706	0.711

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Alternative Interpretation

Selection on Patient Severity

	Charlson comorbidity index			Number of chronic conditions		
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbb{I}\{class = 1\} \times Post$	-0.007	0.007	0.001	-0.016	0.002	-0.021
	(0.019)	(0.019)	(0.020)	(0.073)	(0.087)	(0.087)
$\mathbb{I}\{class = 2\} \times Post$	0.014	0.004	0.002	0.035	0.025	0.004
	(0.017)	(0.018)	(0.019)	(0.057)	(0.042)	(0.042)
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes
Year-month FE	Yes	Yes	Yes	Yes	Yes	Yes
Hospital FE	Yes	Yes	No	Yes	Yes	No
Diagnosis FE	Yes	No	No	Yes	No	No
Diagnosis-by-year FE	No	Yes	Yes	No	Yes	Yes
Hospital-by-diagnosis FE	No	No	Yes	No	No	Yes
Dep. Means (Preintervention)	1.350	1.350	1.350	2.051	2.052	2.052
Observations	31,158	31,098	31,085	31,158	31,098	31,085
R-squared	0.131	0.136	0.185	0.405	0.411	0.456

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Alternative Interpretation

Mean Reversion

Define $\Delta P_{dj} = \frac{P_g - E_{dj0}}{E_{dj0}}$ for control group:

$$\ln\left(E_{idjt}\right) = \alpha_0 + \alpha_1 \Delta P_{dj} \times \text{Post}_t + \alpha_2 \Delta P_{dj} + \boldsymbol{X}_{it}\eta + \mu_t + \mu_j + \mu_d + e_{idjt}$$

Dependent variable	Medical expense of the admission (in logarithms)	
	(1)	(2)
$\Delta P_{dgj} \times Post_t$	-0.000	-0.005
	(0.013)	(0.013)
Individual controls	Yes	Yes
Year-month FE	Yes	Yes
Hospital FE	Yes	Yes
Diagnosis FE	Yes	No
Hospital-by-diagnosis FE	No	Yes
Observations	21,980	21,979
R-squared	0.396	0.421

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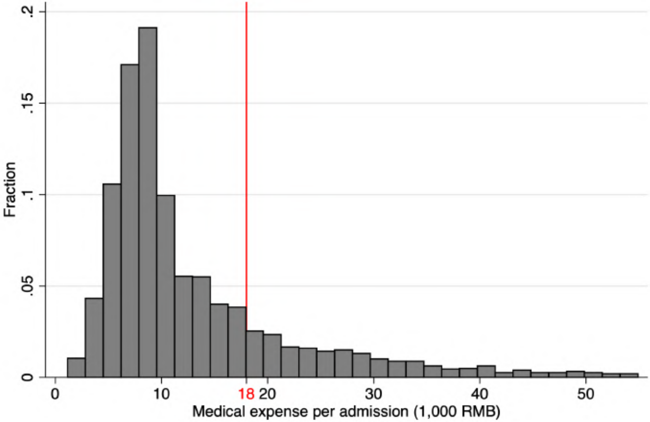
Anchoring effects ⇒ bunching at the fixed price (Bernheim et al., 2015)



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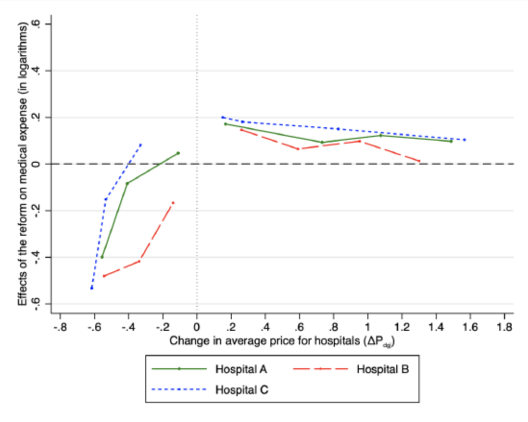
Alternative Interpretation

Heterogeneity in Hospitals



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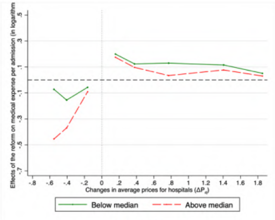
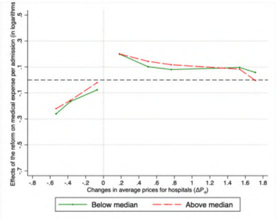
Alternative Interpretation

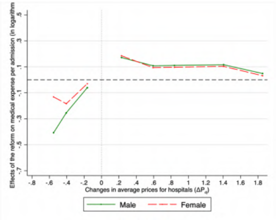
Differences in Price Sensitivity Among Patients



(a) Income



(b) Age



(c) Gender

Figure A9. Effects of the reform on medical expense for patients with different socioeconomic characteristics

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Alternative Interpretation

Differences in Patient Involvements Across Diagnoses

Focusing on admissions with single cerebral infarction

	$\Delta P_{dj} < 0$	$\Delta P_{dj} > 0$
Panel (a)		
Average medical expense per admission before the reform	14,167.060	13,294.729
	(13,728.241)	(12,019.660)
Diff.	872.332	
	(1,019.153)	
Panel (b)		
$\mathbb{I}\{class = 1\} \times Post$	-0.064	
	(0.044)	
$\mathbb{I}\{class = 2\} \times Post$	0.180	
	(0.020)	
Individual controls	Yes	
Year-month FE	Yes	
Hospital FE	Yes	
R-squared	0.164	
Observations	10,755 (34.5% of total obs.)	

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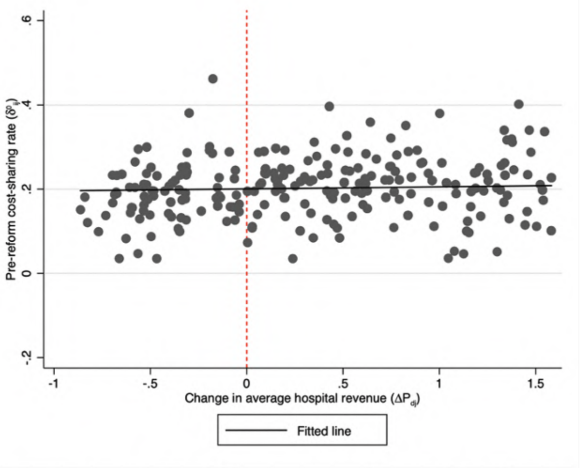
Alternative Interpretation

Variation in Patient Cost-sharing across Admissions Before the Reform



Relationship between the share of the OOP portion of medical expense (δ^0_{ij}) and changes in average hospital revenue (ΔP_{dj})

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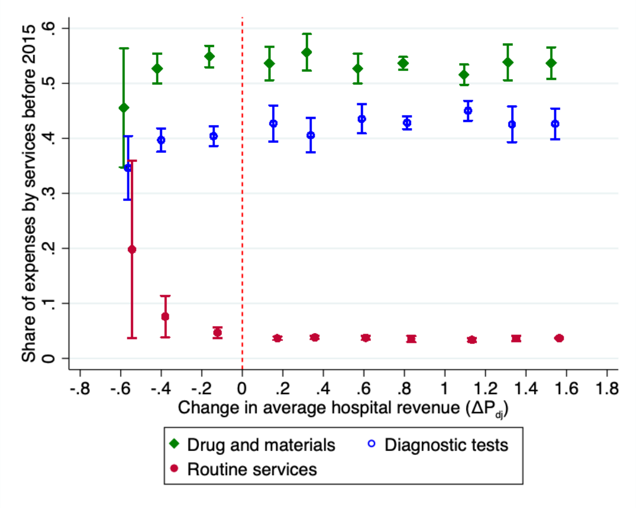
Alternative Interpretation

Heterogeneous Marginal Cost across Cases



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Alternative Interpretation

Heterogeneous Marginal Cost across Cases

	Share of expense on drugs and materials	Share of expense on diagnostic tests	Share of expense on routine services
	(1)	(2)	(3)
$\mathbb{1}(\text{class} = 1) \times Post_t$	0.002	0.002	-0.004
	(0.009)	(0.009)	(0.006)
$\mathbb{1}(\text{class} = 2) \times Post_t$	0.008	-0.005	-0.002
	(0.005)	(0.006)	(0.002)
Individual controls	Yes	Yes	Yes
Year-month FE	Yes	Yes	Yes
Hospital-by-diagnosis FE	Yes	Yes	Yes
Observations	31,154	31,154	31,154
R-squared	0.362	0.330	0.584

Standard errors in parentheses

$^{*}p < 0.10$ $^{**}p < 0.05$ $^{***}p < 0.01$

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Parameterization

1. Patient's health benefit

$$h\left(E_{idjt}, \omega_{idjt}\right) = -\frac{1}{2\alpha}\left(E_{idjt} - \omega_{idjt}\right)^2$$

2. $\omega_{idjt} = \boldsymbol{X}_{it} \cdot \phi + \zeta_t + \zeta_j + \zeta_d$
3. The observed medical expense, E^o_{idjt}, contains measurement errors, υ_{idjt}:

$$\ln(E^o_{idjt}) = \ln(E_{idjt}) + \upsilon_{idjt},$$

$$\ln(\upsilon_{idjt}) \sim \mathcal{N}\left(0, \sigma\right).$$

4. Normalize the physician's weight on gain-loss utility (η) as 1.

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Maximum Likelihood Estimation

Before reform or untreated

$$E_{idjt} = E^{G*}_{idjt,0} = \omega_{idjt,0} - \alpha\delta_{idjt,0} + \alpha(1-c)\frac{1-\theta}{\theta} \quad (5)$$

After reform and treated: $E_{idjt} = \min\{E^{G*}_{idjt,1}, \max\{E^{L*}_{idjt,1}, r_{idjt,1}\}\}$, where

$$E^{G*}_{idjt,1} = \omega_{idjt} - \alpha \cdot c \cdot \frac{1-\theta}{\theta} \quad (6)$$

$$E^{L*}_{idjt,1} = \omega_{idjt} - \alpha \cdot c \cdot \frac{1-\theta}{\theta}\frac{1+\lambda}{2} \quad (7)$$

$$r_{idjt,1} = \frac{\left(P_g - E^*_{dj,0}\right)}{c} + E^*_{dj,0} \quad (8)$$

Maximum Likelihood Estimation

The density of the logarithm of observed medical expense ($\log(E_{idjt})$) is

$$\varrho\left[\ln\left(E^{o}_{idjt}\right)\right] = \frac{1}{\sigma \cdot \sqrt{2\pi}} \cdot e^{-\frac{1}{2}\left[\frac{\ln\left(E^{o}_{idjt}\right) - \ln(E^{o}_{idjt})}{\sigma}\right]^2}$$

The log-likelihood function is

$$LL(\Omega) = \sum_i \sum_j \sum_d \sum_t 1_{idjt} \log\left\{\varrho\left[\log\left(E_{idjt}\right)\right]\right\}$$

where 1_{idjt} is an indicator that patient i with diagnosis d is treated by physician j in year t. Ω denotes the vector of parameters to be estimated.

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Identification

The key parameters in the model are related to the patient's price sensitivity (α), the physician's bargaining weight ($1-\theta$), the degree of loss aversion (λ), and the physician's marginal cost (c).

$$E_{idjt} = E^{G*}_{idjt,0} = \omega_{idjt,0} - \alpha\delta_{idjt,0} + \alpha(1-c)\frac{1-\theta}{\theta} \tag{9}$$

$$E^{G*}_{idjt,1} = \omega_{idjt} - \alpha \cdot c \cdot \frac{1-\theta}{\theta} \tag{10}$$

$$E^{L*}_{idjt,1} = \omega_{idjt} - \alpha \cdot c \cdot \frac{1-\theta}{\theta}\frac{1+\lambda}{2} \tag{11}$$

$$r_{idjt,1} = \frac{\left(P_g - E^{*}_{dj,0}\right)}{c} + E^{*}_{dj,0} \tag{12}$$

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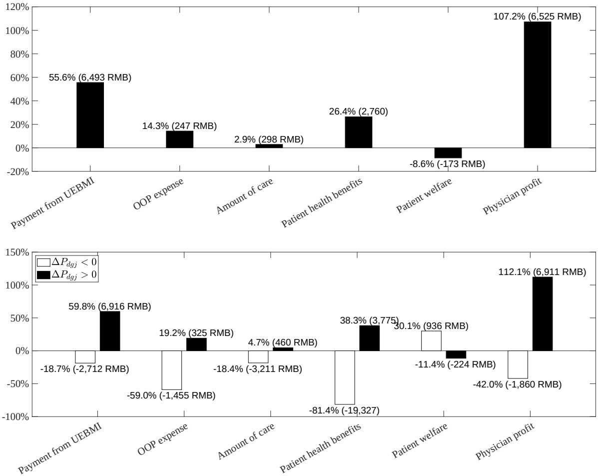
Effects of the Reform



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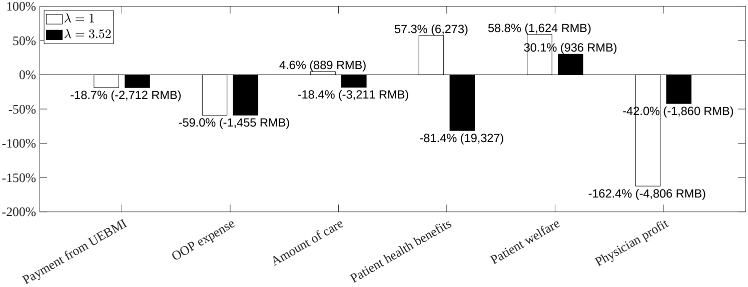
Effects of Loss Aversion



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