Estimating Demand Elasticity in the Stock Market

Evidence from the 2016 Tick Size Pilot

Shidong Shao
Chinese University of Hong Kong
Jason Jushen Zou
Cornell University

December 2, 2024

The Elasticity of Stock Market is a Mystery

- Canonical Capital Asset Pricing Model (CAPM):
  - A supply shock of -10% reduces prices by 0.0016% (Petajisto, 2009).
  - Stocks are perfect substitutions.
- Koijen and Yogo (2019) assume *logit* demand function and estimate 5% price impacts.
  - Becomes the new norm in literature.
- However, their estimators are probably biased (Fuchs et al., 2023)
  - BLP-style IV is NOT exogenous.
  - Mechanical demand elasticity.
  - Ignore cross-asset substitutions.

What We do

- Use an exogenous *supply* shock to estimate the demand elasticity in the stock market.
  - This shock comes from the SEC quasi-RCT in 2016.
- This RCT reduces share repurchase by 0.1% of total asset value.
- Repurchasing 1% of total assets increases the share price by 3.9%.
- Larger and more liquid firms have higher demand elasticity.

Contributions:

- The first paper using the *supply* shock to estimate demand elasticity.
- The nature of this experiment allows us to avoid concerns on biased estimators.

Outline

Academic Background

Three Challenges

Empirical Settings

Empirical Results

Conclusion

Academic Background (Koijen and Yogo, 2019)

Investors have CARA utility

$$\max_{\mathbf{q_i}} \mathbb{E}\left[-\exp(-\gamma_i A_{1,i})\right]$$

$$A_{1,i} = \mathbf{q}_i'\left(\mathbf{D}_2 - \mathbf{P_1}\right)$$

Investors have heterogeneous beliefs in the future profitability:

$$\begin{aligned}
\mathbf{D}_2 &= \mu_i + \rho_i \mathbf{F} + \eta \\
\mu_i(n) &= \Phi_i^{\mu\prime} x(n) + \varepsilon_i^{\mu}(n) \\
\rho_i(n) &= \Phi_i^{\rho\prime} x(n) + \varepsilon_i^{\rho}(n)
\end{aligned}$$

Academic Background (Koijen and Yogo, 2019)

Logit demand function from portfolio choice problem:

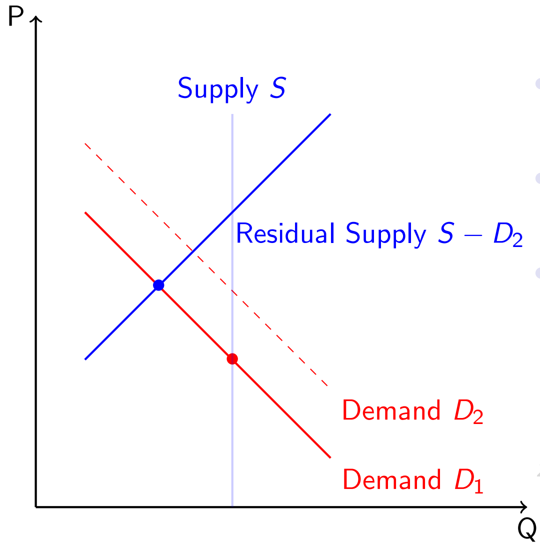
$$\frac{w_{i,t}(n)}{w_{i,t}(0)} = \exp\left\{\beta_{0,i,t}p_t(n) + \sum_{k=1}^{K-1}\beta_{k,i,t}x_{k,t}(n) + \alpha_{K,i,t}\right\}\varepsilon_{i,t}(n)$$

- **IV for $p_t(n)$:**

$$z_{i,t}(n) = \log\left(\sum_{j\notin\{i,1\}} A_{j,t}\frac{\mathbf{1}_j(n)}{1+|\mathcal{N}_{j,t}|}\right)$$

Outline

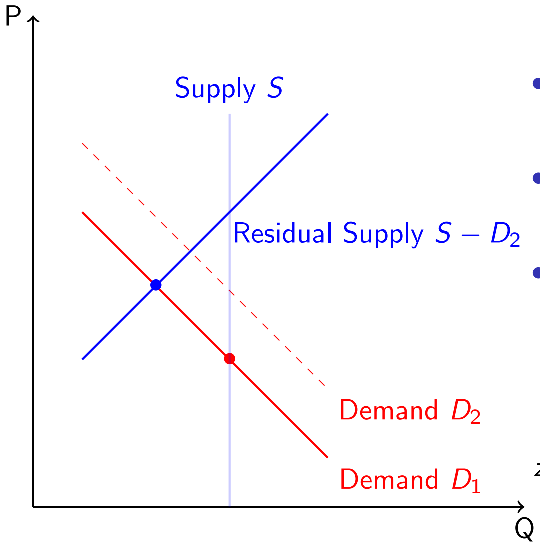
Challenge I: Invalid IV



- Instrument D_2 using other investors' investment mandates;
- However, demand identification requires shift in D_2 is orthogonal to D_1.
- Are investors' investment mandates really orthogonal?

$$z_{i,t}(n) = \log \left(\sum_{j \notin \{i,1\}} A_{j,t} \frac{\mathbf{1}_j(n)}{1 + |\mathcal{N}_{j,t}|} \right)$$

Challenge I: Invalid IV



- Instrument D_2 using other investors' investment mandates;
- However, demand identification requires shift in D_2 is orthogonal to D_1.
- Are investors' investment mandates really orthogonal?

$$z_{i,t}(n) = \log\left(\sum_{j \notin \{i,1\}} A_{j,t} \frac{\mathbf{1}_j(n)}{1 + |\mathcal{N}_{j,t}|}\right)$$

Challenge II: Mechanical Elasticity (van der Beck, 2023)

Suppose a passive investor equally allocates her asset into 100 stocks:

$$S_1(n) = \frac{1}{P_1(n) \times 100}$$

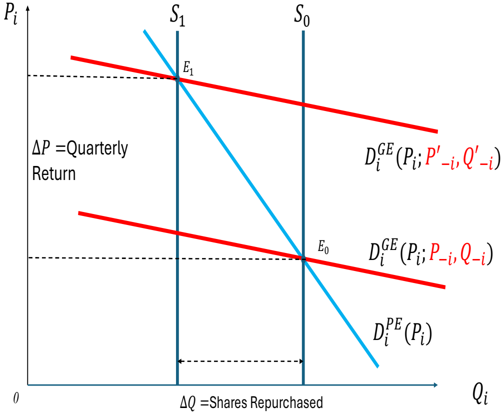
$$w_1(n) = \frac{1}{100}$$

Now, if $P_2(n) > P_1(n)$ increases, all else equal,

$$w_2(n) = \frac{\frac{P_2(n)}{100 \times P_1(n)}}{1 + \frac{P_2(n) - P_1(n)}{100 \times P_1(n)}} = \frac{P_2(n)}{99 P_1(n) + P_2(n)} > \frac{1}{100}$$

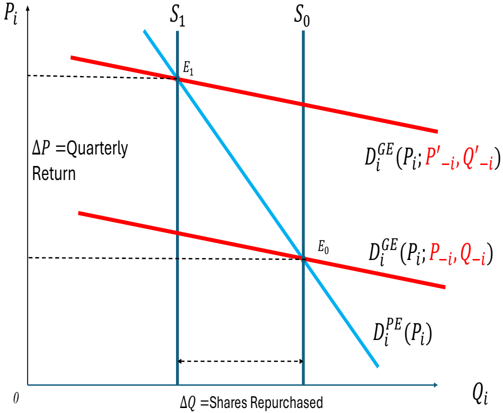
- Can be easily solved by taking first-difference: ΔQ.

Challenge III: Isolated Cross-Asset Substitutions



- Demand for asset j depends on other asset characteristics and prices: $D_j = D_j\left(P_j, P_{-j}, Q_{-j}\right)$.
- Koijen and Yogo (2019) only consider cross-substitutions through investor's wealth distributions.
- Also, they restrict the price spillovers between assets.

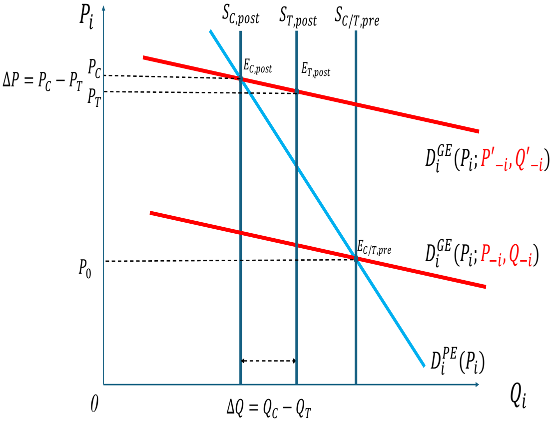
Challenge III: Isolated Cross-Asset Substitutions



- Demand for asset j depends on other asset characteristics and prices: $D_j = D_j(P_j, P_{-j}, Q_{-j})$.
- Koijen and Yogo (2019) only consider cross-substitutions through investor's wealth distributions.
- Also, they restrict the price spillovers between assets.

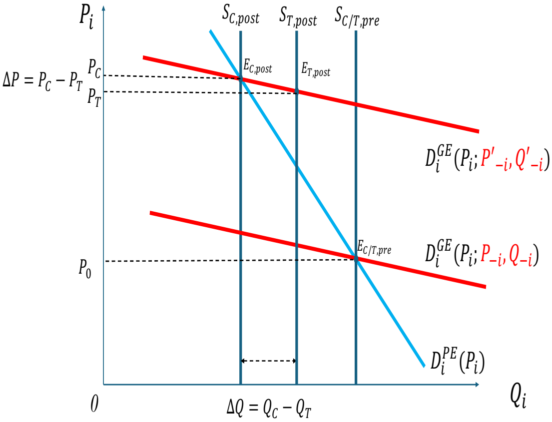
Outline

Identification Intuitions



- **Exogenous shock:** reduction in the share repurchases (*de facto* a supply shock) from a Quasi-RCT.
- **Matching:** Pre-shock characteristics so that two groups are substitutable.
- **Elasticity:** $\Delta P \sim \Delta Q$.

Identification Intuitions



- **Exogenous shock:** reduction in the share repurchases (*de facto* a supply shock) from a Quasi-RCT.
- **Matching:** Pre-shock characteristics so that two groups are substitutable.
- **Elasticity:** $\Delta P \sim \Delta Q$.

Quasi-RCT by the SEC

- Regulators concern reduced tick size caused the decline in small firm IPOs.
  - 2012 Jumpstart Our Business Startups (JOBS) Act directed SEC to investigate it.
- **Tick-Size-Pilot:** Launched on Oct 3, 2016 (2016Q4), and terminated on Oct 1, 2018 (2018Q4).
- Three treatment groups with 400 stocks each ($3 \times 400 = 1,200$), control group with 1,200 stocks (2,400 in total, $\sim$ 55% **of the 4,300 listed stocks**).
  - Share price $\geq$ \$1.50, VWAP $\geq$ \$2, market cap $\leq$ \$3B, avg. volume $<$ 1M shares.
  - The assignment follows a stratified **random** sampling procedure.
- 2016 TSP features:
  - Controls: \$0.01 tick size.
  - Group 1: \$0.05 quotes, \$0.01 trades.
  - Group 2: \$0.05 quotes and trades.
  - Group 3: same as Group 2 + Trade-at Rule (priority to displayed orders).

An Exogenous Supply Shock

- The change of tick sizes is NOT intended to change share repurchase.
- Stocks are randomly selected.
- Yet, share repurchases significantly decreases (Li et al., 2024).

	Repurchase (1)	Dividend (2)	Total Payout (3)	Payout Ratio (4)
Treatment×Post	**-0.096***** **(-2.90)**	**-0.008** **(-0.57)**	**-0.103***** **(-2.92)**	**-0.084***** **(-2.85)**
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes	Yes
Obs.	20,205	20,205	20,205	20,205
Adj. R-squared	0.341	0.706	0.461	0.356

Identification

1. Match each of the Treatment firm *i* with two Control firms in the same SIC 2-digit industry based on pre-treatment average size, growth, profitability, and repurchase payout.

2. Calculate the return differences between treatment and controls,
$\Delta p = log\left(\frac{p_{\text{Treatment,t+1}}}{\bar{p}_{\text{Treatment,t-1}}}\right) - log\left(\frac{p_{\text{Control,t+1}}}{\bar{p}_{\text{Control,t-1}}}\right)$. Stock price is adjusted by stock split.

3. Calculate differences of the repurchase expenditure (scaled by total shares outstanding) between treatment and control firms, $\Delta q = \Delta Repo_{\text{Treatment},t} - \Delta Repo_{\text{Control},t}$.

4. Estimate $\Delta p_{i,t} = \xi \Delta q_{i,t} + \gamma' X_{i,t} + \alpha_t + \eta_j + \varepsilon_{i,t}$
   - ξ: the price impact of repurchasing 1% value of total asset;
   - $X_{i,t}$: the difference of controls between treatment and control firms;
   - α_t and η_j: year-quarter and industry fixed effects.

Identification

1. Match each of the Treatment firm i with two Control firms in the same SIC 2-digit industry based on pre-treatment average size, growth, profitability, and repurchase payout.

2. Calculate the return differences between treatment and controls, $\Delta p = log\left(\frac{p_{\text{Treatment,t+1}}}{\bar{p}_{\text{Treatment,t-1}}}\right) - log\left(\frac{p_{\text{Control,t+1}}}{\bar{p}_{\text{Control,t-1}}}\right)$. Stock price is adjusted by stock split.

3. Calculate differences of the repurchase expenditure (scaled by total shares outstanding) between treatment and control firms, $\Delta q = \Delta Repo_{\text{Treatment},t} - \Delta Repo_{\text{Control},t}$.

4. Estimate $\Delta p_{i,t} = \xi \Delta q_{i,t} + \gamma' X_{i,t} + \alpha_t + \eta_j + \varepsilon_{i,t}$
   - ξ: the price impact of repurchasing 1% value of total asset;
   - $X_{i,t}$: the difference of controls between treatment and control firms;
   - α_t and η_j: year-quarter and industry fixed effects.

Identification

1. Match each of the Treatment firm i with two Control firms in the same SIC 2-digit industry based on pre-treatment average size, growth, profitability, and repurchase payout.

2. Calculate the return differences between treatment and controls,
$\Delta p = log\left(\frac{p_{\text{Treatment,t+1}}}{\bar{p}_{\text{Treatment,t-1}}}\right) - log\left(\frac{p_{\text{Control,t+1}}}{\bar{p}_{\text{Control,t-1}}}\right)$. Stock price is adjusted by stock split.

3. Calculate differences of the repurchase expenditure (scaled by total shares outstanding) between treatment and control firms, $\Delta q = \Delta Repo_{\text{Treatment},t} - \Delta Repo_{\text{Control},t}$.

4. Estimate $\Delta p_{i,t} = \xi \Delta q_{i,t} + \gamma' X_{i,t} + \alpha_t + \eta_j + \varepsilon_{i,t}$
    - ξ: the price impact of repurchasing 1% value of total asset;
    - $X_{i,t}$: the difference of controls between treatment and control firms;
    - α_t and η_j: year-quarter and industry fixed effects.

Identification

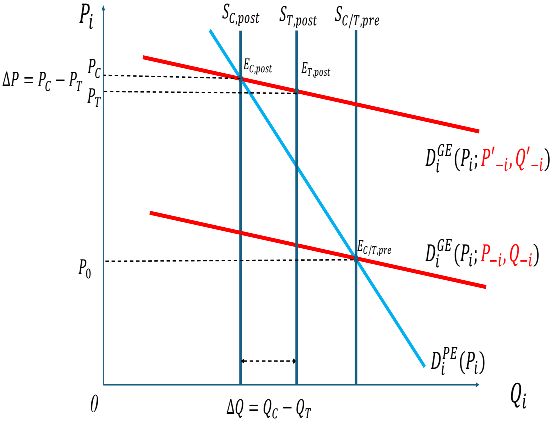
1. Match each of the Treatment firm i with two Control firms in the same SIC 2-digit industry based on pre-treatment average size, growth, profitability, and repurchase payout.

2. Calculate the return differences between treatment and controls, $\Delta p = log\left(\frac{p_{\text{Treatment,t+1}}}{\bar{p}_{\text{Treatment,t-1}}}\right) - log\left(\frac{p_{\text{Control,t+1}}}{\bar{p}_{\text{Control,t-1}}}\right)$. Stock price is adjusted by stock split.

3. Calculate differences of the repurchase expenditure (scaled by total shares outstanding) between treatment and control firms, $\Delta q = \Delta Repo_{\text{Treatment},t} - \Delta Repo_{\text{Control},t}$.

4. Estimate $\Delta p_{i,t} = \xi \Delta q_{i,t} + \gamma' X_{i,t} + \alpha_t + \eta_j + \varepsilon_{i,t}$
   - ξ: the price impact of repurchasing 1% value of total asset;
   - $X_{i,t}$: the difference of controls between treatment and control firms;
   - α_t and η_j: year-quarter and industry fixed effects.

Why is it better?



1. Use supply shock to identify demand function.
2. First-difference to avoid mechanical substitutions: $\Delta P \sim \Delta Q$.
3. Diff-in-Diff to control for price spillovers/ cross-asset substitutions.

Outline

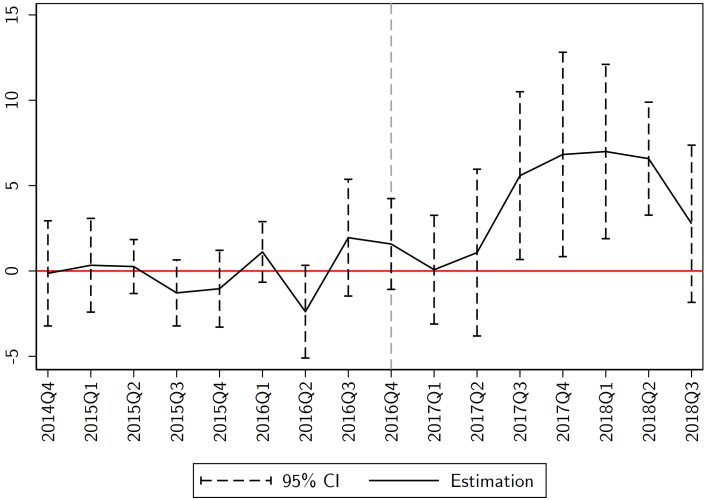
Main Results

	$\Delta p_{i,t}$ (%)		
	(1)	(2)	(3)
$\Delta q_{i,t}$ (%)	**6.110*** **	**4.255*** **	**3.914*** **
	(3.59)	**(4.60)**	**(4.10)**
Controls	No	Yes	Yes
Industry FE	No	No	Yes
Year-quarter FE	Yes	Yes	Yes
Obs.	3,669	3,655	3,655
Adj. R-squared	0.010	0.548	0.582

- Repurchasing 1% of total assets increases the share price by 3.9%.

Event Study

- This figure shows the dynamics of our estimation.



Robustness Checks: the Same Demand Curve

- Placebo test (1): Pre- and post-treatment period as 2013Q4–2014Q3, 2014Q4–2015Q3.
- Pre-treatment (2): Estimation in pre-treatment period (2014Q4-2016Q3).

	$\Delta p_{i,t}$ (%)	
	Placebo	Pre-treatment
	(1)	(2)
$\Delta q_{i,t}$ (%)	**2.339**	**-0.328**
	(1.50)	**(-0.69)**
Controls	Yes	Yes
Industry FE	Yes	Yes
Year-quarter FE	Yes	Yes
Obs.	1,472	3,364
Adj. R-squared	0.512	0.214

Robustness Checks: Subsample Analysis

- Column (1): Repurchasing firms only (firms ever repurchased in pre-treatment period).
- Column (2): Group G1 & G2 only.
- Column (3): Group G3 only.

	$\Delta p_{i,t}$ (%)		
	Repurchasing firms	G1&2	G3
	(1)	(2)	(3)
$\Delta q_{i,t}$ **(%)**	**4.282*** **	**3.579** **	**3.538***
	(3.90)	**(3.03)**	**(1.94)**
Controls	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes
Obs.	1,811	2,525	1,130
Adj. R-squared	0.606	0.575	0.619

Robustness Checks: Alternative Measures

- Column (1): 1% shares repurchased relative to total shares outstanding.
- Column (2): One-to-one match.

	$\Delta p_{i,t}$ (%)	
	1% share	1-to-1 match
	(1)	(2)
$\Delta q_{i,t}$ **(%)**	**1.009*****	**3.692*****
	(3.82)	**(6.16)**
Controls	Yes	Yes
Industry FE	Yes	Yes
Year-quarter FE	Yes	Yes
Obs.	3,655	3,455
Adj. R-squared	0.580	0.591

Heterogeneity Analysis: Koijen and Yogo (2019) Price Impact

- A stock is assigned to "low impact" ("high impact") subsample if its pre-treatment average price impact from Koijen and Yogo (2019) is below (above) the cross-sectional median.

Panel A: Koijen and Yogo (2019)

	$\Delta p_{i,t}$ (%)	
	High KY impact	Low KY impact
	(1)	(2)
$\Delta q_{i,t}$ (%)	**5.268*** **	**4.264** **
	(4.73)	**(2.84)**
Controls	Yes	Yes
Industry FE	Yes	Yes
Year-quarter FE	Yes	Yes
Obs.	1,688	1,237
Adj. R-squared	0.586	0.611

Heterogeneity Analysis: Quote Spread

- A stock is assigned to "large spread" ("small spread") subsample if its pre-treatment average percent quote spread is above (below) the cross-sectional median.

Panel B: Tick Constraints		
	$\Delta p_{i,t}$ (%)	
	Large spread	Small spread
	(1)	(2)
$\Delta q_{i,t}$ (%)	**3.890*** **	**2.630** **
	(3.55)	**(2.66)**
Controls	Yes	Yes
Industry FE	Yes	Yes
Year-quarter FE	Yes	Yes
Obs.	1,376	1,320
Adj. R-squared	0.577	0.632

Heterogeneity Analysis: Firm Size

- A stock is assigned to "small firm" ("large firm") subsample if its pre-treatment average market cap is below (above) the cross-sectional median.

Panel C: Firm Size		
	$\Delta p_{i,t}$ (%)	
	Small firm	Large firm
	(1)	(2)
$\Delta q_{i,t}$ **(%)**	**4.234****	**2.058**
	(2.39)	**(1.89)**
Controls	Yes	Yes
Industry FE	Yes	Yes
Year-quarter FE	Yes	Yes
Obs.	1,368	1,826
Adj. R-squared	0.586	0.630

Outline

Conclusion

- This paper is the first to estimate the demand elasticity in the U.S. stock market through the lens of supply shocks.
  - Evidence from the Tick Size Pilot shows that, market value decreases by 3.9% for an 1% decrease of share supply in total asset value.
  - More to be done: a structural model to rationalize our identification methods.
- Policy Implications: “save” the market with a little amount of money, *i.e.*, quantitative easing.

References I

Fuchs, W., Fukuda, S., and Neuhann, D. (2023). Demand-system asset pricing: Theoretical foundations. *Available at SSRN 4672473*.

Koijen, R. S. and Yogo, M. (2019). A demand system approach to asset pricing. *Journal of Political Economy*, 127(4):1475–1515.

Li, X., Ye, M., and Zheng, M. (2024). Price ceilings, market structure, and payout policies. *Journal of Financial Economics*, 155:103818.

Petajisto, A. (2009). Why do demand curves for stocks slope down? *Journal of Financial and Quantitative Analysis*, 44(5):1013–1044.

van der Beck, P. (2023). Demand-based asset pricing: Theory, estimation and applications. Technical report, EPFL.