Conservative Holdings, Aggressive Trades: Learning, Equilibrium Flows, and Risk Premia

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Motivation

Periods of **high uncertainty** are frequently associated with:

- A **flow of risky assets** from institutional to individual investors'
  - Institutions **sell**/individuals **buy** when uncertainty is high
- An **increase in risk premia**
  - E.g. FOMC, macro, or earning announcements

Existing explanations

- **Flows:**
  - **Portfolio constraints, information asymmetry...**
  - **Liquidity provision** by individual investors
    (Barrot, Kaniel, and Sraer, 2016, Glossner, Matos, Ramelli, and Wagner, 2020, Kaniel, Saar, and Titman, 2008, Pástor and Vorsatz, 2020)
  - **"Attention-induced" trading**
    (Barber and Odean, 2008, Frazzini and Lamont, 2007, Hirshleifer, Myers, Myers, and Teoh, 2008, Barber, Huang, Odean, and Schwarz, 2021)
- **Risk premium:**
  - Rational expectations: counter-cyclical **objective** risk premium (habits, long-run risks, disasters,...)
    (survey: Cochrane, 2017)
  - Parameter uncertainty and **learning**: dynamics of **subjective risk premium** ("out-of-sample")
    (Lewellen and Shanken, 2002, Collin-Dufresne, Johannes, and Lochstoer, 2016b, Nagel and Xu, 2022, ...)

This paper

- Alternative explanation for **equilibrium** flows **and** risk premia that relies on **two channels**:
  1) **Learning** about the underlying parameters of the economy
     - Economy with iid-normal dividend, unknown **mean** and **variance**
  2) **Heterogeneity** in agents' **confidence** in parameter estimates
     - **Ambiguity-neutral** vs. **Ambiguity-averse** investors (Knightian uncertainty/robustness)

- **Key** channels to explain the effects of cash flow "surprises" on:
  - portfolio flows
  - risk premia

Main results

- **Equilibrium flows**
  - **Ambiguity-averse**: conservative holdings but aggressive trades after dividend surprises
  - **Ambiguity-neutral**: aggressive holdings but conservative after dividend surprises
- **Equilibrium risk premia**
  - Endogenously time-varying **subjective** risk-premium: increasing following **large dividend surprises**
    - Variance estimate increases after cash flow **surprises**
  - Skewness in **objective** risk premium:
    - Increases more after negative dividend surprises
    - Left-skewed price innovations
- **Methodology**: show how to handle learning about variance in an infinite-horizon OLG economy
  - Bayesian updating with "**truncated**" priors
- **Empirically:** provide support of predictions using institutional investors data

Outline

- Intuition in a simple **two-period** model
- An **infinite-horizon** overlapping generations **(OLG)** model
  - (Unknown mean, **known variance** $\Longrightarrow$ no portfolio flows)
  - Unknown mean, **unknown variance** $\Longrightarrow$ portfolio flows
- **Empirical** evidence
- Conclusion

Two-period model – Economy

- **Risky asset** in finite supply: produces perishable dividends $\tilde{d} \sim \mathcal{N}(\mu, \sigma^2)$
  - μ **unknown**
  - σ **known**
- **Riskless asset** in infinite supply—exogenous risk-free rate r
- No initial consumption
- At initial date agents have observed a history of t dividends
  - time series **average**: m and **standard error** $s = \frac{\sigma}{\sqrt{t}}$
- **Two types** of CARA agents with same risk aversion $\gamma > 0$
  - Type-S: **ambiguity neutral** (**S**ubjective Expected Utility)
  - Type-A: **ambiguity averse**

Two-period model – Beliefs

- Type S subjective distribution of the dividend ("**single-prior**")

$$\tilde{d} \sim^S \mathcal{N}\left(\mu^S, \sigma^2\left(\frac{t+1}{t}\right)\right), \quad \text{where } \mu^S = m$$

- Type A subjective distribution of the dividend ("**multi-prior**")

$$\tilde{d} \sim^A \mathcal{N}\left(\mu^A, \sigma^2\left(\frac{t+1}{t}\right)\right), \quad \text{where } \mu^A \in \mathcal{P} \equiv [m - \kappa s, m + \kappa s]$$

with $\kappa > 0$ coefficient of **ambiguity aversion**

- **Classical statistics**, $\kappa =$ quantile of a distribution (see, e.g., Bewley, 2011)
- κ captures **heterogeneity** between agents: $\kappa = 0 \implies A = S$
- Note: size of set of priors $\mathcal{P}$ depends on **standard error** s

Two-period model – Optimal portfolios

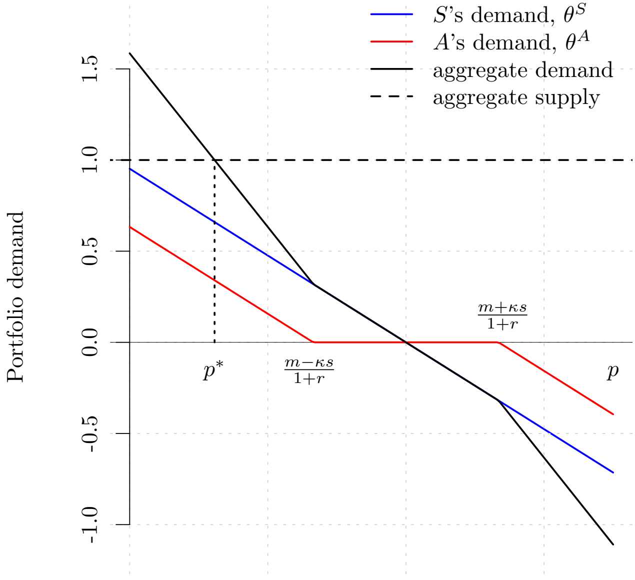
- Type-S **portfolio problem**

$$\max_{\theta^S} \mathbb{E}\left[-\frac{1}{\gamma}e^{-\gamma \tilde{W}^S}\right], \quad \text{s.t.} \quad \widetilde{W}^S = W^S(1+r) + \theta^S(\tilde{d} - p(1+r))$$

- Type-A **portfolio problem** (Gilboa and Schmeidler (1989))

$$\max_{\theta^A} \min_{\mu^A \in \mathcal{P}} \mathbb{E}^A\left[-\frac{1}{\gamma}e^{-\gamma \widetilde{W}^A}\right], \quad \text{s.t.} \quad \begin{array}{l} \widetilde{W}^A = W^A(1+r) + \theta^A(\tilde{d} - p(1+r)) \\ \mathcal{P} = [m - \kappa s, m + \kappa s] \end{array}$$

Two-period model - Demand and Equilibrium



- $p^* < \frac{m-\kappa s}{1+r}$: both participate
- $p^* > \frac{m-\kappa s}{1+r}$: A does not participate

Two-period model – Equilibrium

- **Equilibrium price**: p^* s.t. $\theta^A + \theta^S = 1$

$$p^* = \frac{1}{1+r} m - \lambda, \quad \text{with} \quad \lambda = \begin{cases} \frac{\gamma}{2}\left(\frac{t+1}{t}\right)\sigma^2 + \frac{\kappa}{2}\frac{\sigma}{\sqrt{t}} & \text{if } \kappa \le \kappa^* \quad \text{(A\&S participate)} \\ \gamma\left(\frac{t+1}{t}\right)\sigma^2 & \text{if } \kappa > \kappa^* \quad \text{(Only S participates)} \end{cases}$$

- Agent A participates only if ambiguity aversion κ is **sufficiently low** $(\kappa \le \kappa^*)$
- If agents A participate, risk premium **linear-quadratic** in σ
  - **Ambiguity aversion** has a **first-order effect** on asset prices
  - A is locally not risk neutral ("First-order risk aversion")
- λ is S's **subjective risk premium**: $\lambda = \mu^S - (1+r)p^*$, $\mu^S = m$

Two-period model – Equilibrium portfolio holdings

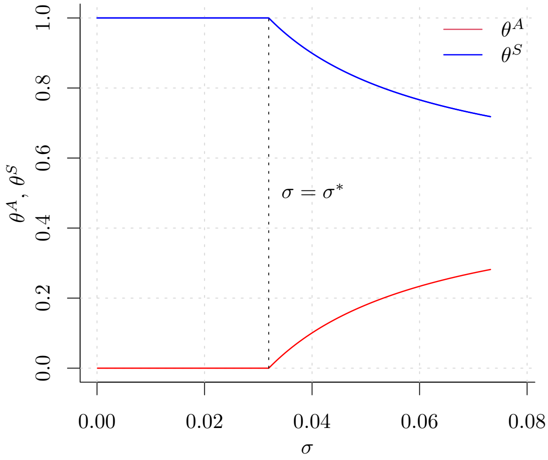
- **Equilibrium risky holdings:** Replace equilibrium p^* in agents' risky asset demands

$$\theta^A = \frac{1}{2} - \frac{\kappa}{2\gamma}\left(\frac{\sqrt{t}}{t+1}\right)\frac{1}{\sigma}$$
$$\theta^S = \frac{1}{2} + \frac{\kappa}{2\gamma}\left(\frac{\sqrt{t}}{t+1}\right)\frac{1}{\sigma}$$

- An **increasing** dividend **volatility** σ leads to:
  - an increase in θ^A ("aggressive A trades")
  - a decline in θ^S ("conservative S trades")

Note: equilibrium portfolio weights θs **independent** of beliefs about **dividend mean** μ

Equilibrium Portfolios



- Ambiguity-averse equilibrium holdings θ^A **increase** with dividend volatility
- Ambiguity-neutral equilibrium holdings θ^S **decrease** with dividend volatility

Intuition

- Because of ambiguity aversion A holds **less** risky asset than S
  - A has more **marginal "risk capacity"** than S
  - A's risky-asset demand shows **less risk sensitivity**
- Following an increase in variance:
  - A requires **less** return compensation than S to keep the same portfolio
  - As a "response to an increase" in volatility (*handwaving* argument, more rigorous later)
  - $\Rightarrow$ A **buys** and S **sells** risky asset Intuition
- Ambiguity aversion (A agents) implies
  - "conservative" holdings: $\theta^A < \theta^S$ **BUT**
  - "aggressive" trades: $\Delta\theta^A > 0$, $\Delta\theta^S < 0$
- **Caveat**: comparative statics w.r.t. $\sigma \neq$ portfolio flows!

An Overlapping-Generations (OLG) model

- **Infinite horizon**. Two types of agents:
  - **Ambiguity averse**: A
  - **Ambiguity neutral** (subjective expected utility): S
- Agents live for **two periods** with **overlapping generations**, CARA utility.
- Risky and risk-free assets. No first-period consumption.
- iid dividend process $d_t \sim \mathcal{N}(\mu, \sigma^2)$:
  - μ, σ **constant** but **unknown**
- Portfolios of generation-t: θ_t^i, $i = A, S$
- Inter-generational **flows**

$$\Delta\theta_t^i = \theta_t^i - \theta_{t-1}^i, \quad i = A, S$$

Why learning about volatility?

- For **tractability**, literature focused mainly on uncertainty about mean, not variance
  - High-frequency observations $\Longrightarrow$ variance estimated precisely (Merton 1980)
- Learning about variance relevant if information arrives in **"chunks"**, e.g., FOMC announcements
- Weitzman (2007, AER): "for asset pricing implications [...] the most critical issue involved in Bayesian learning [...] is the unknown variance"
  - Fat tails of predictive distribution can reverse macro-finance puzzles (risk premium, riskfree, volatility)

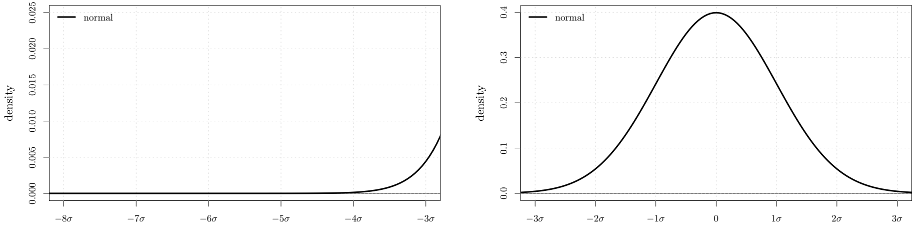
Why not stochastic volatility?

- Starkly different implication for equilibrium flows.
- **Stochastic and observable volatility**
  - any new dividend observation **reduces** the standard error of the mean and hence its confidence interval
- **Unobservable volatility and learning**
  - a change in the estimated variance implies a change in the **perceived** information quality of *all* historically observed dividends
  - any new dividend observation can both **increase** or **decrease** the standard error of the mean

Two issues

1) OLG with **unknown variance** $\implies$ subjective d_{t+1} is Student-t (fat tails!)

- $\mathbb{E}_t[u(d_{t+1})] = \mathbb{E}_t\left[-\frac{1}{\gamma}e^{-\gamma d_{t+1}}\right]$ **does not exist**!! (see Geweke, 2001)
- Solution: Assume $\sigma \in [\underline{\sigma}, \overline{\sigma}]$, precision $\phi = 1/\sigma^2$ is **truncated Gamma**
  - ⋆ Bakshi and Skoulakis (2010) provide Bayesian updating theory that preserves **conjugacy**



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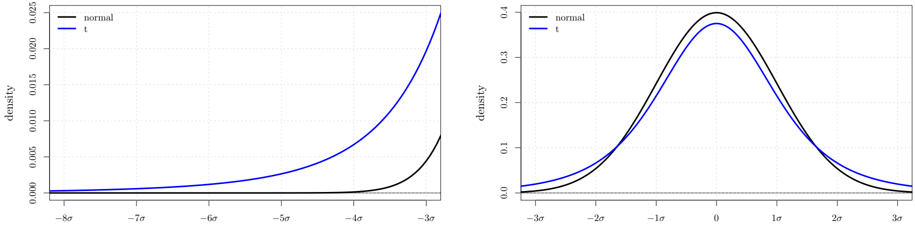

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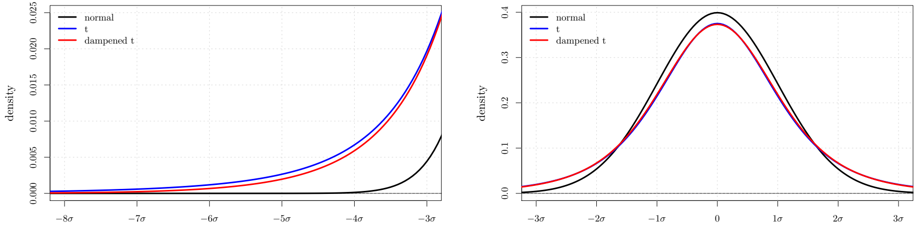

Two issues (cont.)

2) **OLG with constant parameters** $(\mu, \sigma) \implies$ learning eventually irrelevant

- **Perpetual learning** is relevant when there is **"leakage"** in **information transfer** from generation t to generation $t+1$
- Model **information leakage** as **shocks** that **"blur" priors** on μ and σ
- Similar to **"fading memory"** (Nagel and Xu, 2021) or **"age-related experiential learning"** (Malmendier and Nagel, 2016, Collin-Dufresne, Johannes, and Lochstoer, 2016a, Ehling, Graniero, and Heyerdahl-Larsen, 2018, Malmendier, Pouzo, and Vanasco, 2020)

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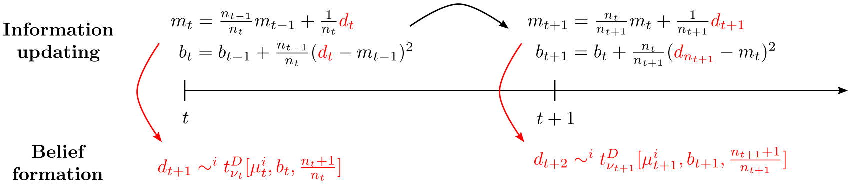
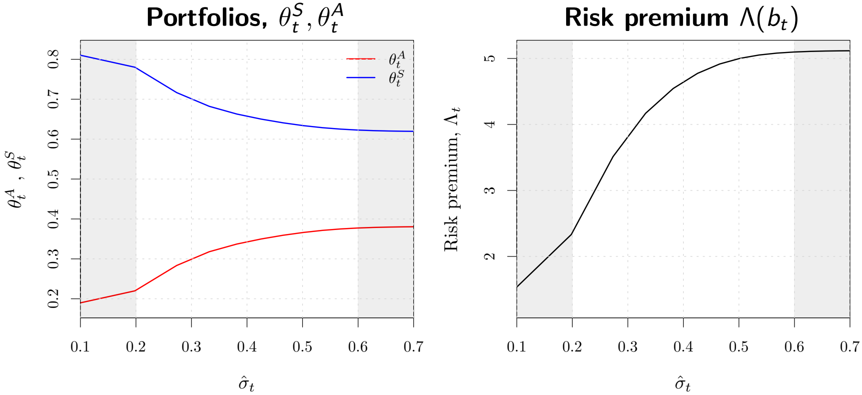
$\Rightarrow$ OLG with **unknown variance** and **perpetual learning**

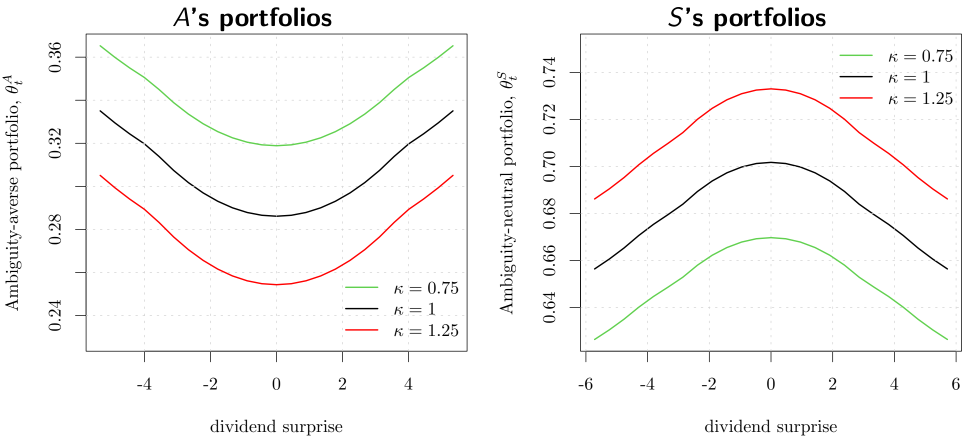


OLG with unknown variance and perpetual learning: Equilibrium portfolios and risk premia



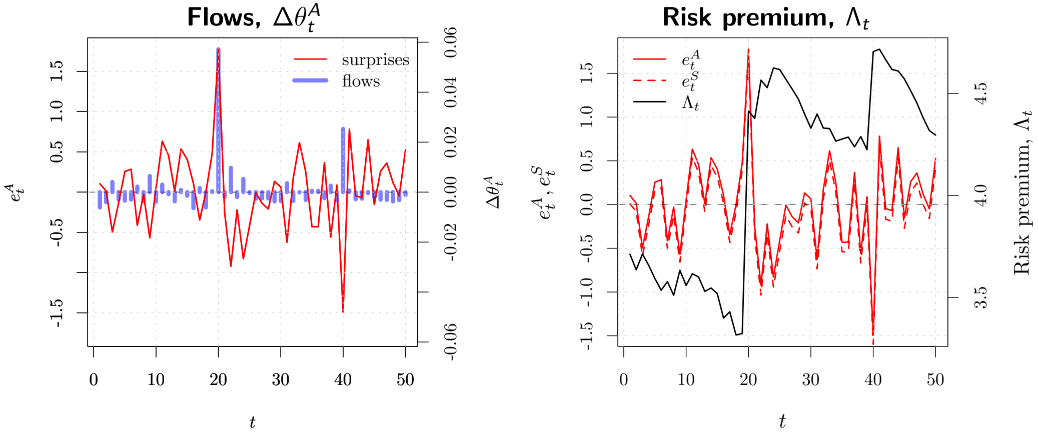
- As in the two-pd model, an **increase** in $\hat{\sigma} \equiv \sqrt{b_t/\overline{n}}$ leads to:
  - an increase in θ_t^A ("aggressive A trades") and a **decrease** in θ_t^S
  - an increase in risk premium

Equilibrium portfolios and dividend surprises



- Dividend **surprise**: $e^i_{t+1} = d_{t+1} - \mu^i_t$. **Deviation** from **subjective mean** belief
- Equilibrium flows large positive and negative surprises $\implies$ A buys and S sells the risky asset

Equilibrium portfolio flows and risk premia vs. dividend surprises



- Large surprises $\implies$ A buys ($\Delta\theta_t^A > 0$)
- Large surprises $\implies$ high risk premium Λ_t (right axis)

Return predictability

- **Objective** risk premium. Using the equilibrium price $p_t = \frac{1}{r} m_t - \Lambda(b_t)$, we have

$$\Lambda_t^{\text{obj}} \equiv \frac{\mu}{r} - p_t = \begin{cases} \frac{1}{r}(\mu - m_t) + \Lambda(t), & \text{if } \textbf{known} \text{ variance} \\ \frac{1}{r}(\mu - m_t) + \Lambda(b_t), & \text{if } \textbf{unknown} \text{ variance} \end{cases}$$

  b_t: measure of **variance**

- $\mu - m_t$ detectable **ex-post** but not exploitable **ex-ante** (Lewellen and Shanken, 2002)

- **Subjective** risk premium $\Lambda(b_t)$ **not countercyclical**, **increases** with estimated **volatility** (Nagel and Xu, 2022)

- **Skewness**: asymmetry of Λ_t^{obj} response to news shocks:
  - Bad news $\Longrightarrow$ High b_t and low m_t $\Longrightarrow$ **amplification** effect on Λ_t^{obj}
  - Good news $\Longrightarrow$ High b_t and high m_t $\Longrightarrow$ **dampening** effect on Λ_t^{obj}

Empirical analysis (in progress. . .)

Two key challenges:

1) How to **map** agents in the model to observable market participants?
   - **Individual** more averse to uncertainty than **institutions** (Li, Tiwari, and Tong, 2017)
   - Ambiguity aversion influenced by perceived **competence** (Heath and Tversky, 1991, Fox and Tversky, 1995)
   - $\Rightarrow$ Type-$A \approx$ **retail** investors, Type-$S \approx$ **institutional** investors

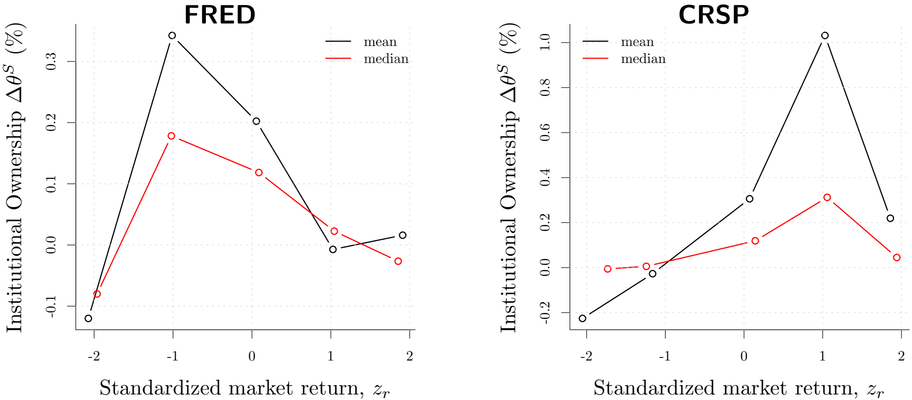
2) How to measure uncertainty/surprises?
   - Use large market return realizations (Δp_t) as **proxy** for increase in uncertainty (e_t)

Data and methodology

- **Holdings**:
  - **Aggregate** level and flow data on corporate equity holdings of **households** and **financial sector**: 1952.Q1–2020.Q4 (Federal Reserve of St. Louis, FRED)
  - **Institutional** holdings of U.S. **firms**: 2000.Q1–2020.Q1 (Thomson Reuters OP Global Ownership database + Compustat-CapitalIQ)
    - 13F reporting institutions, mutual, pension and insurance funds: 274,697 firm-quarter observations
- **Returns**:
  - CRSP return data of all NYSE, AMEX, and NASDAQ firms, 1965.01–2020.12
- **Surprises** in firms' future profitability:
  - Deviation from standarized market returns over a rolling 20-quarter window (Mkt return from Kenneth French's data library)
- **Subjective** risk premium, conditional on surprises
  - **Aggregate**. Households and financials holdings return in excess of the 3-month risk-free rate (FRED)
  - **Cross sectional**. Fama-MacBeth regression using stock return data (CRSP)

Evidence – institutional investors portfolio flows

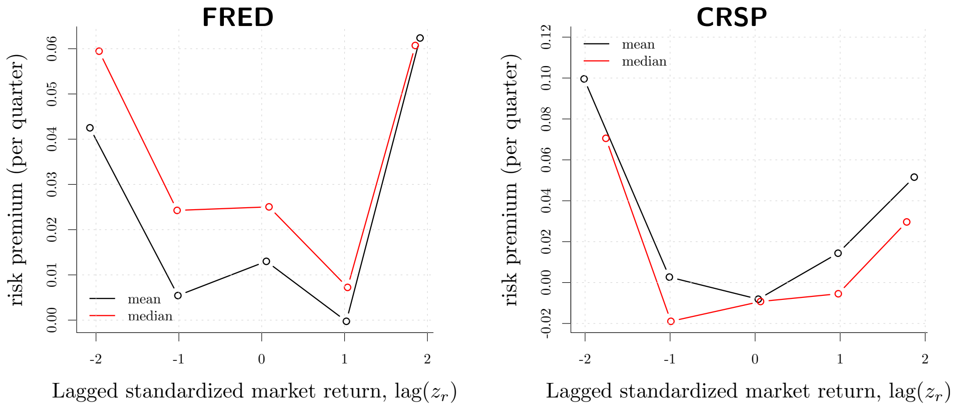
- Institutional investors **reduce** risky holdings after extreme surprises



- **"Surprise":** standardized market return $\quad \Delta\theta_t^S$: change in risky asset holding of institutions

Evidence – subjective risk premium

- Large **surprises** (positive and negative) imply a **high** subjective **risk premium**



New dataset / New revision

- **EUR STOXX 50 futures** transactions on Eurex
- January 2002 to December 2020
- **824 million trades** at a frequency of **milliseconds**
- Three trader types: **Agency traders**, **proprietary traders**, **market makers**
- Argue that **agency traders** (trading for clients) are **less ambiguity averse** than proprietary traders and market makers
  - **Desire** for **robustness** as a reaction of market makers' **inventory risk**, Routledge and Zin (2009), Easley and O'Hara (2010) and Zhou (2021)
  - **Proprietary traders** and **market makers** do **less informed** trades, Menkveld and Saru (2023)
- **Confirm** our **model predictions** regarding flows and risk premia

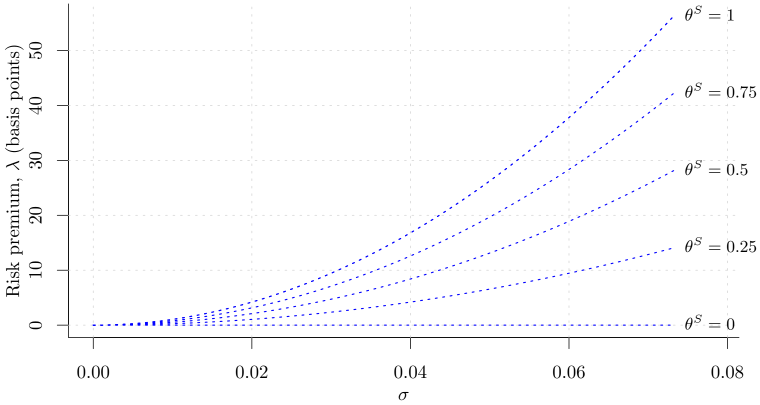
Conclusions

- Develop a **general equilibrium asset pricing model** with
  - **learning** about the **moments** of the endowment process
  - **heterogeneous confidence** in parameter estimates
- **Learning** about **variance** (not just the mean)
  - key to understanding risk-premia and portfolio flows around dividend "surprises"
- Can **explain** features of both **asset prices** and **flows**
  - **Individuals** hold **conservative portfolios** but **buy** in response to **positive and negative surprises**
  - Endogenously time-varying risk premium
- **Verify** these predictions **empirically**
- Understanding the dynamics of flows in **inelastic** markets ("demand-based asset pricing")

Additional Slides

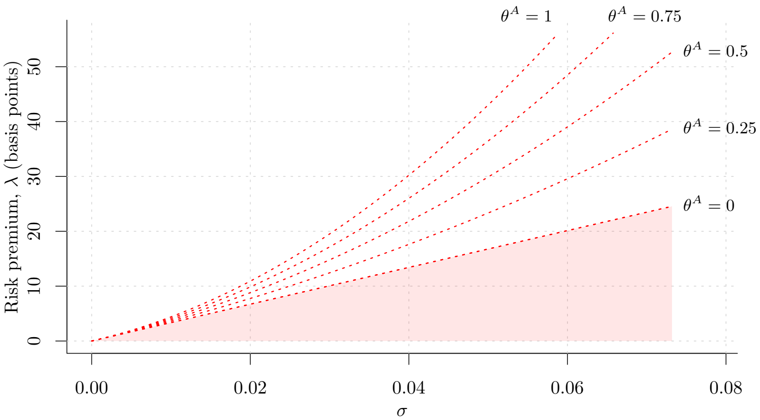
Intuition–Type-S agents' iso-portfolios

- **Iso-portfolios**: pairs (σ, λ) s.t. S's portfolio θ^S is constant



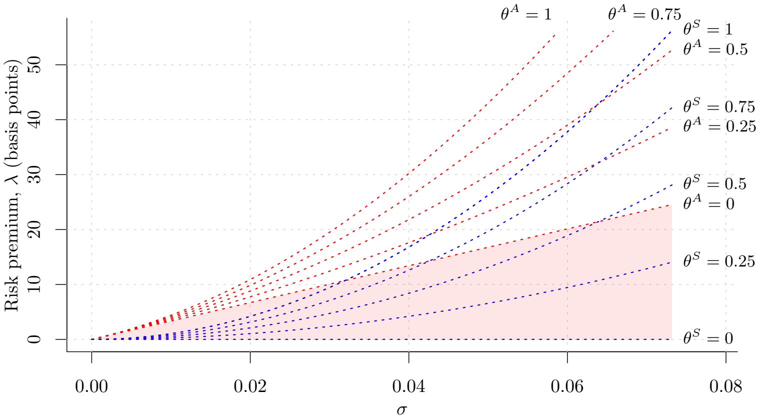
- Agents S are "locally risk neutral" (second-order risk aversion) Back

Intuition–Type-A agents' iso-portfolios



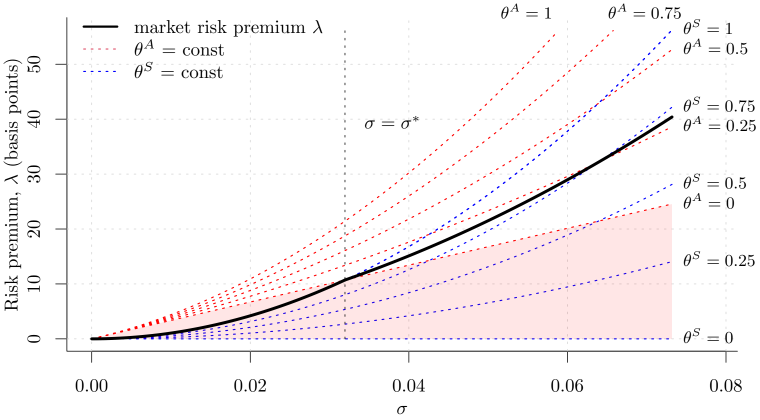
- If $\lambda < \kappa\sigma/\sqrt{t} \Rightarrow$ **no participation**
- Agents A are "locally risk averse" (first-order risk aversion) Back

Intuition–Market clearing, $\theta^A + \theta^S = 1$



- A iso-lines always **flatter** than S at equilibrium $(\theta^A + \theta^S = 1)$ Back
  - Agents A require a **smaller compensation** for bearing **extra risk** than S

Intuition–Equilibrium Risk Premium



- Ambiguity averse agents **increase** θ^A as σ increases ▸ Back
  - A (S) iso-lines always intersect λ from above (below)

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