Princeton Initiative 2016: Institutional Finance and Heterogeneous Asset Demand

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Traditional asset pricing

- Assume rational expectations and no constraints.
- Portfolio-choice problem for investor i:

$$\max_{\mathbf{w}_i} \mathbb{E}\left[\frac{A_{i,T}^{1-\gamma_i}}{1-\gamma_i}\right]$$

subject to $A_{i,T} = A_i(w_i(0)R(0) + \mathbf{w}_i'\mathbf{R})$.

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1. Optimal portfolio choice:

$$\mathbf{w}_i \approx \frac{1}{\gamma_i}\Sigma^{-1}\mu$$

   - Portfolio separation theorem implies homogeneous demand up to leverage (Tobin 1958).
   - Trivially rejected by data on individual or institutional portfolios.

2. Market clearing implies CAPM:

$$\mu = \mu_M \beta$$

Two literatures

1. Empirical asset pricing: Ignore micro-foundations and test equilibrium implications (CAPM and multi-factor models) on price data alone.
2. Asset pricing theory: Break the portfolio separation theorem and introduce heterogeneity in asset demand.
   - Heterogeneous expectations: Work in behavioral finance on over-reaction, under-reaction, and extrapolative expectations.
   - Hedging motives: Uninsurable income or liability risk.
   - Career concerns and herding: Fund managers are evaluated relative to a benchmark.
   - Constraints: Investment mandates (pension funds), regulatory capital (banks and insurance companies), or leverage (hedge funds).
   - Large institutions must account for price impact when they trade.

Data on institutional holdings

1. SEC Form 13F: Quarterly stock holdings of institutions managing over $100m since 1980.
2. Thomson Reuters eMAXX: Quarterly bond holdings of institutions (mutual funds and insurance companies) since 2002.
    - Fed: System Open Market Accounts since 2003.
3. Securities Holding Statistics: Comprehensive holdings for the Euro area since 2014.
4. Household-level data from Statistics Sweden for 1983–2007.

- Today, use SEC Form 13F to illustrate what could be done with these types of data.

Questions

1. Have financial markets become more liquid over the last 30 years with the growing importance of institutional investors?
2. How much of the volatility and predictability of asset prices is explained by institutional trades?
3. Do large investment managers amplify volatility? Should they be regulated as SIFI (OFR 2013)?
4. How do large-scale asset purchases affect asset prices through institutional holdings?

Contributions

1. A new demand system for financial assets.
   - Model asset demand as a logit function of prices and characteristics.
   - Matches institutional holdings.
   - Derived from traditional asset pricing and portfolio choice with heterogeneous beliefs.
2. Identification in the presence of price impact by IV.
3. Asset pricing applications:
   - Estimate price impact as a liquidity measure.
   - Explain the role of institutions in volatility and predictability.

Asset pricing model

- Investor i has wealth A_i, allocated between an outside asset and inside assets: $\mathcal{N}_i \subseteq \{1, \ldots, N\}$.
- Investor i's demand for asset $n \in \mathcal{N}_i$:

$$w_i(n) = \frac{\exp\{\sum_{k=0}^{K} \beta_{k,i} x_k(n)\}\epsilon_i(n)}{1 + \sum_{m \in \mathcal{N}_i} \exp\{\sum_{k=0}^{K} \beta_{k,i} x_k(m)\}\epsilon_i(m)} \qquad (1)$$

where

- $x_0(n) = p(n) + s(n)$: Log market equity.
- $x_1(n), \ldots, x_{K-1}(n)$: Observed characteristics (e.g., book equity, profitability, investment, dividends).
- $x_K(n) = 1$: Constant.
- $\epsilon_i(n)$: Unobserved characteristics.

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- For example, consider an index fund:

$$w_i(n) = \frac{\exp\{p(n) + s(n) + \beta_{K,i}\}}{1 + \sum_{m \in \mathcal{N}_i} \exp\{p(m) + s(m) + \beta_{K,i}\}}$$

Asset pricing model

- Market clearing:

$$P(n)S(n) = \sum_{i=1}^{I} A_i w_i(n) \tag{2}$$

- Proposition: Unique equilibrium if demand is downward sloping for all investors (i.e., $\beta_{0,i} < 1$).

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- Motivation for our model:
    - Differentiated product demand systems in IO.
    - Traditional asset pricing and portfolio choice with
        1. Heterogenous beliefs.
        2. Factor structure in returns.

Traditional asset pricing and portfolio choice

- Portfolio-choice problem for investor i:

$$\max_{\mathbf{w}_i} \mathbb{E}_i[\log(A_{i,T})]$$

subject to $A_{i,T} = A_i(w_i(0)R(0) + \mathbf{w}_i'\mathbf{R})$.

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1. Euler equation:

$$\mathbb{E}_i\left[\left(\frac{A_{i,T}}{A_i}\right)^{-1}(\mathbf{R} - R(0)\mathbf{1})\right] = \mathbf{0}$$

2. Optimal portfolio choice:

$$\mathbf{w}_i \approx \Sigma_i^{-1}\mu_i$$

- Assumption: Covariance matrix has factor structure, where $\Sigma_i = \Pi_i \Pi_i' + \pi_i \mathbf{I}$ and

$$\mu_i = \mathbf{x}\Phi_i + \phi_i$$
$$\Pi_i = \mathbf{x}\Psi_i$$

- Proposition: Optimal mean-variance portfolio is linear in prices and characteristics:

$$\mathbf{w}_i = \mathbf{x}\beta_i + \log(\epsilon_i)$$

where

$$\beta_i = \frac{1}{\pi_i}(\Phi_i - \Psi_i \times \text{const.})$$
$$\log(\epsilon_i) = \frac{\phi_i}{\pi_i}$$

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- Equivalent to logit model:

$$\frac{\mathbf{w}_i}{w_i(0)} - \mathbf{1} = \exp\{\mathbf{x}\beta_i + \log(\epsilon_i)\} - \mathbf{1} \approx \mathbf{x}\beta_i + \log(\epsilon_i)$$

Inconsistency of OLS

- Cross section of investor i's holdings:

$$\log\left(\frac{w_i(n)}{w_i(0)}\right) = \beta_{0,i}(p(n) + s(n)) + \sum_{k=1}^{K} \beta_{k,i} x_k(n) + \log(\epsilon_i(n))$$

- OLS coefficient on log market equity:

$$\widehat{\beta}_{0,i} \to \beta_{0,i} + \frac{\mathrm{Cov}(\log(\epsilon_i(n)), \overline{\epsilon}(n))}{\mathrm{Var}(p(n) + s(n))}$$

- OLS is consistent if
  1. Investor is atomistic.
  2. Latent demand is uncorrelated across investors.

Summary of 13F institutions

- SEC Form 13F: Quarterly stock holdings of institutions managing over $100m.
    - Types: Banks, insurance companies, investment advisors, mutual funds, pension funds, other.
    - Household sector.
- Merged with stock prices and characteristics in CRSP-Compustat.
- Big data: 44 million observations.

Period	Number of institutions	Percent of market held	Assets under management ($ million) Median	Assets under management ($ million) 90th percentile	Number of stocks held Median	Number of stocks held 90th percentile
1980–1984	544	35	336	2,667	117	382
1985–1989	781	41	399	3,599	114	448
1990–1994	980	46	403	4,549	105	507
1995–1999	1,322	51	464	6,564	101	551
2000–2004	1,803	57	371	6,082	87	516
2005–2009	2,446	65	333	5,415	73	458
2010–2014	2,832	63	325	5,483	67	444

Empirical specification

- Cross section of investor i's holdings:

$$\frac{w_i(n)}{w_i(0)} = \exp\left\{\beta_{0,i}(p(n)+s(n)) + \sum_{k=1}^{K} \beta_{k,i} x_k(n)\right\} \epsilon_i(n)$$

- Characteristics:
  1. Log book equity.
  2. Profitability.
  3. Investment.
  4. Dividends to book equity.
  5. Market beta.
- Estimate coefficients for each 13F institution and the household sector.

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- Estimate coefficients for each 13F institution and the household sector.
- Traditional assumption in endowment economies:

$$\mathbb{E}[\epsilon_i(n)|\mathbf{x}(n), p(n), s(n)] = 0$$

- Price taking may not be appropriate for large institutions.

Identification by IV

- Assumptions:
  1. Investors have an exogenous investment universe.
  2. My demand doesn't depend on investment universe of investors outside my group, defined by type and size.

1. Start with market clearing:

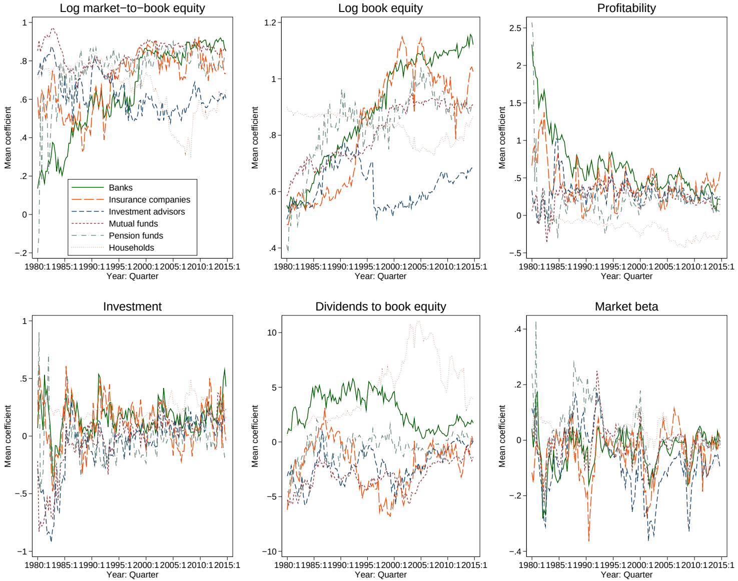
$$P(n)S(n) = \sum_{j \in \mathcal{G}_i} A_j w_j(n) + \sum_{j \notin \mathcal{G}_i} A_j \left(w_j(n) - \frac{1}{|\mathcal{N}_j|} \right) + \underbrace{\sum_{j \notin \mathcal{G}_i} A_j \frac{1}{|\mathcal{N}_j|}}_{\text{exogenous}}$$

2. Isolate price variation from exogenous demand:

$$\widehat{p}_i(n) + s(n) = \log \left(\sum_{j \notin \mathcal{N}_i} A_j \frac{1}{|\mathcal{N}_j|} \right)$$

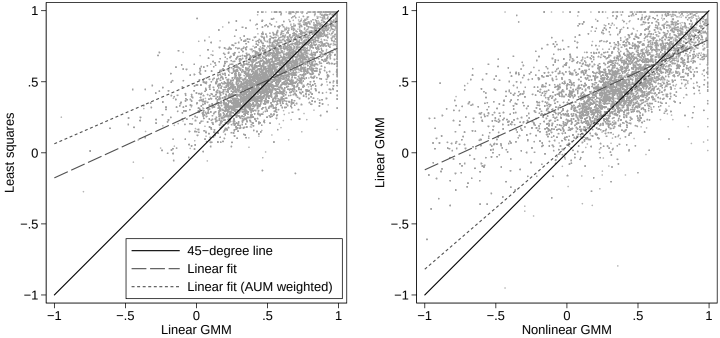
- Moment condition: $\mathbb{E}[\epsilon_i(n) | \mathbf{x}(n), \widehat{p}_i(n), s(n)] = 0.$

Estimated coefficients on price and characteristics



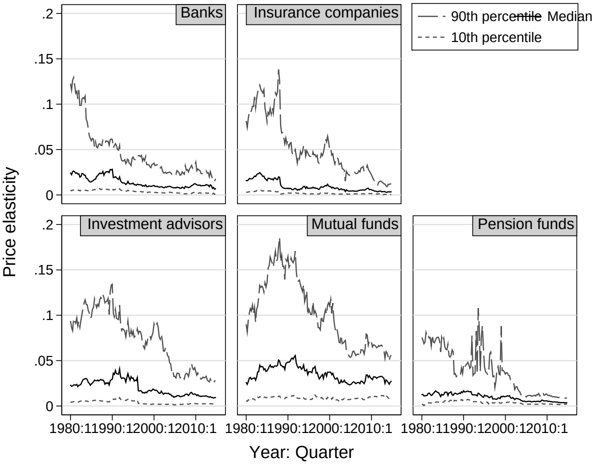
Comparison of estimated coefficients on price

- Left: Least squares is upward biased.
- Right: Linear GMM (i.e., estimating in logs) is upward biased for smaller institutions.



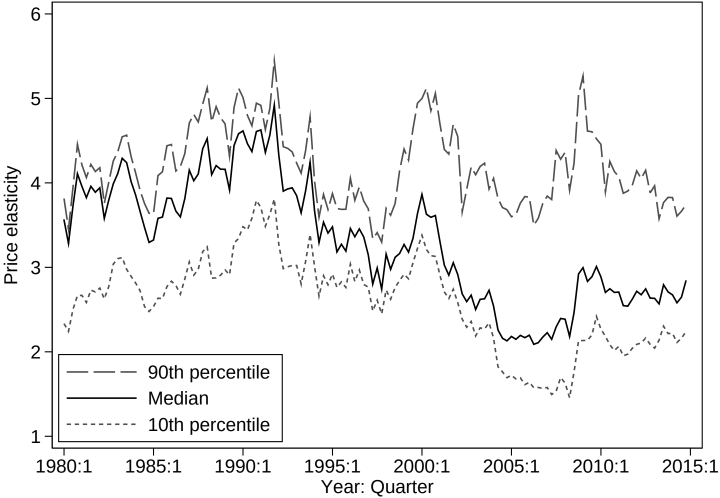
Variation in average price impact across stocks

- Price impact as a liquidity measure (Kyle 1985).
- Price impact for each investor i: $\partial p(n)/\partial \log(\epsilon_i(n))$.



Variation in aggregate price impact across stocks

- Aggregate price impact: $\sum_{i=1}^{I} \partial p(n)/\partial \log(\epsilon_i(n))$.



Variance decomposition of stock returns

- Start with definition of log return:

$$r_{t+1}(n) = p_{t+1}(n) - p_t(n) + \log\left(1 + \frac{D_{t+1}(n)}{P_{t+1}(n)}\right)$$

- Model implies that

$$\mathbf{p}_t = g(\mathbf{s}_t, \mathbf{x}_t, \mathbf{A}_t, \beta_t, \epsilon_t)$$

1. $\mathbf{s}_t$: Shares outstanding.
2. $\mathbf{x}_t$: Asset characteristics.
3. $\mathbf{A}_t$: Assets under management.
4. β_t: Coefficients on characteristics.
5. ϵ_t: Latent demand.

Variance decomposition of stock returns

	Percent of variance
Supply:	
Shares outstanding	1.4
	(0.2)
Stock characteristics	6.1
	(0.3)
Dividend yield	0.4
	(0.0)
Demand:	
Assets under management	28.6
	(0.3)
Coefficients on characteristics	4.7
	(0.2)
Latent demand	58.8
	(0.4)
Observations	125,320

Variance decomposition of stock returns in 2008

- Are large investment managers systemic (OFR 2013)?

AUM ranking	Institution	AUM ($ billion)	Change in AUM (percent)	Percent of variance	
	Supply: Shares outstanding, stock characteristics & dividend yield			5.0	(0.9)
1	Barclays Bank	699	-41	0.5	(0.1)
2	Fidelity Management & Research Co.	577	-63	1.4	(0.2)
3	State Street Corp.	547	-37	0.4	(0.1)
4	Vanguard Group	486	-41	0.5	(0.0)
5	AXA Financial	309	-70	0.4	(0.1)
6	Capital World Investors	309	-44	0.5	(0.2)
7	Wellington Management Co.	272	-51	0.4	(0.1)
8	Capital Research Global Investors	270	-53	0.1	(0.1)
9	T. Rowe Price Associates	233	-44	-0.2	(0.1)
10	Goldman Sachs & Co.	182	-59	0.1	(0.1)
	Subtotal: Largest 25 institutions	5,684	-47	5.5	
	Smaller institutions	6,493	-53	41.9	(2.6)
	Households	6,321	-47	47.6	(3.0)
	Total	18,499	-49	100.0	

Predictability of stock returns

- Recall that

$$\mathbf{p}_{t+1} = g(\mathbf{s}_{t+1}, \mathbf{x}_{t+1}, \mathbf{A}_{t+1}, \beta_{t+1}, \epsilon_{t+1})$$

- First-order approximation of expected log returns:

$$\mathbb{E}_t[\mathbf{r}_{t+1}] \approx g(\mathbb{E}_t[\mathbf{s}_{t+1}], \mathbb{E}_t[\mathbf{x}_{t+1}], \mathbb{E}_t[\mathbf{A}_{t+1}], \mathbb{E}_t[\beta_{t+1}], \mathbb{E}_t[\epsilon_{t+1}]) - \mathbf{p}_t$$

- Model ϵ_{t+1} as mean reverting and everything else as random walk.
- Intuition: Assets with high latent demand are expensive and have low expected returns.

Characteristics of portfolios sorted by expected returns

- Form 5 portfolios in December of each year, sorted by estimated expected returns.
- Model identifies small-value stocks as having high expected returns.

	Portfolios sorted by expected returns				
Characteristic	Low	2	3	4	High
Expected return	-0.26	-0.04	0.06	0.16	0.32
Log market equity	6.44	5.92	5.15	4.12	2.85
Book-to-market equity	0.49	0.54	0.64	0.79	1.12
Profitability	0.23	0.23	0.22	0.18	0.11
Investment	0.08	0.08	0.08	0.07	0.03
Number of stocks	798	795	795	794	760

Equal-weighted portfolios sorted by expected returns

	Portfolios sorted by expected returns					High
	Low	2	3	4	High	−Low
Panel A: Average excess returns (percent)						
1982–2014	8.26	9.64	10.88	11.84	16.30	8.04
	(3.49)	(3.28)	(3.15)	(3.21)	(3.60)	(2.34)
1982–1997	7.13	8.82	9.93	11.67	18.10	10.97
	(4.21)	(4.09)	(4.03)	(4.27)	(4.63)	(2.81)
1998–2014	9.32	10.41	11.78	12.00	14.61	5.29
	(5.50)	(5.09)	(4.81)	(4.78)	(5.47)	(3.68)
Panel B: Fama-French three-factor betas and alpha						
Market beta	1.15	1.06	0.96	0.89	0.79	-0.35
	(0.03)	(0.02)	(0.02)	(0.03)	(0.04)	(0.04)
SMB beta	0.62	0.65	0.74	0.85	0.99	0.37
	(0.06)	(0.05)	(0.05)	(0.06)	(0.10)	(0.10)
HML beta	0.29	0.32	0.28	0.30	0.29	0.00
	(0.05)	(0.04)	(0.05)	(0.06)	(0.09)	(0.09)
Alpha (percent)	-2.92	-1.03	1.10	2.44	7.51	10.43
	(0.95)	(0.87)	(1.00)	(1.29)	(2.09)	(2.07)

Conclusion

- Asset pricing model that matches institutional holdings.
  1. Rich heterogeneity in asset demand.
  2. Potential price impact.
- Could answer questions that are difficult with reduced-form regressions or event studies.
- Additional questions:
  1. Which institutions drive anomalies?
  2. How does QE affect financial markets?
  3. How would regulatory reform (banks and insurance companies) affect asset prices and real investment?