Demand System Asset Pricing: Prediction, Identification, and Counterfactuals

NBER New Developments in Long-Term Asset Management

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What is demand system asset pricing?

- A framework to study asset prices in relation to investor portfolios, beliefs, and fundamentals (firm characteristics and macro variables).
- Uses data on asset prices, fundamentals, and portfolio holdings and flows.
- Emphasizes demand elasticities and demand shifters/shocks to understand asset price movements and to inform asset pricing models.
- A new approach, but not a new theory.
  - Findings from DSAP could challenge existing theories and guide new ones.

What is demand system asset pricing?

- All asset pricing models imply an SDF and an asset demand system.
- We are testing different implications of the same model, using portfolio holdings data.
- Some models imply a more realistic demand system that explains both asset prices and portfolio holdings.
- Does not necessarily assume
  - Presence of frictions, intermediation, or market segmentation. But these ingredients could imply a more realistic demand system.
  - Inelastic demand. But this could be an empirical finding.

Why do we need an asset demand system?

- Many asset pricing questions concern shifts in asset supply or demand.
- For example, what is the impact of
  1. QE/QT on government bond yields (and other asset prices)?
  2. US-China decoupling on global asset prices and exchange rates?
  3. Capital regulation of banks and insurers on asset prices?
  4. ESG investing on the cross section of stock prices and returns?
  5. Transition from active to passive investment management on stock prices and price informativeness?
- Credible answers to these quantitative questions require a realistic demand system.

How does DSAP relate to the earlier literature?

1. Macro models of asset demand and portfolio rebalancing (Brainard and Tobin, 1968; Kouri, 1976).
   - Big micro data and modern identification methods.
2. Market microstructure.
   - Focus on demand shifters and asset prices (levels) in addition to demand shocks and returns (changes).
   - Lower-frequency identification methods.
   - Counterfactuals by market clearing.
3. Index effects (Harris and Gurel, 1986; Shleifer, 1986).
   - Identification for all assets.
   - Counterfactuals by market clearing.
4. Portfolio flows and returns (Coval and Stafford, 2007; Ellul, Jotikasthira, and Lundblad, 2011).
   - Causal effects of demand shocks on asset prices.

Portfolio holdings data

- SEC Form 13F: Quarterly US stock holdings of institutions managing over $100m since 1980 (Koijen and Yogo, 2019).
- FactSet Ownership: SEC Form 13F and mutual fund holdings (Koijen, Richmond, and Yogo, 2024).
  - Some international coverage, especially UK.
- Thomson Reuters eMAXX: Quarterly bond holdings of institutions since 1998 (Gabaix et al., 2025).
  - Primarily mutual funds and insurers with international coverage.
- Schedule D: Comprehensive holdings of US insurers since 1991 (Koijen and Yogo, 2023).
- Securities Holdings Statistics: Comprehensive holdings for the euro area since 2014 (Koijen et al., 2021).

Portfolio holdings data

- Key features of institutional portfolios.
  - Big data with 3 dimensions (investors, assets/firms, and time).
  - Household holdings are shares outstanding minus aggregate institutional holdings.
- Data on household portfolios.
  - Statistics Sweden: Household holdings for 1983–2007 (Calvet, Campbell, and Sodini, 2007).
  - Norwegian Central Securities Depository: Stock holdings and transactions for 1996–2017 (Betermier et al., 2024).
  - Brazilian Stock Exchange: All transactions since 2014 (Schmickler and Tremacoldi-Rossi, 2022a).
  - Addepar: US household holdings for 2016–2023 (Gabaix et al., 2023).

Outline

1. Microfoundation: Asset pricing model appropriate for the research question and data.
   - Structural versus reduced-form demand.
2. Prediction: Estimate asset and investor embeddings through reduced-form demand.
   - US stock market (Gabaix et al., 2024).
   - US corporate bond market (Gabaix et al., 2025).
3. Identification: Estimate structural demand by IV.
   - Simple example based on Koijen and Yogo (2020).
   - Review of the evidence and implications for asset pricing models.
4. Counterfactual analysis and further predictions.
   - Variance decomposition of stock returns.
   - Predictability of stock returns.

Asset market

- N assets, indexed by $n = 1, \ldots, N$.
- Price $P_{n,t}$ at time t.
- Payoff at time $t+1$:

$$D_{n,t+1} = \phi_{n,t} + \psi_{n,t} F_{t+1} + \nu_{n,t+1}$$

where $F_{t+1} \sim \mathbb{N}(0,1)$ and $\nu_{n,t+1} \sim \mathbb{N}\left(0, \sigma^2\right)$.
- Expected payoff and factor loading:

$$\begin{aligned} \phi_{n,t} &= \mathbf{\Phi}_t' \boldsymbol{X}_{n,t} + \widetilde{\phi}_{n,t} \\ \psi_{n,t} &= \mathbf{\Psi}_t' \boldsymbol{X}_{n,t} + \widetilde{\psi}_{n,t} \end{aligned}$$

  - $\boldsymbol{X}_{n,t}$: Observed asset characteristics.
  - $\left(\widetilde{\phi}_{n,t}, \widetilde{\psi}_{n,t}\right)$: Unobserved asset characteristics.
- Riskless asset with zero interest.

Investors

- I investors, indexed by $i = 1, \ldots, I$.
- Wealth at time $t+1$:

$$A_{i,t+1} = A_{i,t} + \left(\boldsymbol{D}_{t+1} - \boldsymbol{P}_t\right)' \boldsymbol{Q}_{i,t}$$

- Investors agree to disagree about expected payoff and factor loading.

$$\begin{aligned} \phi_{i,n,t} &= \boldsymbol{\Phi}_{i,t}' \boldsymbol{X}_{n,t} + \widetilde{\phi}_{i,n,t} \\ \psi_{i,n,t} &= \boldsymbol{\Psi}_{i,t}' \boldsymbol{X}_{n,t} + \widetilde{\psi}_{i,n,t} \end{aligned}$$

- Investor i solves

$$\max_{\boldsymbol{Q}_{i,t}} \mathbb{E}_{i,t}\left[-\exp\left(-\gamma_i A_{i,t+1}\right)\right]$$

- Euler equation:

$$\mathbb{E}_{i,t}\left[\exp\left(-\gamma_i A_{i,t+1}\right)\left(\boldsymbol{D}_{t+1} - \boldsymbol{P}_t\right)\right] = 0$$

Asset demand

- Optimal portfolio:

$$Q_{i,n,t} = -\pi_{i,t} P_{n,t} + \underbrace{\beta'_{i,t} \boldsymbol{X}_{n,t} + \epsilon_{i,n,t}}_{\text{demand shifter}} \tag{1}$$

- Demand elasticities:

$$\begin{aligned} \pi_{i,t} &= \frac{1}{\gamma_i \sigma^2} \\ \beta_{i,t} &= \frac{1}{\gamma_i \sigma^2} \left(\boldsymbol{\Phi}_{i,t} - \kappa_{i,t} \boldsymbol{\Psi}_{i,t} \right) \end{aligned}$$

- Latent demand:

$$\epsilon_{i,n,t} = \frac{1}{\gamma_i \sigma^2} \left(\widetilde{\phi}_{i,n,t} - \kappa_{i,t} \widetilde{\psi}_{i,n,t} \right)$$

- Substitution summarized by a scalar:

$$\kappa_{i,t} = \frac{\boldsymbol{\psi}'_{i,t} \left(\boldsymbol{\phi}_{i,t} - \boldsymbol{P}_t \right)}{\boldsymbol{\psi}'_{i,t} \boldsymbol{\psi}_{i,t} + \sigma^2}$$

Equilibrium

- Market clearing:

$$S_{n,t} = \sum_{i=1}^{I} Q_{i,n,t}$$

- Equilibrium price:

$$P_{n,t} = \frac{1}{\overline{\pi}_t} \left(\overline{\boldsymbol{\beta}}_t' \boldsymbol{X}_{n,t} + \overline{\epsilon}_{n,t} - S_{n,t} \right) \tag{2}$$

  where $\overline{\boldsymbol{\beta}}_t = \sum_{i=1}^{I} \boldsymbol{\beta}_{i,t}$ and $\overline{\epsilon}_{n,t} = \sum_{i=1}^{I} \epsilon_{i,n,t}$.
- $\overline{\pi}_t = \sum_{i=1}^{I} \pi_{i,t}$: Aggregate demand elasticity.
- $\frac{1}{\overline{\pi}_t}$: Price impact.

Reduced-form demand

- Substituting equilibrium price (2) in asset demand (1), reduced-form demand is

$$Q_{i,n,t} = \boldsymbol{\lambda}_{i,t}' \boldsymbol{x}_{n,t} + \varepsilon_{i,n,t} \tag{3}$$

- Interpret equation (3) as a factor model to be estimated by PCA.
  - $\boldsymbol{\lambda}_{i,t}$: Investor embeddings
  - $\boldsymbol{x}_{n,t}$: Asset embeddings.
- Asset embeddings contain all information that investors use for portfolio choice.

Different microfoundations, elasticities, and estimators

- Microfoundation depends on the asset market and data structure.
  1. Log utility with investment mandates and short-sale constraints (Koijen and Yogo, 2019).
  2. Background risk and direct tastes for asset characteristics like ESG (Koijen, Richmond, and Yogo, 2024).
  3. Risk-based capital constraint (Koijen and Yogo, 2023).
  4. GE model with multiple countries and asset classes (Koijen and Yogo, 2020).
  5. Infinite horizon with dynamics (Gabaix and Koijen, 2022).
- Different elasticities for different asset markets and levels of aggregation.
  - Macro (across asset classes) versus micro (within asset class) elasticities.
- Extensions of logit demand:
  - Nested logit for heterogeneous elasticities and substitution across asset classes (Koijen and Yogo, 2020).
  - Asset embeddings for richer substitution effects.

Appropriate microfoundation and estimator

Koijen and Yogo (2019)	Fuchs, Fukuda, and Neuhann (2024)
Mean-variance portfolio	Mean-variance portfolio
Factor structure and characteristics imply logit demand	Near perfect substitutes (R, G) and complement (C)
Designed for cross section of stocks	Not relevant for data studied
Elasticities determined by π_i	2 elasticities: R–G and R–C
Identified by cross-sectional IV estimator	KY estimator correctly estimates R–G. Mischaracterized as an estimator for R–C.

- Full response (Koijen and Yogo, 2025).

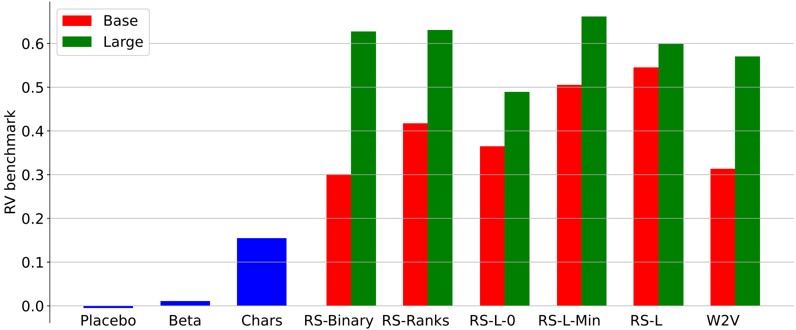
Applying AI methods to economics

- We typically use firm characteristics to measure of similarity.
  - Market beta, market equity, market-to-book equity, and industry.
- Investors also use characteristics that are difficult to measure.
  - AI capability, intangible capital, and sensitivity to a trade war.
- Estimate asset embeddings to recover this information from portfolio holdings data.
  1. Recommender systems: PCA.
  2. Shallow neural network models: Word2Vec.
  3. Transformer models: BERT.
- Competing representation of firms.
  1. Observed characteristics.
  2. Text-based embeddings from Cohere and OpenAI.

Benchmarks

- Competition to evaluate relative performance.
  - ImageNet Large Scale Visual Recognition Challenge.
- Equity benchmarks (Gabaix et al., 2024).
  1. Predicting relative valuations.
  2. Explaining the comovement of stock returns.
  3. Predicting institutional portfolio decisions.
- Fixed income benchmarks (Gabaix et al., 2025).
  1. Predicting credit spreads.
  2. Explaining comovement of changes in credit spreads.
  3. Predicting volatility of credit spreads and default.

Relative valuation benchmark



Source: Gabaix et al. (2024)

Additional applications of embeddings

- Asset embeddings.
  1. Generative portfolios: Recommend additional stocks, based on current portfolio.
  2. Risk management and stress testing: Generate stress scenarios.
  3. Fixed income: Findings buyers in the primary market and matrix pricing in the secondary market.
- Investor embeddings.
  1. Investor classification beyond observed characteristics (type, size, and activeness).
  2. Performance evaluation.
  3. Detecting crowded trades.

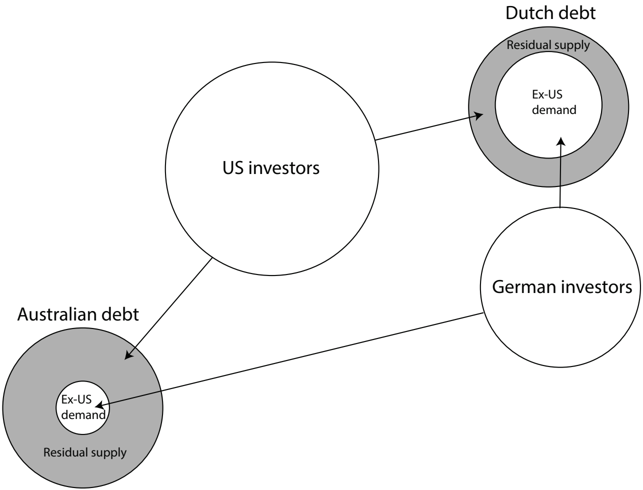
Key idea behind identification in asset pricing

- Write market clearing as

$$Q_{i,n} = \underbrace{S_n - \sum_{j \neq i}^{I} Q_{j,n}}_{\text{residual supply}}$$

- To estimate investor i's demand elasticity, we need exogenous variation in other investors' demand.
- Illustrate in a simple example.
  - US and German investors.
  - Dutch and Australian debt.

Illustration of identification strategy



Simple model of identification

- Asset demand of US ($i = U$) and German ($i = G$) investors:

$$Q_{i,n} = -\pi P_n + \beta D_{i,n} + \epsilon_{i,n}$$

  - $D_{i,n}$: Distance between countries i and n.
- Market clearing of Dutch and Australian debt:

$$S_n = Q_{G,n} + Q_{U,n}$$

- Equilibrium price:

$$P_n = \frac{1}{\pi}\left(\beta\left(D_{G,n} + D_{U,n}\right) + \epsilon_{G,n} + \epsilon_{U,n} - S_n\right)$$

- Relevance: $\mathrm{Cov}\left(P_n, D_{G,n} \mid D_{U,n}\right) = \frac{\beta}{\pi}\mathrm{Var}\left(D_{G,n}\right) \neq 0$.
- Exogeneity: $\mathrm{Cov}\left(\epsilon_{U,n}, D_{G,n} \mid D_{U,n}\right) = 0$.

Identification strategies

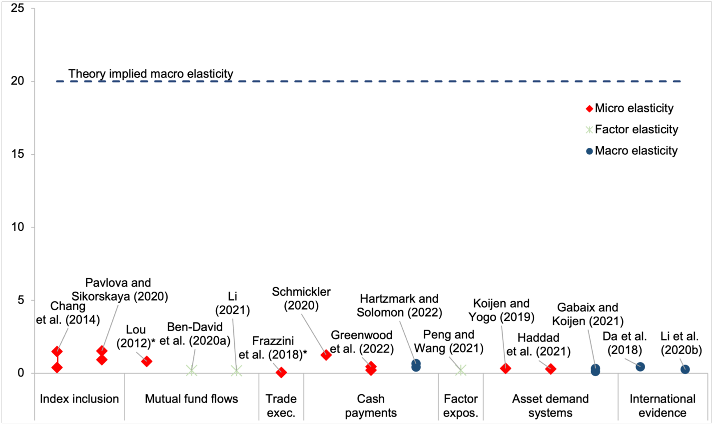
1. Investment mandates (Koijen and Yogo, 2019).
   - Total market fund (US investors) and banking fund (German investors).
   - J.P. Morgan (Dutch debt) and Walmart (Australian debt).
   - Relevance: J.P. Morgan is in the investment universe of the banking fund, but Walmart is not.
   - Exogeneity: Investment mandate of the banking fund does not directly affect the total market fund.
2. Index effects (Chang, Hong, and Liskovich, 2014).
   - Diff-in-diff version of investment mandates.
   - Cross-sectional variation in demand shocks at the Russell 1000/2000 cutoff.

Identification strategies

3. Payout-induced trading (Kvamvold and Lindset, 2018; Hartzmark and Solomon, 2022; Schmickler and Tremacoldi-Rossi, 2022b; Chen, 2024).
    - Preannouced payouts and predictable portfolio rebalancing.
    - Not mutual fund flows, which depend on prices through portfolio choice.
4. Central bank purchases (Koijen et al., 2021).
    - ECB purchases proportional to the capital key (i.e., average of GDP and population).
5. Granular IV (Gabaix and Koijen, 2024).

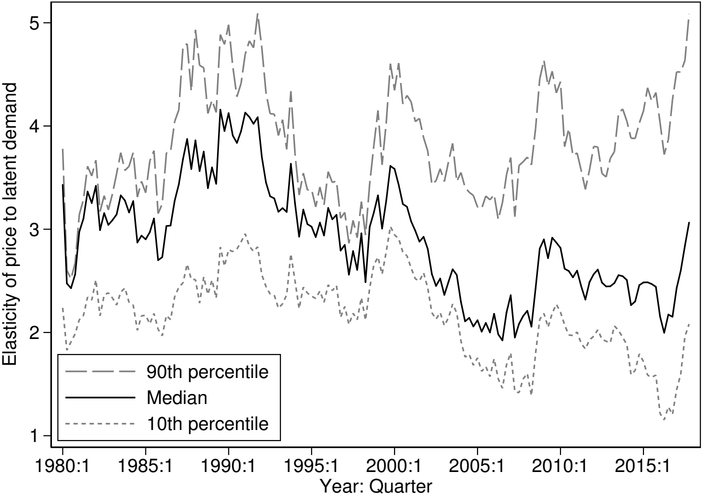
Estimates of demand elasticities

- Low elasticities, based on a variety of identification strategies.



Source: Gabaix and Koijen (2022)

Price impact across US stocks



Source: Koijen and Yogo (2019, Figure 6)

Price impact of euro-area QE

- Elasticity of 3.21 for euro-area government bonds.

Country	Instrument	Yield effect (%)
Austria	0.18	-0.45
Belgium	0.15	-0.38
Finland	0.33	-0.83
France	0.18	-0.45
Germany	0.24	-0.60
Ireland	0.32	-0.80
Italy	0.16	-0.40
Latvia	0.33	-0.83
Lithuania	0.33	-0.83
The Netherlands	0.20	-0.50
Portugal	0.33	-0.83
Slovakia	0.33	-0.83
Slovenia	0.33	-0.83
Spain	0.21	-0.53
Mean	0.26	-0.65

Source: Koijen et al. (2021, Table 11)

Examples of counterfactuals

- By market clearing, equilibrium prices are

$$\boldsymbol{p}_t = \boldsymbol{p}\left(\boldsymbol{x}_t, \boldsymbol{A}_t, \boldsymbol{\beta}_t, \boldsymbol{\epsilon}_t\right)$$

  - $\boldsymbol{x}_t$: Supply and asset characteristics.
  - $\boldsymbol{A}_t$: Assets under management.
  - $\boldsymbol{\beta}_t$: Coefficients on characteristics.
  - $\boldsymbol{\epsilon}_t$: Latent demand.

1. Which investors caused stock market volatility in 2008?

$$\boldsymbol{r}_{t+1} = \boldsymbol{p}\left(\boldsymbol{x}_{t+1}, \boldsymbol{A}_{t+1}, \boldsymbol{\beta}_{t+1}, \boldsymbol{\epsilon}_{t+1}\right) - \boldsymbol{p}_t$$

2. Predicting stock returns.

$$\mathbb{E}_t\left[\boldsymbol{p}_T - \boldsymbol{p}_t\right] \approx \boldsymbol{p}\left(\mathbb{E}_t\left[\boldsymbol{x}_T\right], \mathbb{E}_t\left[\boldsymbol{A}_T\right], \mathbb{E}_t\left[\boldsymbol{\beta}_T\right], \mathbb{E}_t\left[\boldsymbol{\epsilon}_T\right]\right) - \boldsymbol{p}_t$$

Which investors caused stock market volatility in 2008?

AUM ranking	Institution	AUM ($ billion)	Change in AUM (%)	% of variance	
	Supply: Shares outstanding, stock characteristics & dividend yield			8.1	(1.0)
1	Barclays Bank	699	-41	0.3	(0.1)
2	Fidelity Management & Research	577	-63	0.9	(0.2)
3	State Street Corporation	547	-37	0.3	(0.0)
4	Vanguard Group	486	-41	0.4	(0.0)
5	AXA Financial	309	-70	0.3	(0.1)
6	Capital World Investors	309	-44	0.1	(0.1)
7	Wellington Management Company	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 & Company	182	-59	0.1	(0.1)
	Subtotal: 30 largest institutions	6,050	-48	4.4	
	Smaller institutions	6,127	-53	40.7	(2.3)
	Households	6,322	-47	46.9	(2.6)
	Total	18,499	-49	100.0	

Source: Koijen and Yogo (2019, Table 4)

Predicting stock returns

Characteristic	All stocks	Excluding microcaps
Expected return	0.18	0.11
	(0.04)	(0.04)
Log market equity	-0.25	-0.15
	(0.08)	(0.08)
Book-to-market equity	0.04	0.06
	(0.04)	(0.05)
Profitability	0.30	0.29
	(0.06)	(0.06)
Investment	-0.38	-0.21
	(0.03)	(0.03)
Market beta	0.08	0.01
	(0.08)	(0.10)
Momentum	0.24	0.37
	(0.08)	(0.10)

Source: Koijen and Yogo (2019, Table 5)

Moments to evaluate asset pricing models

1. Aggregate demand elasticity pins down the variance of aggregate demand shocks.

$$P_{n,t} = \frac{1}{\overline{\pi}_t} \left(\underbrace{\overline{\beta}_t' \boldsymbol{X}_{n,t} + \overline{\epsilon}_{n,t}}_{\text{demand shifter}} - S_{n,t} \right)$$

   - Rejects models with elastic demand that require highly correlated demand shocks across investors.
   - Informs models with costly intermediation (e.g., Vayanos and Vila, 2021; Gabaix and Maggiori, 2015; Itskhoki and Mukhin, 2021).
   - Fully specified models allow for counterfactuals robust to the Lucas critique.
2. Variance decomposition reveals source of demand shocks.
   - Informs relative importance of sectors (e.g., broker-dealers, insurers, and hedge funds) in intermediary asset pricing (He and Krishnamurthy, 2013). Guides research effort.

Promising directions

1. Improving models of asset demand.
   - Elasticities depend on asset characteristics and embeddings.
   - Substitution in the extensive margin and short positions (Mainardi, 2024; Graves, 2025).
   - Evaluate performance based on the managed portfolio benchmark (Gabaix et al., 2024).
2. Continued progress on identification.
3. Connecting estimated demand shifters to survey expectations.
   - Which investors have rational inattention, diagnostic expectations, fading memory, etc.?
   - Tractable models of beliefs and portfolio choice can improve predictions and counterfactuals.
4. Resolving puzzles in empirical asset pricing. Which investors cause prices to move?
   - For example, value, momentum, and ESG (van der Beck, 2021; Huebner, 2023; Tamoni, Sokolinski, and Li, 2024).

Corporate finance applications

- Need asset demand estimation to identify investor preferences, controlling for price.
  - For example, hedge funds hold brown stocks because they are cheap, not because they like brown stocks (Koijen, Richmond, and Yogo, 2024).
- With estimates of investor preferences, test catering theory.

1. Firms cut emissions to cater to investors who exert stock price pressure (Noh, Oh, and Song, 2024).
2. Institutional bond investors have preferences for maturity, seniority, and covenants. Firms issue bonds with these features, lowering the cost of capital (Mota and Siani, 2024).
3. More generally, which aspects of investment, capital structure, and payout policy are sensitive to investor preferences?

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