Traditional asset pricing

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

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

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

1. Optimal portfolio choice:
   \[
   w_i \approx \frac{1}{\gamma_i} \Sigma^{-1} \mu 
   \]
   - 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


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 account for price impact when they trade.
Data on institutional holdings

1. SEC Form 13F: Quarterly U.S. stock holdings of institutions managing over $100m since 1980.
2. Capital IQ or FactSet Ownership: International stock holdings.
3. Thomson Reuters eMAXX: Quarterly bond holdings of institutions (mutual funds and insurance companies) since 2002.

- Illustration on SEC Form 13F today.
- For details, see “An Equilibrium Model of Institutional Demand and Asset Prices” by Koijen & Yogo.
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 demand?
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?
New approach to asset pricing

1. A new demand system for financial assets.
   - Model asset demand as a function of characteristics.
   - Matches institutional holdings.
   - Derived from traditional portfolio choice with
     Heterogenous beliefs.
     Factor structure in returns.

2. IV estimator to address the endogeneity of institutional demand and asset prices.

3. Asset pricing applications:
   - Estimate the price impact of demand shocks.
   - Explain the role of institutions in volatility and predictability.
Portfolio choice

Portfolio-choice problem for investor $i$:

$$\max_{w_i} \mathbb{E}_i \left[ \log(A_i, T) \right]$$

subject to $A_i, T = A_i(w_i(0)R(0) + w_i'R)$. 
Portfolio choice

- Portfolio-choice problem for investor $i$:

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

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

1. Euler equation:

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

2. Optimal portfolio choice:

$$w_i \approx \Sigma_i^{-1} \mu_i$$
• **Assumption:** Covariance matrix has factor structure, where
\[ \Sigma_i = \Gamma_i \Gamma_i' + \gamma_i I \] and
\[ \mu_i(n) = y(n)'\Phi_i + \phi_i \]
\[ \Gamma_i(n) = y(n)'\Psi_i + \psi_i \]

• **Proposition:** Mean-variance portfolio is linear in characteristics:
\[ \frac{w_i(n)}{w_i(0)} = 1 + y(n)'\Pi_i \]

where
\[ \Pi_i = \frac{1}{\gamma_i w_i(0)}(\Phi_i - \Psi_i \times \text{const.}) \]
Special case of mean-variance portfolio

- Specify vector of characteristics:
  \[ y(n) = \begin{bmatrix} x(n) \\ \log(\epsilon_i(n)) \end{bmatrix}, \Pi_i = \begin{bmatrix} \beta_i \\ 1 \end{bmatrix} \]

- Mean-variance portfolio:
  \[
  \frac{w_i(n)}{w_i(0)} = 1 + y(n)'\Pi_i \approx \exp\{y(n)'\Pi_i\} \\
  = \exp\{x(n)'\beta_i\}\epsilon_i(n)
  \]

- Approximation can be made arbitrary precise through polynomial in characteristics.
Three implementations of the mean-variance portfolio

- Estimate mean-variance portfolio among stocks in the S&P 500 index, subject to short-sale constraints.
  - 2. Factor structure: Impose FF 5-factor model on mean and covariance.

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Benchmark</th>
<th>Factor structure</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (%)</td>
<td>1.1</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Standard deviation (%)</td>
<td>4.5</td>
<td>6.3</td>
<td>6.3</td>
</tr>
<tr>
<td>Certainty equivalent (%)</td>
<td>1.0</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>Correlation:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factor structure</td>
<td>0.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Characteristics</td>
<td>0.52</td>
<td>0.95</td>
<td></td>
</tr>
</tbody>
</table>
Asset pricing model

- Investor $i$ allocates wealth $A_i$ across assets in the investment universe $\mathcal{N}_i \subseteq \{1, \ldots, N\}$ and an outside asset.

- Investor $i$’s demand for asset $n \in \mathcal{N}_i$:

$$w_i(n) = \frac{\delta_i(n)}{1 + \sum_{m \in \mathcal{N}_i} \delta_i(m)}$$

$$\delta_i(n) = \exp \left\{ \beta_{0,i} \text{me}(n) + \sum_{k=1}^{K} \beta_{k,i} x_k(n) \right\} \epsilon_i(n)$$

- Budget constraint implies demand for the outside asset:

$$w_i(0) = \frac{1}{1 + \sum_{m \in \mathcal{N}_i} \delta_i(m)}$$
Asset pricing model

- Characteristics:
  - $x_1(n), \ldots, x_{K-1}(n)$: Log book equity, profitability, investment, dividends...
  - $x_K(n) = 1$: Constant.
  - $\epsilon_i(n)$: Unobserved characteristics.

- For example, an index fund:

$$w_i(n) = \frac{\text{ME}(n)}{\exp\{-\beta_{K,i}\} + \sum_{m \in \mathcal{N}_i} \text{ME}(m)}$$
Asset pricing model

- Characteristics:
  - $x_1(n), \ldots, x_{K-1}(n)$: Log book equity, profitability, investment, dividends...
  - $x_K(n) = 1$: Constant.
  - $\epsilon_i(n)$: Unobserved characteristics.

- For example, an index fund:

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

- Market clearing:

$$\ME(n) = \sum_{i=1}^{l} A_i w_i(n)$$

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

<table>
<thead>
<tr>
<th>Period</th>
<th>Number of institutions</th>
<th>% of market held</th>
<th>Assets under management ($ million)</th>
<th>Number of stocks held</th>
<th>Number of stocks in investment universe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Median</td>
<td>90th percentile</td>
<td>Median</td>
</tr>
<tr>
<td>1985–1989</td>
<td>781</td>
<td>41</td>
<td>399</td>
<td>3,599</td>
<td>114</td>
</tr>
<tr>
<td>1990–1994</td>
<td>980</td>
<td>46</td>
<td>403</td>
<td>4,549</td>
<td>105</td>
</tr>
<tr>
<td>1995–1999</td>
<td>1,322</td>
<td>51</td>
<td>464</td>
<td>6,564</td>
<td>101</td>
</tr>
<tr>
<td>2000–2004</td>
<td>1,803</td>
<td>57</td>
<td>371</td>
<td>6,082</td>
<td>87</td>
</tr>
<tr>
<td>2005–2009</td>
<td>2,446</td>
<td>65</td>
<td>333</td>
<td>5,415</td>
<td>73</td>
</tr>
<tr>
<td>2010–2014</td>
<td>2,832</td>
<td>63</td>
<td>325</td>
<td>5,483</td>
<td>67</td>
</tr>
</tbody>
</table>
Empirical specification

- Cross section of investor $i$’s holdings:

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

- Characteristics:
  2. Profitability.
  3. Investment.
  5. Market beta.

- Estimate coefficients for each 13F institution and the household sector.
Empirical specification

- Cross section of investor $i$’s holdings:
  $$\frac{w_i(n)}{w_i(0)} = \exp \left\{ \beta_{0,i} \text{me}(n) + \sum_{k=1}^{K-1} \beta_{k,i} x_k(n) + \beta_{K,i} \right\} \epsilon_i(n)$$

- Characteristics:
  2. Profitability.
  3. Investment.
  5. Market beta.

- Estimate coefficients for each 13F institution and the household sector.

- Traditional assumption in endowment economies:
  $$\mathbb{E}[\epsilon_i(n)|\text{me}(n), x(n)] = 1$$

  1. Investor is atomistic.
  2. Latent demand is uncorrelated across investors.
IV Estimator

\[
\frac{w_i(n)}{w_i(0)} = \begin{cases} 
\mathbb{1}_i(n) \exp \left\{ \beta_{0,i} \bar{m}_i(n) + \sum_{k=1}^{K} \beta_{k,i} x_k(n) \right\} \epsilon_i(n) & \text{if } n \in \mathcal{N}_i \\
\mathbb{1}_i(n) = 0 & \text{if } n \notin \mathcal{N}_i 
\end{cases}
\]

- Investors may not hold an asset for two reasons.
  1. \( \epsilon_i(n) = 0 \): Chooses not to hold an asset.
  2. \( \mathbb{1}_i(n) = 0 \): Cannot hold an asset outside the investment universe. (e.g., S&P 500 index fund has \( \mathbb{1}_i(n) = 0 \) for stocks outside the index).

- **Assumption**: Investment universe is exogenous.
- **Valid instrument**:

\[
\hat{m}_i(n) = \log \left( \sum_{j \neq i} A_j \frac{\mathbb{1}_j(n)}{1 + \sum_{m=1}^{N} \mathbb{1}_j(m)} \right)
\]

- **Moment condition**: \( \mathbb{E}[\epsilon_i(n) | \hat{m}_i(n), x(n)] = 1 \)
Coefficients on characteristics

- Log market-to-book equity
- Log book equity
- Profitability
- Investment
- Dividends to book equity
- Market beta
Standard deviation of latent demand

![Graph showing the standard deviation of latent demand over time for different financial institutions. The graph displays the standard deviation on the y-axis and the year: quarter on the x-axis. The financial institutions include Banks, Insurance companies, Investment advisors, Mutual funds, Pension funds, and Households.]
Comparison of the coefficients on log market equity

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

- Price impact as a liquidity measure (Kyle 1985).
- Price impact for each investor $i$: $\frac{\partial p(n)}{\partial \log(\epsilon_i(n))}$.
Aggregate price impact across stocks

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

\[ p_t = g(s_t, x_t, A_t, \beta_t, \epsilon_t) \]

1. \( s_t \): Shares outstanding.
2. \( x_t \): Asset characteristics.
3. \( A_t \): Assets under management.
4. \( \beta_t \): Coefficients on characteristics.
5. \( \epsilon_t \): Latent demand.
Variance decomposition of stock returns

<table>
<thead>
<tr>
<th>Supply:</th>
<th>% of variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shares outstanding</td>
<td>1.4</td>
</tr>
<tr>
<td>Stock characteristics</td>
<td>6.1</td>
</tr>
<tr>
<td>Dividend yield</td>
<td>0.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Demand:</th>
<th>% of variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assets under management</td>
<td>28.6</td>
</tr>
<tr>
<td>Coefficients on characteristics</td>
<td>4.7</td>
</tr>
<tr>
<td>Latent demand</td>
<td>58.8</td>
</tr>
</tbody>
</table>

Observations 125,320
## Variance decomposition of stock returns in 2008

### Are large investment managers systemic (OFR 2013)?

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

- Recall that

\[ p_T = g(s_T, x_T, A_T, \beta_T, \epsilon_T) \]

- Model \( \epsilon_T \) as mean reverting and everything else as random walk.

- First-order approximation of expected long-run capital gain:

\[
E_t[p_T - p_t] \approx g(E_t[s_T], E_t[x_T], E_t[A_T], E_t[\beta_T], E_t[\epsilon_T]) - p_t
\]

\[
= g(s_t, x_t, A_t, \beta_t, 1) - p_t
\]

- **Intuition**: Assets with high latent demand are expensive and have low expected returns.
Relation between stock returns and characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>All stocks</th>
<th>Excluding microcaps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected return</td>
<td>0.24</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>(0.04)</td>
<td>(0.04)</td>
</tr>
<tr>
<td>Log market equity</td>
<td>-0.25</td>
<td>-0.17</td>
</tr>
<tr>
<td></td>
<td>(0.08)</td>
<td>(0.08)</td>
</tr>
<tr>
<td>Book-to-market equity</td>
<td>0.01</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>(0.04)</td>
<td>(0.06)</td>
</tr>
<tr>
<td>Profitability</td>
<td>0.31</td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(0.06)</td>
</tr>
<tr>
<td>Investment</td>
<td>-0.36</td>
<td>-0.20</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.03)</td>
</tr>
<tr>
<td>Market beta</td>
<td>0.11</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>(0.09)</td>
<td>(0.10)</td>
</tr>
<tr>
<td>Momentum</td>
<td>0.26</td>
<td>0.36</td>
</tr>
<tr>
<td></td>
<td>(0.09)</td>
<td>(0.10)</td>
</tr>
</tbody>
</table>
Extensions and open issues

1. Endogenize supply (i.e., shares outstanding and characteristics) through the firm’s problem.
2. Endogenize flows into institutions through the household’s problem.
3. Data issues:
   - Data on aggregate short interest for NYSE, AMEX, and Nasdaq stocks.
   - Household sector is residual, but more detailed data for Sweden.
   - Linking stock and bond holdings data.
   - Fund-level data for mutual funds.
Conclusion

- Asset pricing model that matches institutional holdings.
  2. Endogeneity of institutional demand and asset prices.
- 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?