How Competitive is the Stock Market?
Theory, Evidence from Portfolios, and Implications for the Rise of Passive Investing

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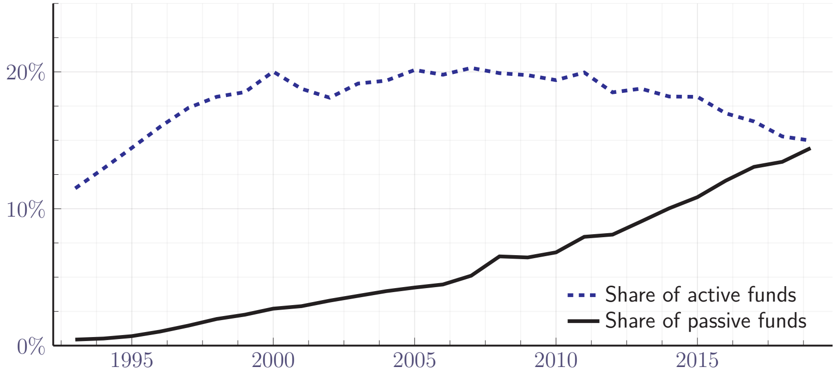
What is the effect of changes in the trading strategy of some institutions on the equilibrium behavior of asset prices?

The Rise of Passive Investing

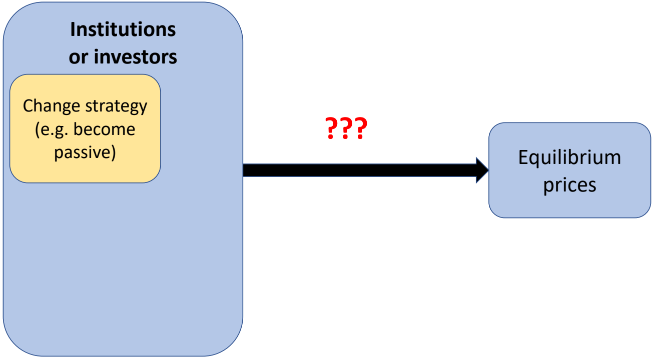
Active and passive (+ ETF) mutual funds as fraction of US total market cap. (source: ICI)



→ *How does this change prices and investment opportunities?*

What is the effect of changes in the strategy of some institutions on the equilibrium behavior of prices?

- **The rise of passive investing**



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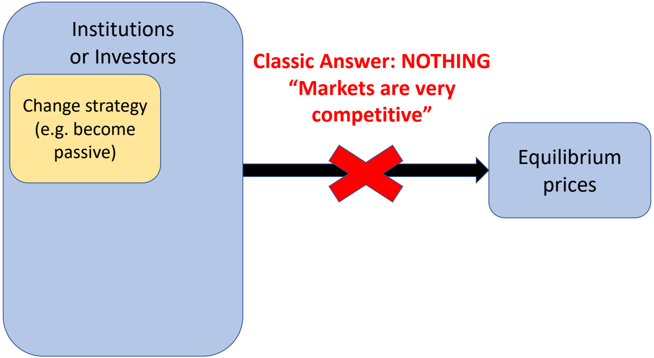

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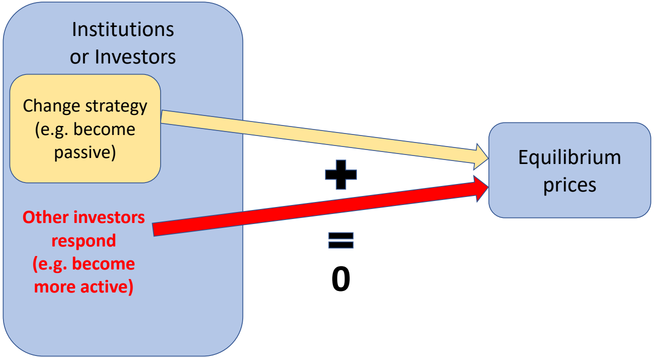

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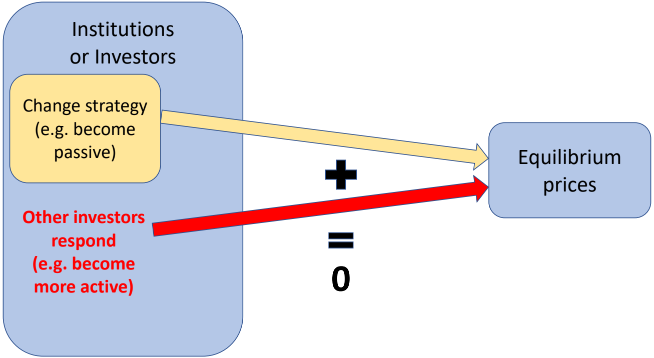
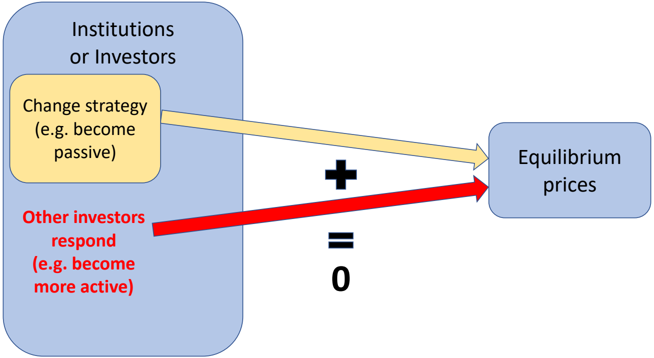


→ How large is the strategic response?

What is the effect of changes in the strategy of some institutions on the equilibrium behavior of prices?

- **The rise of passive investing**
- Regulated financial intermediaries trading more conservatively
- An "arbitrageur" (e.g. Melvin Capital) going bust



→ **How large is the strategic response?**

This Paper

1. **What is the strategic response of investors?**
   - Investor interact in setting trading strategies
     - How does my trading strategy respond to what other investors are doing?

This Paper

1. **What is the strategic response of investors?**
   - Investor interact in setting trading strategies
     - How does my trading strategy respond to what other investors are doing?
   - Across many theories, change in trading strategy can be summarized by change in demand elasticity (= aggressiveness)
     - Information acquisition (Grossman Stiglitz 1980)
     - Market power (Kyle 1989)
     - Behavioral friction: bounded rationality, cursed equilibrium
   - Simple statistic, degree of strategic response χ: how much does my demand elasticity respond to the aggregate demand elasticity?
     - **If someone stops looking for $20 bills on the floor, how much harder do you look?**

This Paper

2. **Provide a framework to quantify the degree of strategic response and its implications for prices**
   - Semi-structural approach: equilibrium with exogenously specified decision functions
     - Demand system accounting for large heterogeneity across stocks and investors
   - 2-layer equilibrium
     - Competition for the asset: *Prices so that investor demands clear market*
     - Competition in strategies: *Investor interactions in choosing their demand elasticities*

This Paper

3. **Measure strategic responses in the U.S. stock market**
   - Strategic response much weaker than benchmark, $\chi = 2$ ("competitive" $\chi = \infty$, no response $\chi = 0$)
   - Direct effect of changes in individual behavior reduced by 60%
   - Rise of passive investing leads to 15% more inelastic aggregate demand curves for individual stocks
     - If buying \$1 of a stock used to raise its price by \$2.5, now the response is \$3
     - More volatility, less liquidity

Outline

Outline

Investor Competition Framework: 2-Layer Equilibrium

	Individual Decision	Equilibrium Condition
Competition for the asset	$d_i = \underline{d}_i - \mathcal{E}_i \times (p - \bar{p})$	$\int_i D_i(p) = S$

- **Demand elasticity** $\mathcal{E}_i$:
  - Inelastic markets: more impact of flows on prices: 1% increase in demand creates an $M_{agg} = \mathcal{E}_{agg}^{-1}\%$ increase in prices
    - in simple theories: more volatility, less price informativeness, less liquidity

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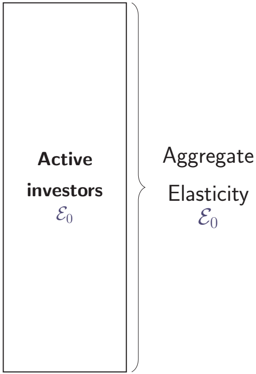
- **Degree of strategic response χ**
  - $\chi = 0$, *no response*: each investor follows independent strategies
  - $\chi \to \infty$, *"financial markets are competitive"*: any change completely counteracted by investor reaction

What Determines the degree of Strategic Response?

Limits to the ability to have a strategic response:

- Investment mandates
- Imperfect knowledge of others' behavior
- Costly information acquisition (Grossman Stiglitz 1980)
- Endogenous risk
- Partial equilibrium thinking (Eyster Rabin 2005, Greenwood Hanson 2014)
- *Complementarity* ($\chi < 0$): Liquidity (Kyle 1989), peer effects (Hong Kubik Stein 2004, Reddit)

Impact of the Rise in Passive Investing



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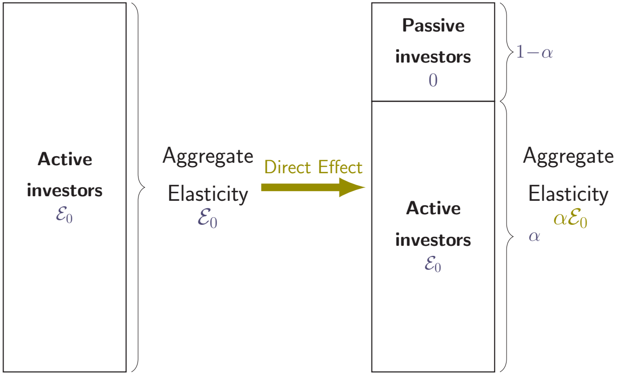

- Empirical increase in fraction of passive investors: $\alpha = 70\%$
  - No strategic response ($\chi = 0$): proportional reduction, $\mathcal{E}_{NEW} = \alpha\mathcal{E}_0 = 70\% \times \mathcal{E}_0$

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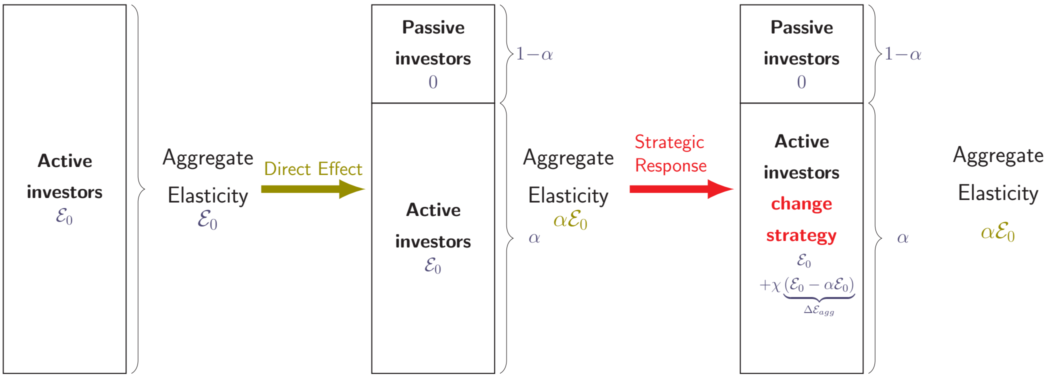

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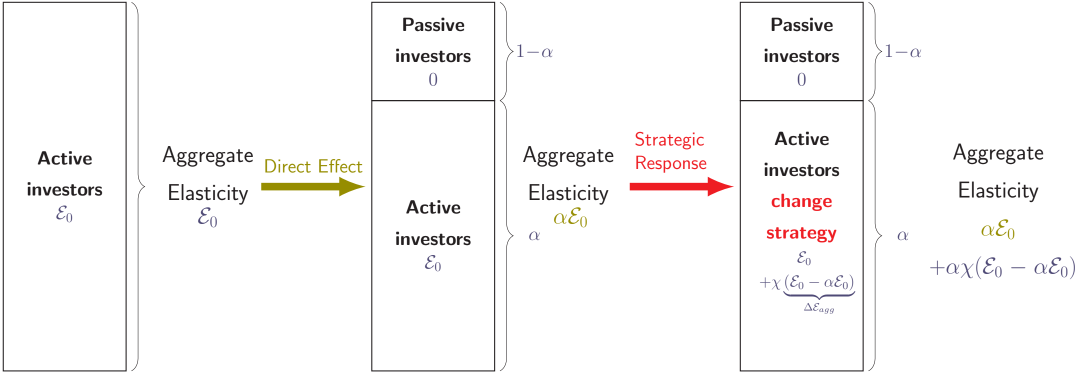

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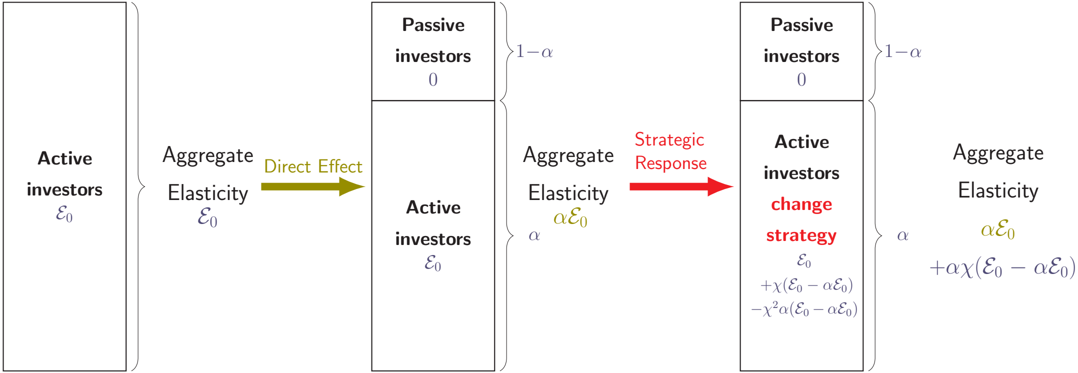

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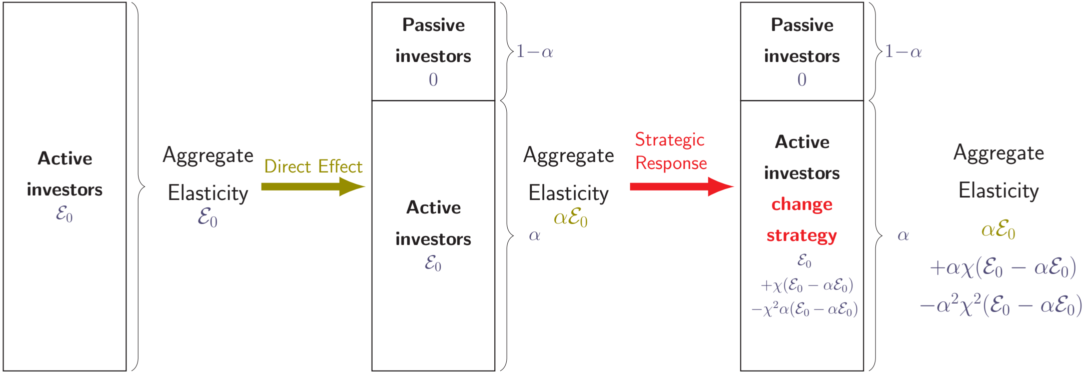

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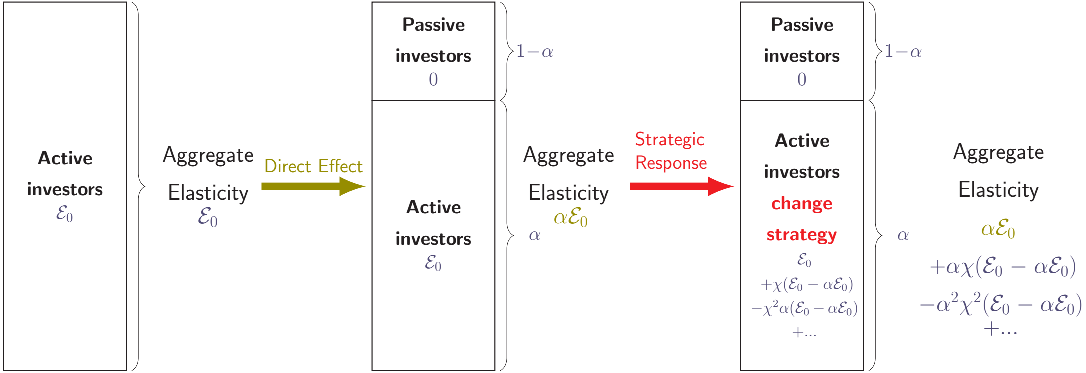

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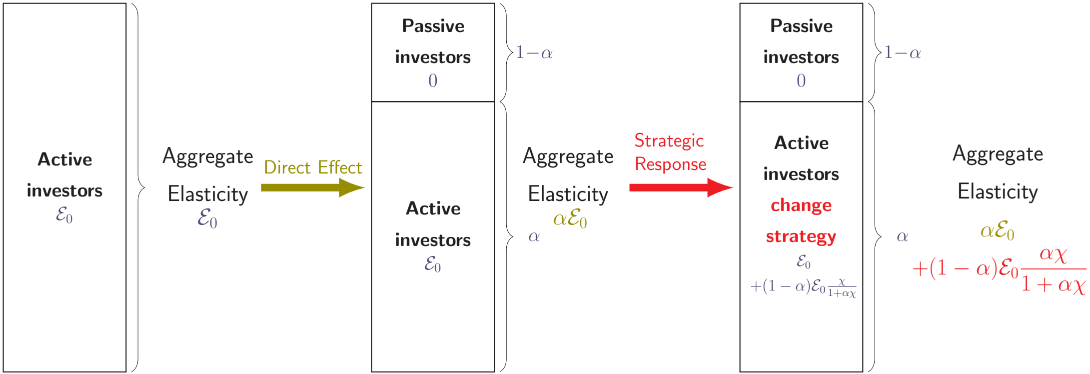

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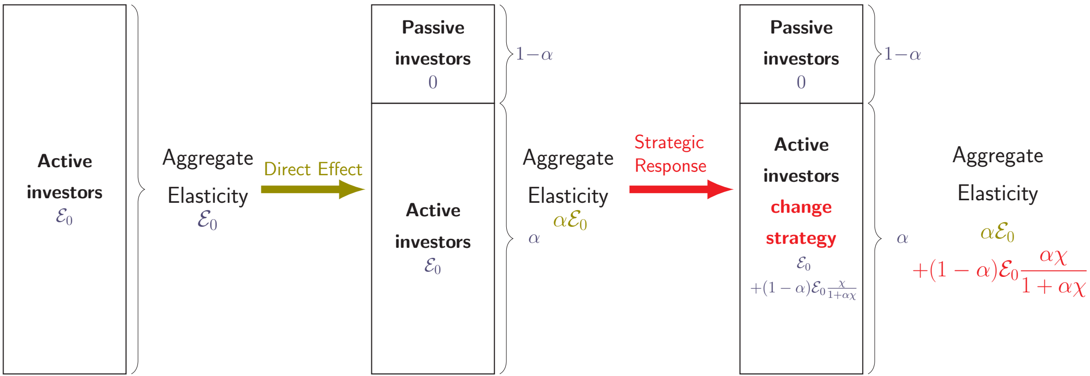
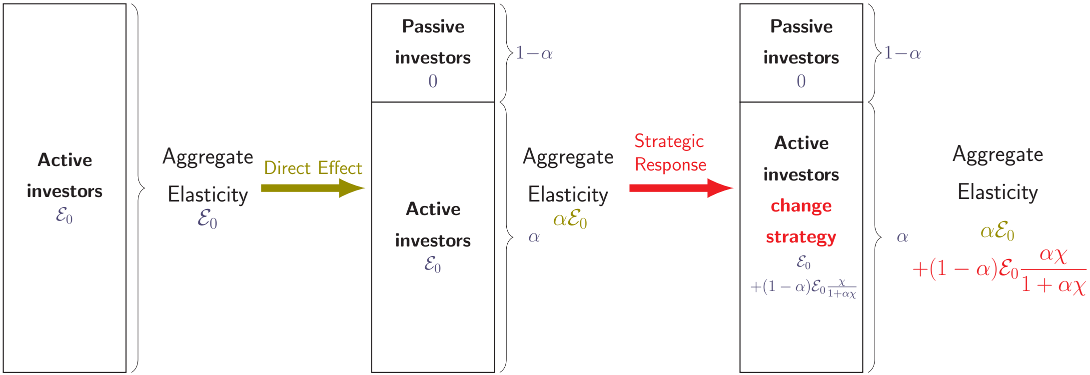


- Empirical increase in fraction of passive investors: $\alpha = 70\%$
  - No strategic response ($\chi = 0$): proportional reduction, $\mathcal{E}_{NEW} = \alpha\mathcal{E}_0 = 70\% \times \mathcal{E}_0$
  - "Perfectly competitive financial markets" ($\chi \to \infty$): nothing happens, $\mathcal{E}_{NEW} = \alpha\mathcal{E}_0 + (1-\alpha)\mathcal{E}_0 = \mathcal{E}_0$

Impact of the Rise in Passive Investing



- Empirical increase in fraction of passive investors: $\alpha = 70\%$
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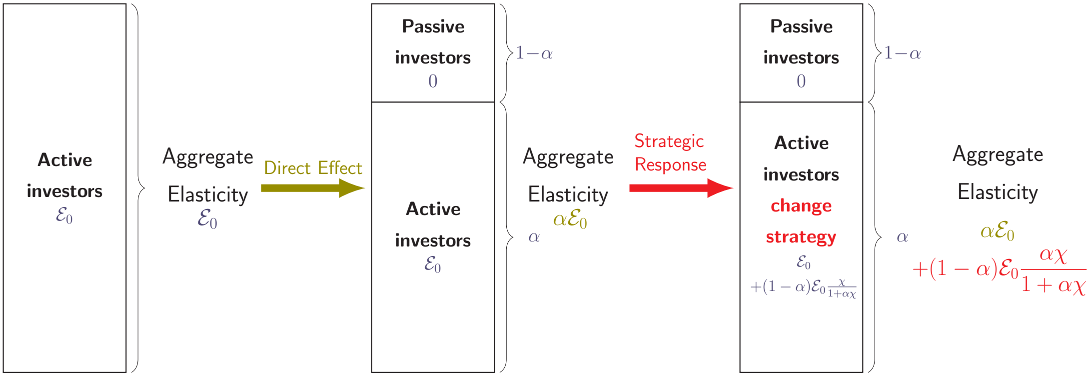

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$\Rightarrow \mathcal{E}_{NEW} = 87.5\% \times \mathcal{E}_0$ (vs 100% with full response and 70% without strategic response)

Outline

1. Our Framework
2. Quantitative Model
3. Estimates of Strategic Response and Implications

Data

- Stock level data
  - CRSP and COMPUSTAT
  - Price and characteristics: book equity, dividends, profitability, investment
- Portfolio data
  - 13F filings from SEC, 2000–2020 (Backus, Conlon and Sinkinson, 2020)
  - Every institution with AUM over $100m reports stock positions quarterly
  - Includes 80% of total ownership in U.S. stock market (2008)
  - Residual for market clearing collected as "households"
  - **Each quarter: keep track of 1300 investors and 2800 stocks**

Quantitative Model

- Portfolio choice represented by a logit in portfolio shares w_{ik} (Koijen Yogo 2019)

$$\underbrace{\log \frac{w_{ik}}{w_{i0}} - p_k}_{\text{relative demand}} = \underbrace{-\,\mathcal{E}_{ik}\; p_k}_{\text{price elasticity}} + \underbrace{\underline{d}_{0i} + \underline{d}'_{1i} X_k + \epsilon_{ik}}_{\text{baseline demand}}$$

$$\mathcal{E}_{ik} = \underbrace{\underline{\mathcal{E}}_{0i} + \underline{\mathcal{E}}'_{1i} X_k}_{\text{baseline elasticity}} - \underbrace{\chi\, \mathcal{E}_{agg,k}}_{\text{strategic response}}$$

- Baseline demand $\underline{d}_i$
- Baseline elasticity $\underline{\mathcal{E}}_i$
  - Embeds Koijen Yogo 2019, who assume no competition: $\chi = 0$
- **Passive investors**: $\mathcal{E}_i = 0$ (includes index investing, identified using KY elasticity)

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equilibrium of individual $\mathcal{E}_{ik}$'s

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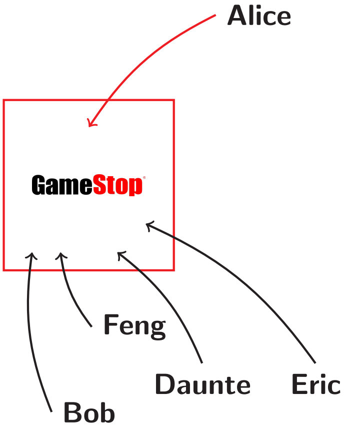
Three Challenges for Estimation

- *Reflection problem* (Manski 1993)
- *Endogeneity in demand estimation*
  - Koijen-Yogo (2019) price instrument + model-based instruments for aggregate elasticity
- *Implementation*
  - An efficient algorithm to run large dimensional regressions and solve all the equilibria simultaneously: **process each quarter of data in about 2 minutes**

The Reflection Problem

- Does Alice trade GameStop agressively because
  - she is an agressive trader: high $\underline{\mathcal{E}}_i$
  - of the influence of other traders: $\chi < 0$



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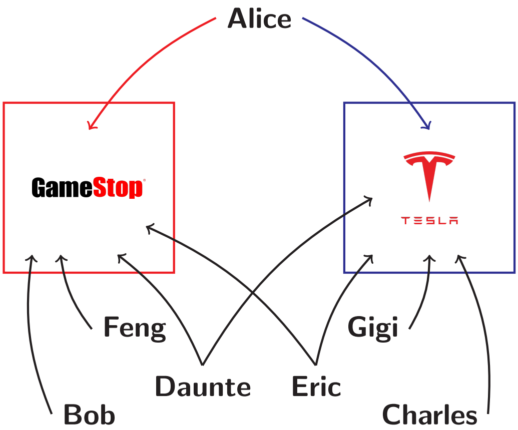
$\rightarrow$ **Alice faces a different mix of other investors for different stocks**



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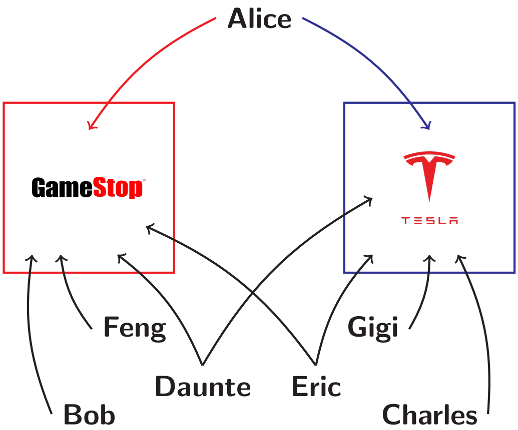
$\rightarrow$ **Alice faces a different mix of other investors for different stocks**

Theorem

Unique decomposition between $\underline{\mathcal{E}}_i$ and χ if:

1. *Graph $\mathcal{G}$ of investor-stock links is connected*
2. *Average individual elasticities $\sum_i \underline{\mathcal{E}}_{ik} w_{ik} A_i / p_k$ vary across stocks*



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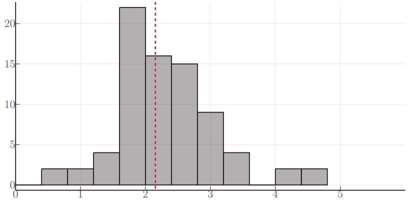
Estimates of Strategic Response χ



- **Degree of strategic response**
  estimate stable over time, $\chi = 2.15$

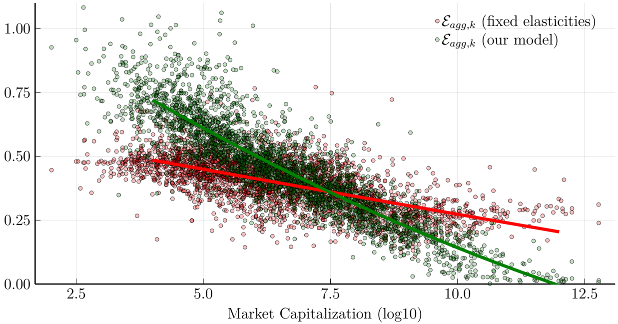
- **Substantial individual response**: The same investor responds less to price movements for assets with more aggressive investors than assets with less aggressive investors
  - If all other investors are more elastic by 1, lower my elasticity by 2.15

- **Far from "competitive financial markets"**, $\chi \ll \infty$
  - In simple calculation, needed $\chi > 18$ to compensate 90% of direct effect

Robustness of Competition Estimates

	Estimates for χ		
	Median	25th pct.	75th pct.
(1) Baseline Specification	2.15	1.81	2.76
(2) BE-weighted Instrument for $\mathcal{E}_{agg}$	1.91	1.52	2.31
(3) Additional Controls	2.51	2.09	3.5
(4) AUM-weighted Regression	2.3	1.81	2.8
(5) Book-weighted Regression	2.27	1.76	2.78
(6) Investor-Type Grouping	2.42	1.93	2.94
(7) Constant χ	1.95		
(8) No Instrument for $\mathcal{E}_{agg}$	1.21	0.77	1.56
(9) No Instruments	0.96	0.67	1.38

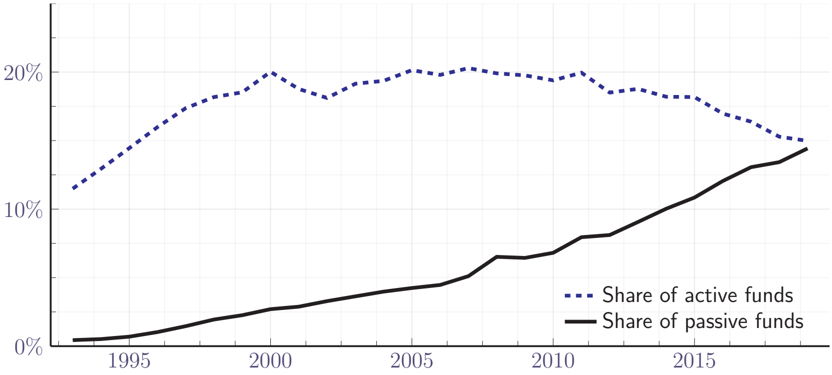
Estimates of Aggregate Elasticity by Stock



- **Elasticities are low** ≈ 0.4: consistent with previous studies
- **Size effect**: less willing to adjust positions with large weights
- **Less cross-sectional variation**: important to account for the elasticity equilibrium
  - If an active investor shows up in one stock, others become more passive

The Rise of Passive Investing

Active and passive (+ ETF) mutual funds as fraction of US total market cap. (source: ICI)



- In our estimation, fraction of active investors down from 81% to 59% from 2001 to 2020

The Rise of Passive Investing

What does the model predict about the effect of this trend?

- Aggregate elasticity equilibrium:

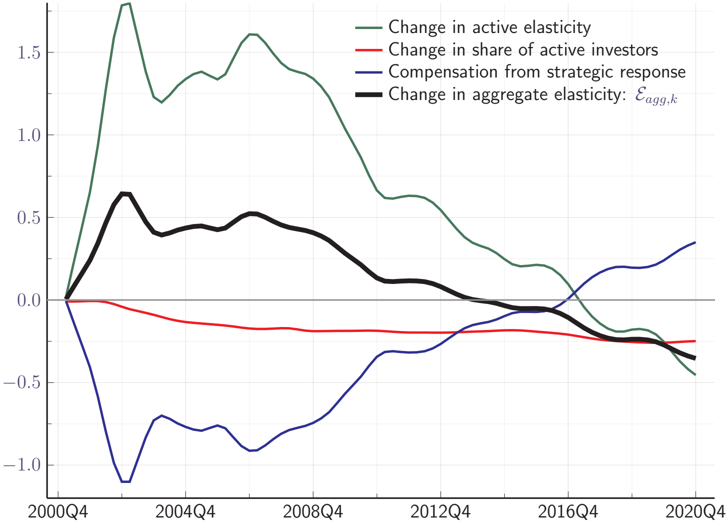
$$\mathcal{E}_{agg,k} = \underbrace{|A_k|}_{\text{fraction active}} \times \underbrace{\mathbf{E}\left(\mathcal{E}_{ik} | i \in A_k\right)}_{\text{avg. active elasticity}} \times \underbrace{\frac{1}{1+\chi|A_k|}}_{\text{general equilibrium}}$$

- Effect of change in active share:
  - Assuming random investors switch:

$$\frac{d\log \mathcal{E}_{agg}}{d\log |A|} = \frac{1}{1+\underbrace{\chi}_{2.15}\underbrace{|A|}_{68\%}} = 40.6\%$$

Elasticities drop by $40.6\% \times 32\% = 13\%$

Decomposing Actual Changes in Elasticity



Implications for Price Dynamics

The rise of passive investing decreased elasticities by 13%

elasticity $\downarrow \Rightarrow$ volatility $\uparrow$, price informativeness $\uparrow$, liquidity$\downarrow$

	Total Volatility (1)	Idiosyncratic Volatility (2)	Price informativeness (3)	Illiquidity (4)
Elasticity	-0.867^{***}	-0.846^{***}	-0.365	-0.742^{***}
	(0.173)	(0.145)	(0.833)	(0.278)
Controls	Yes	Yes	Yes	Yes
Estimator	IV	IV	IV	IV
N	219,663	206,134	66,707	216,893
R^2	0.164	0.193	0.015	0.551

Beyond Passive Investing

Lack of strategic response implies that:

- There are profitable trading opportunities where others haven't stepped in yet
- There are crowded trades that many take even if unprofitable
- **Key source of information**: follow where different investors are going, analyze holdings data

Conclusion

- **Degree of strategic response** χ: useful statistic to understand the equilibrium effect of changes in specific investors' behavior
  - A tractable approach: 2-layer equilibrium
- **Stock market far from the "perfectly competitive ideal"**, $\chi = 2 \ll \infty$
  - Dampen direct effects by 60%
- **Rise of passive investing leads to 15% more inelastic markets**
  - Effect on cross-section of stocks in the paper

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  - Effect on cross-section of stocks in the paper
- More applications:
  - Financial health and regulation of intermediaries
  - Role of big data
  - International finance: what if China stops buying treasuries?

APPENDIX

Asymmetry of Mispricing

Do prices respond more to demand when the asset is overpriced or underpriced?

$$M_{agg} = \frac{1}{\mathcal{E}_{agg}} \cdot \frac{1}{1 + \frac{\chi}{1+\chi} \frac{Var[\mathcal{E}_i]}{\mathcal{E}_{agg}} (p - \bar{p})},$$

- No competition: overpriced asset drives out elastic investors, aggregate elasticity drops $\rightarrow$ high multiplier
- Full competition: competition compensate previous effect, and higher individual elasticity drives lower demand when asset is overpriced $\rightarrow$ low multiplier
- *Overpricing stronger than underpricing when competition is low, strength depends on investor heterogeneity*
  - Stock strategies: Stambaugh Yu Yuan (2012, 2015)

Back

Arbitrage Dynamics

- Key source of instability with limits to arbitrage: aggressive investors suffer more when mispricing gets worse $\rightarrow$ arbitrage capacity is lost $\rightarrow$ mispricing becomes even worse (Shleifer Vishny 1990, Brunnermeier Pedersen 2008)
- *How much does competition limit this instability?*

$$\Delta p = M_{agg} \times \left[\mathbf{E}\left(\Delta \underline{d}_i\right) + \frac{\chi}{1+\chi}\left(p - \bar{p}\right)\ Cov(\mathcal{E}_i, \Delta \underline{d}_i) \right]$$

  - Consider an underpriced asset becoming worse: negative demand shock affecting disproportionately high-elasticity investors ($p < \bar{p}$, $Cov(\mathcal{E}_i, \Delta \underline{d}_i) < 0$)
  - Classic force: high-elasticity investors have larger position, so contribute more to a drop in price
  - Competition compensation: increase in all other investors elasticity creates more demand

Back

Linearity-Generating Cost Functions

Proposition. For any $a > 0$ and $b > 0$ so that $ab > 1$, assume the information cost follows the function:

$$c_i(x) = 0, \text{ if } \; x < 0,$$

$$c_i(x) = \frac{1}{\rho_i} \frac{1}{\sqrt{2ab-1}} \arctan\left(\frac{b\frac{x}{\rho_i} + (1-ab)}{\sqrt{2ab-1}} \right) + K, \text{ if } 0 \leq x/\rho_i \leq a - b^{-1}$$

$$c_i(x) = +\infty, \text{ if } \; x/\rho_i \geq a - b^{-1},$$

where K is such that $c_i(0) = 0$. This cost function is increasing and convex. Then the optimal elasticity is:

$$\mathcal{E}_i = \underline{\mathcal{E}}_i - \chi \mathcal{E}_{agg},$$

with $\underline{\mathcal{E}}_i = a$ and $\chi = \sqrt{(2\sigma_x^{-2})/(\rho_i b)}$.

▸ Back

Demand Estimation

$$\log \frac{w_{ik}}{w_{i0}} - p_k = \underline{d}_{0i} + \underline{d}'_{1i} X_k - \left(\underline{\mathcal{E}}_{0i} + \underline{\mathcal{E}}'_{1i} X_k - \chi \; \mathcal{E}_{agg,k} \right) \times p_k + \epsilon_{ik}$$

Demand Estimation

$$\log \frac{w_{ik}}{w_{i0}} - p_k = \underline{d}_{0i} + \underline{d}_{1i}' X_k - \left(\underline{\mathcal{E}}_{0i} + \underline{\mathcal{E}}_{1i}' X_k - \chi\, \mathcal{E}_{agg,k}\right) \times p_k + \epsilon_{ik}$$

Classic endogeneity in demand estimation: aggregate elasticity and prices are equilibrium outcomes

- If investors demand more of the stock, the price will be high
  - OLS invalid: $\mathbb{E}[\epsilon_{ik}|p_k] \neq 0$
- Instrument for the price: $\mathbb{E}[\epsilon_{ik}|\hat{p}_{ik}] = 0$
  - $\hat{p}_{ikt}$: how much money would go towards stock k if all other investors invested in equal-weighted portfolio (Koijen Yogo 2019)
- *Model-based instrument* for the aggregate elasticity $\mathbb{E}[\epsilon_{ik}|\hat{\mathcal{E}}_{agg,k}] = 0$
  - $\hat{\mathcal{E}}_{agg,k}$: what would the aggregate elasticity if investors used equal-weighted portfolios (depends on estimates of $\mathcal{E}_{ik}$)

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Implementation: Confronting the 2-Layer Equilibrium

$$\log \frac{w_{ik}}{w_{i0}} - p_k = \underline{d}_{0i} + \underline{d}'_{1i} X_k - \left(\underline{\mathcal{E}}_{0i} + \underline{\mathcal{E}}'_{1i} X_k - \chi \, \mathcal{E}_{agg,k} \right) \times p_k + \epsilon_{ik}$$

- Competition χ ties together investor decisions
  - Without competition: only investor-specific coefficients $\rightarrow$ lots of small regressions
  - Together: many fixed effects, interacted fixed effects, ...
- Unknown equilibrium aggregate elasticities $\mathcal{E}_{agg,k}$
  - Must satisfy elasticity equilibrium condition

Implementation: Confronting the 2-Layer Equilibrium

$$\log \frac{w_{ik}}{w_{i0}} - p_k = \underline{d}_{0i} + \underline{d}_{1i}' X_k - \left(\underline{\mathcal{E}}_{0i} + \underline{\mathcal{E}}_{1i}' X_k - \chi \, \mathcal{E}_{agg,k} \right) \times p_k + \epsilon_{ik}$$

- Competition χ ties together investor decisions
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$\rightarrow$ **Solution**: Flip fixed point problem in terms of χ instead of $\mathcal{E}_{agg,k}$ (5 minutes vs. hours)

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Instruments

- Price (Koijen Yogo 2019)

$$\hat{p}_{k,i} = \log\left(\sum_{j\neq i} A_j \frac{\mathbf{1}_{k\in\mathcal{K}_j}}{|\mathcal{K}_j|}\right),$$

- Aggregate elasticity

$$\hat{\mathcal{E}}_{agg,k} = \frac{1}{1+\chi|Active_k|}\frac{\sum_{j\in Active_k} A_j/|\mathcal{K}_j|\cdot\mathbf{1}_{k\in\mathcal{K}_j}\cdot\underline{\mathcal{E}}_{jk}}{\sum_{j\in Active_k} A_j/|\mathcal{K}_j|\cdot\mathbf{1}_{k\in\mathcal{K}_j}}$$

  - Model-based instrument: depends on estimated $\underline{\mathcal{E}}_{jk}$
  - Valid for estimation
  - Renders 2SLS impossible: must be computed simultaneously with estimation

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- Efficient solution:
  1. Start with $(\chi, \mathcal{E}_{agg})$
     - ★ Estimate $(\underline{\mathcal{E}}_{0i}, \underline{\mathcal{E}}_{1i})$ using regression for each investor i
     - ★ Update $\mathcal{E}'_{agg}$ by solving the elasticity equilibrium conditions
  2. Fixed point gives $\chi \mapsto \mathcal{E}_{agg}(\chi)$
  3. Start with χ
     - ★ Estimate the overall regression (with all investors) with $\mathcal{E}_{agg}(\chi)$ as data
     - ★ Gives an estimate χ'
  4. Fixed point of the mapping from $\chi \mapsto \chi'$

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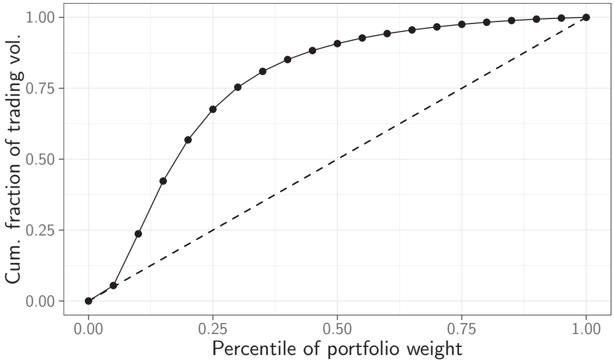
Trading Activity as a Function of Portfolio Weight

Define trading activity as relative square change in shares:

$$\left(\frac{Shares_{ik,t} - Shares_{ik,t-1}}{Shares_{ik,t}}\right)^2$$

Cumulative fraction of cumulative trading activity by percentile of portfolio weight:



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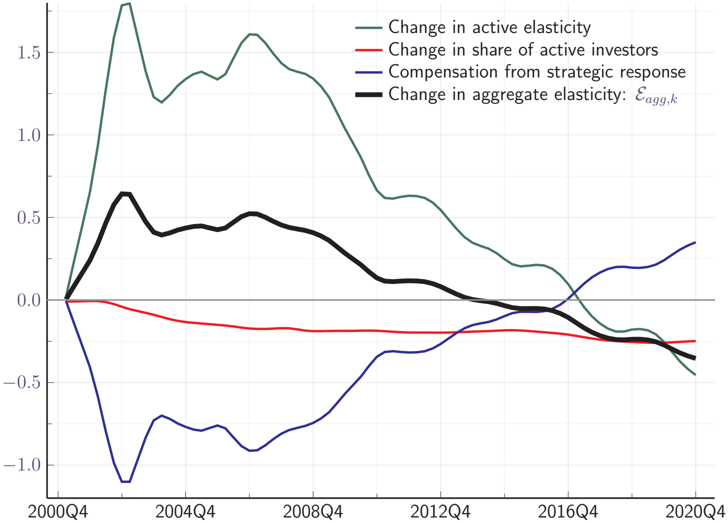
Decomposing Actual Changes in Elasticity



Counterfactual Changes in Elasticity

What would have been the effect of these changes with different levels of competition?

- Start from 2000 distribution of equilibrium elasticities
- Assume same changes in passive share, and in individual level elasticity $\underline{\mathcal{E}}_{i,k}$
- Input different competitive response:
  - Perfect competition: stock-level elasticities unchanged
  - No competition: no change in competitive response

Counterfactual Changes in Elasticity

What would have been the effect of these changes with different levels of competition?