

# Belief Distortions, Asset Prices, and Unemployment Fluctuations

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## Motivation: Unemployment Volatility Puzzle (Shimer 2005)

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**Finance approach:** Hiring is a forward-looking investment with risky cash flows

- ▶ Firms post vacancies based on their valuation of a new hire
- ▶ Valuation depends on beliefs about:
  - Expected cash flows: Future profits generated by the worker
  - Discount rates: Risk-adjusted present value of future profits

# Motivation: Unemployment Volatility Puzzle (Shimer 2005)

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**Finance approach:** Hiring is a forward-looking investment with risky cash flows

- ▶ Firms post vacancies based on their valuation of a new hire
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  - Discount rates: Risk-adjusted present value of future profits

**Standard model:** Limited sources of unemployment volatility

- ▶ Risk neutral  $\Rightarrow$  Constant discount rates
- ▶ Rational expectations  $\Rightarrow$  Ties beliefs to true cash flows, which are too stable

## **Subjective expectations:** This paper

- ▶ Subjective beliefs implied by survey forecasts overreact to cash flow news
  - Good news about cash flow leads to overoptimism  $\Rightarrow$  Inflates value of new hire
- ▶ Explains both aggregate volatility and dispersion across firms
  - Overreaction applies to both aggregate and idiosyncratic news

## **Rational expectations:** Hall 2017, Borovičková-Borovička 2017, Kehoe et al. 2023, ...

- ▶ Time-varying discount rates under full-information rational expectations
  - Recessions bring high discount rates  $\Rightarrow$  Depresses value of new hire
- ▶ Cross-sectional puzzle: In the data, firms respond strongly to idiosyncratic news
  - Hard to explain with rational discounting since idiosyncratic risk is largely diversifiable

**Question:** To what extent can belief overreaction explain labor market fluctuations?

**Approach:** Decompose variation in hiring using measured belief distortion

- ▶ Belief distortion  $\mathbb{F}_t - \mathbb{E}_t$ : Predictable mistakes in subjective beliefs
- ▶ Subjective belief  $\mathbb{F}_t$ : Survey forecast (equity research analysts)
- ▶ Objective belief  $\mathbb{E}_t$ : Machine learning forecast (neural network; Bianchi et al. 2025)

**Main findings:**

- ▶ Belief distortion measures survey overreaction (machine does not overreact)
- ▶ Belief distortion explains 90% of vacancy filling rate (68% of unemp.) variation
- ▶ Same mechanism drives firm-level hiring & return response to idiosyncratic news
- ▶ Search model with learning generates 60%+ of aggregate & firm-level variation

1. **Measure belief distortions:** Compare survey vs. machine learning forecasts
2. **Document overreaction:** Quantify survey overreaction using belief distortion
3. **Aggregate evidence:** Decompose U.S. vacancy filling rate variation
4. **Firm-level evidence:** Decompose cross-sectional hiring rate variation
5. **Firm-level dynamics:** Estimate impulse response to idiosyncratic news
6. **Model:** Search and matching with learning about cash flows

## Labor market outcomes

	Scope	Measure
Labor market	Time-series	Vacancy filling rate (JOLTS)
	Cross-section	Firm-level hiring rate (Compustat)

## Beliefs: Subjective $\mathbb{F}_t$ vs. objective $\mathbb{E}_t$

	Scope	Subjective	Objective
Cash flows	Time-series	IBES analyst	Machine learning
	Cross-section	IBES analyst	Machine learning
Discount rates	Time-series	CFO forecast	Machine learning
	Cross-section	IBES & Value Line	Machine learning

**Time-series:**  $q_t$  = U.S. Vacancy filling rate for quarter  $t$  (Source: JOLTS, BLS)

$$q_t = \frac{f_t U_t}{V_t} = \frac{\text{Total Hires}}{\text{Total Job Vacancies}}$$

- ▶  $V_t$  job vacancies,  $U_t$  unemployment,  $f_t$  job finding rate (= total hires/unemployment)
- ▶ Countercyclical: High  $U_t$  relative to  $V_t$  during recession  $\Rightarrow$  High  $q_t$

**Cross-section:**  $hl_{i,t}$  = Hiring rate for firm  $i$  quarter  $t$  (Source: Compustat, JOLTS)

$$hl_{i,t} = \frac{L_{i,t+1} - (1 - \delta_{i,t})L_{i,t}}{L_{i,t}} = \frac{\text{Total Hires}}{\text{Total Employment}}$$

- ▶  $L_{i,t}$  employees at fiscal year-end, carried forward to quarterly
- ▶  $\delta_{i,t}$  job separation rate of firm  $i$ 's 2-digit NAICS industry
- ▶ **Firm-level sample:** Firms with common stocks (share codes 10, 11) on NYSE/AMEX/NASDAQ with IBES analyst coverage of expected earnings and stock price targets

**Cross-section:**  $E_{i,t}$  = Firm-level “street” earnings (IBES, 1983Q4-2023Q4):

- ▶ “Street”: Exclude one-off items not relevant to firm’s future operation
- ▶ Transformation to ensure positive values (Vuolteenaho 2002):

$$E_{i,t} = (1 - \lambda)E_{i,t}^* + \lambda r_t^f P_{i,t-1} > 0, \quad \lambda = 0.10$$

- Interpret as portfolio of 90% equity and 10% T-bills
- Allows  $\log(E_{i,t})$  to be well-defined when reported earnings negative  $E_{i,t}^* \leq 0$
- Apply similar transformation to firm-level stock returns

**Time-series:**  $E_t$  = Aggregate to S&P 500 level from firm-level

$$E_t = \Omega_t \sum_{i \in x_t} E_{i,t}^* / Divisor_t$$

- ▶  $x_t$  S&P 500 firms with IBES data,  $\Omega_t$  adjust for IBES coverage,  $Divisor_t$  S&P 500 divisor

**Cross-section:**  $\mathbb{F}_t[\Delta e_{i,t+h}]$  = IBES median consensus forecast of street earnings growth

- ▶ Respondents: Equity research analysts (1983Q4-2023Q4)
- ▶ Years  $h = 1, 2$ : Construct annual log growth forecast  $\mathbb{F}_t[\Delta e_{i,t+h}]$  from level forecast
  - Growth forecast:  $\mathbb{F}_t[\Delta e_{i,t+h}] \approx \log(\mathbb{F}_t[E_{i,t+h}]/\mathbb{F}_t[E_{i,t+h-1}])$
- ▶ Years  $h = 3, 4, 5$ : Interpret long-term growth (LTG) forecast as  $\mathbb{F}_t[\Delta e_{i,t+h}]$ 
  - LTG: Annualized growth forecast over next “three-to-five years”

**Time-series:**  $\mathbb{F}_t[\Delta e_{t+h}]$  = Aggregate to S&P 500 level from firm-level

- ▶ Years  $h = 1, 2$ : Aggregate using  $\mathbb{F}_t[E_{t+h}] = \Omega_t \sum_{i \in x_t} \mathbb{F}_t[E_{i,t+h}^*] \cdot S_{i,t} / \text{Divisor}_t$
- ▶ Years  $h = 3, 4, 5$ : Value-weighted average of LTG forecasts

**Time-series:**  $r_t$  = Log annual return on the S&P 500 with dividends

- Expected:  $\mathbb{F}_t[r_{t+h}]$  = CFO survey median consensus forecast (2001Q4-2023Q4)
  - Respondents: CFOs, VPs of finance, directors ( $\sim 1,600$  members as of 2022)
  - Horizon  $h$ : 1 and 10 years ahead; interpolate intermediate horizons linearly

**Cross-section:**  $r_{i,t}$  = Log annual return on firm  $i$ 's stock with dividends

- Expected:  $\mathbb{F}_t[r_{i,t+h}]$  from IBES & Value Line median consensus price target  $\mathbb{F}_t[P_{i,t+h}]$

$$\mathbb{F}_t[r_{i,t+h}] \approx \log \left( \frac{\mathbb{F}_t[P_{i,t+h}]}{P_{i,t}} + \frac{D_{i,t}}{P_{i,t}} \frac{\mathbb{F}_t[D_{i,t+h}]}{D_{i,t}} \right)$$

- Respondents: Equity research analysts (1999Q4-2023Q4)
- Horizon  $h$ : 1 year (IBES) and 5 years (Value Line), interpolate intermediate horizons
- Price  $P_{i,t}$  (CRSP), dividend  $D_{i,t}$  (Compustat),  $\mathbb{F}_t[D_{i,t+h}]/D_{i,t} \approx 1.064$  (postwar avg)

**Long Short-Term Memory (LSTM) neural network** (Bianchi, Lee, Ludvigson, Ma 2025):

$$\mathbb{E}_t[y_{t+h}] = G(\mathcal{X}_t, \beta_t^{TS}; \lambda_t^{TS}) \quad (\text{Time-Series})$$

$$\mathbb{E}_t[y_{i,t+h}] = G(\mathcal{X}_{i,t}, \beta_t^{CS}; \lambda_t^{CS}) \quad (\text{Cross-Section})$$

- ▶ Forecast target:  $y \in \{r, \Delta e\}$  at horizons  $h = 1, \dots, 5$  years
- ▶ Parameter  $\beta_t$ : Re-estimate quarterly (TS) or annually (CS) over rolling sample
- ▶ Regularization  $\lambda_t$ :  $L_1/L_2$  penalty, dropout, early stopping, ensemble average

**Input data:**

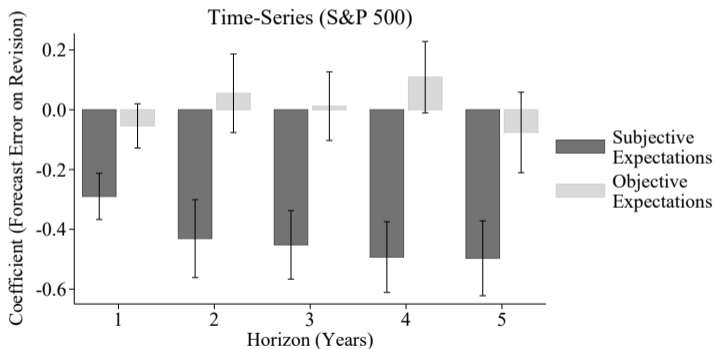
- ▶ Time-series:  $\mathcal{X}_t = \text{Real-time macro/financial, text (LDA from WSJ), survey data}$
- ▶ Cross-section:  $\mathcal{X}_{i,t} = [\mathcal{X}_t, \mathcal{C}_{i,t}]$  where  $\mathcal{C}_{i,t}$  includes firm characteristics (e.g. valuation, profitability, size, momentum, volatility), industry dummies (Chen-Zimmermann 2022)

⇒ Proxy for rational agent's real-time forecast without knowing true data generating process

# Survey $\mathbb{F}_t$ Overreacts, Machine Learning $\mathbb{E}_t$ Does Not: Time-Series

$$\overbrace{\Delta e_{t,t+h} - \mathbb{F}_t[\Delta e_{t,t+h}]}^{\text{Forecast Error}} = \beta \cdot \overbrace{[\mathbb{F}_t[\Delta e_{t,t+h}] - \mathbb{F}_{t-1}[\Delta e_{t,t+h}]]}^{\text{Forecast Revision}} + \varepsilon_t$$

- ▶ Survey:  
(+) forecast revision  
predicts (-) forecast error  
 $\Rightarrow$  Overreaction
- ▶ Machine:  
Forecast errors not  
predictable  
 $\Rightarrow$  No overreaction

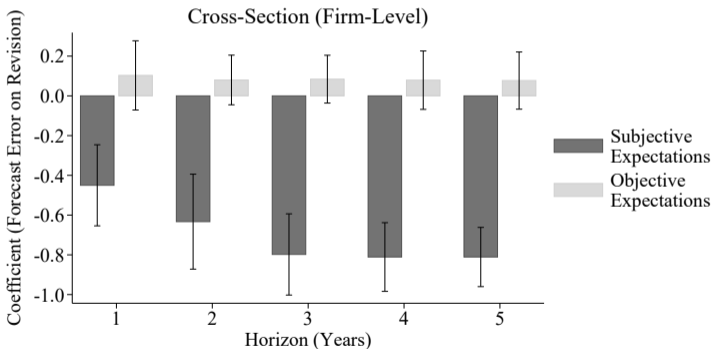


Notes: Figure reports  $\beta$  from time-series Coibion and Gorodnichenko 2015 regressions of survey and machine forecast errors on forecast revisions for aggregate S&P 500 cash flows. Sample: 2005Q1-2023Q4.

# Survey $\mathbb{F}_t$ Overreacts, Machine Learning $\mathbb{E}_t$ Does Not: Cross-Section

$$\overbrace{\Delta e_{i,t,t+h} - \mathbb{F}_t[\Delta e_{i,t,t+h}]}^{\text{Forecast Error}} = \beta \cdot \overbrace{[\mathbb{F}_t[\Delta e_{i,t,t+h}] - \mathbb{F}_{t-1}[\Delta e_{i,t,t+h}]]}^{\text{Forecast Revision}} + \overbrace{\alpha_i + \alpha_t}^{\text{Firm \& Time FE}} + \varepsilon_{i,t}$$

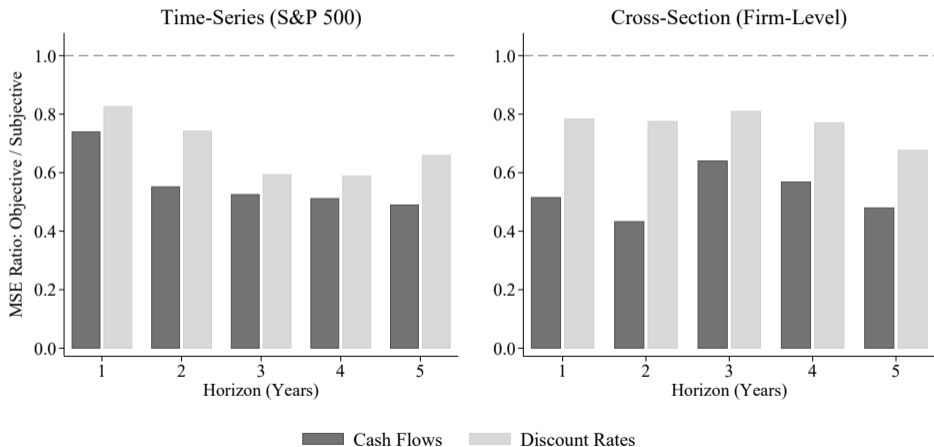
- ▶ Survey:
  - (+) forecast revision predicts (-) forecast error
  - ⇒ Overreaction
- ▶ Machine:
  - Forecast errors not predictable
  - ⇒ No overreaction



Notes: Figure reports  $\beta$  from firm-level Coibion and Gorodnichenko 2015 regressions of survey and machine forecast errors on forecast revisions with firm & time fixed effects. Sample: 2005Q1-2023Q4.

# Machine Learning $\mathbb{E}_t$ More Accurate than Survey $\mathbb{F}_t$

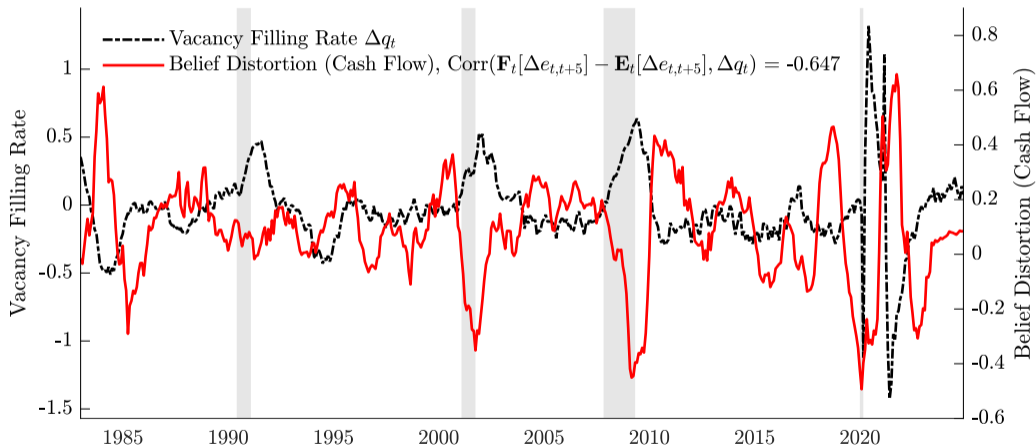
- ▶ Machine MSE lower than survey MSE because survey makes predictable mistakes



Notes: Figure shows relative forecast errors  $MSE_{\mathbb{E}}/MSE_{\mathbb{F}}$  comparing machine learning to survey forecasts. Left panel: aggregate S&P 500 time-series forecasts. Right panel: cross-sectional forecasts across listed firms. Dark bars: cash flows (earnings growth); light bars: discount rates (stock returns). Out-of-sample testing period: 2005Q1–2023Q4.

# Vacancy Filling Rate Tracks Belief Distortions in Cash Flows [► Details](#)

- Recession: Belief distortion  $\downarrow$  (pessimism), vacancy filling rate  $\uparrow$  (high  $U$  relative to  $V$ )



Notes: Left axis: Annual log change in the U.S. vacancy filling rate. Right axis: Belief distortion measured as expectational errors  $\mathbb{F}_t[\Delta e_{t,t+5}] - \mathbb{E}_t[\Delta e_{t,t+5}]$  in 5-year IBES survey forecasts of annualized S&P 500 earnings growth. Gray shaded areas indicate NBER recessions.

# Search and Matching Model (Diamond-Mortensen-Pissarides)

- ▶ Firm posts job vacancies  $V_t$  to attract unemployed workers  $U_t$ 
  - Matches formed at vacancy filling rate  $q_t$ , separated at rate  $\delta_t$
  - Posting a job vacancy costs  $\kappa$  per period
- ▶ Firm value  $\mathcal{V}$  satisfies Bellman equation:

$$\mathcal{V}(A_t, L_t) = \max_{V_t, L_{t+1}} \{E_t + \mathbb{F}_t[M_{t+1}\mathcal{V}(A_{t+1}, L_{t+1})]\}$$
$$s.t. \quad L_{t+1} = (1 - \delta_t)L_t + q_t V_t$$

- Cash flows (earnings):  $E_t = A_t L_t - W_t L_t - \kappa V_t$
- Productivity  $A_t$ , labor input  $L_t$ , wage rate  $W_t$
- Subjective expectation  $\mathbb{F}_t[\cdot]$ , stochastic discount factor  $M_{t+1}$

# Firm's Hiring Condition

- ▶ First-order condition: Firm equates cost of hiring with its expected discounted value

$$\frac{\kappa}{q_t} = \mathbb{E}_t \left[ M_{t+1} \frac{\mathcal{V}(A_{t+1}, L_{t+1})}{L_{t+1}} \right] = \frac{P_t}{L_{t+1}}$$

where  $P_t \equiv \mathbb{E}_t [M_{t+1} \mathcal{V}(A_{t+1}, L_{t+1})]$  ex-dividend market value (stock price)

- ▶ Take logarithms, rearrange terms, split the price-employment ratio  $\frac{P_t}{L_{t+1}}$ :

$$\log q_t = \log \kappa - \underbrace{\log \left( \frac{P_t}{E_t} \right)}_{\equiv pe_t} - \underbrace{\log \left( \frac{E_t}{L_{t+1}} \right)}_{\equiv el_t}$$

- Log-linearize price-earnings ratio  $pe_t \equiv \ln(P_t/E_t)$  around long-run mean  $\overline{pe}$

$$pe_t = c_{pe} - \mathbb{F}_t[r_{t+1}] + \mathbb{F}_t[\Delta e_{t+1}] + \rho \mathbb{F}_t[pe_{t+1}]$$

- $c_{pe}$  constant,  $\rho = \frac{\exp(\overline{pe})}{1+\exp(\overline{pe})} \approx 0.98$  time discount factor from log-linearization
  - $r_{t+1} = \log(\frac{P_{t+1}+E_{t+1}}{P_t})$  stock return, assuming firm pays out dividends = earnings
  - Same identity holds approximately if dividends  $\neq$  earnings e.g.,  $D_t \approx \frac{1}{2}E_t$
- Substitute recursively for the next  $h$  periods to obtain present value identity:

$$\underbrace{pe_t}_{\text{Price-Earnings}} = \underbrace{\sum_{j=1}^h \rho^{j-1} c_{pe}}_{\text{Constant}} - \underbrace{\sum_{j=1}^h \rho^{j-1} \mathbb{F}_t[r_{t+j}]}_{\text{Discount Rate}} + \underbrace{\sum_{j=1}^h \rho^{j-1} \mathbb{F}_t[\Delta e_{t+j}]}_{\text{Cash Flow}} + \underbrace{\rho^h \mathbb{F}_t[pe_{t+h}]}_{\text{Future Price-Earnings}}$$

# Decomposing the Vacancy Filling Rate

- Combine log-linearized  $pe_t$  with firm's hiring equation ( $c_q = \log \kappa - \sum_{j=1}^h \rho^{j-1} c_{pe}$ ):

$$\underbrace{\log q_t}_{\text{Vacancy Filling Rate}} = c_q + \underbrace{\sum_{j=1}^h \rho^{j-1} \mathbb{F}_t[r_{t+j}]}_{\text{Discount Rate} \equiv \mathbb{F}_t[r_{t,t+h}]} - \underbrace{\left[ el_t + \sum_{j=1}^h \rho^{j-1} \mathbb{F}_t[\Delta e_{t+j}] \right]}_{\text{Cash Flow} \equiv \mathbb{F}_t[e_{t,t+h}]} - \underbrace{\rho^h \mathbb{F}_t[pe_{t+h}]}_{\text{Future Price-Earnings} \equiv \mathbb{F}_t[pe_{t,t+h}]}$$

- Vacancy filling rate  $q_t$  is high (recession) either because of:
  - High discount rates (return required to justify hiring)
  - Low expected cash flows (profit from hiring)
  - Or low expected price-earnings (terminal value)

# Variance Decomposition: Subjective vs. Objective Expectations

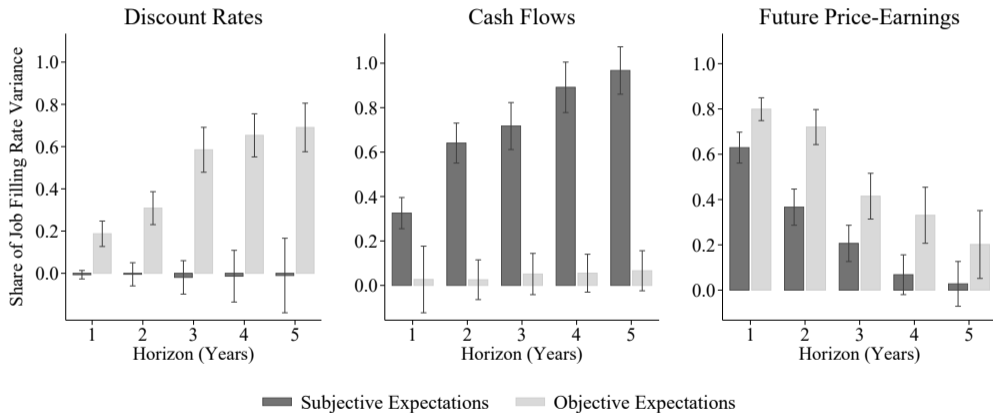
- Decomposition of  $Var [\log q_t]$  under subjective belief: Use survey forecast  $\mathbb{F}_t[\cdot]$

$$1 = \underbrace{\frac{Cov [\mathbb{F}_t[r_{t,t+h}], \log q_t]}{Var [\log q_t]}}_{\text{Discount Rate}} - \underbrace{\frac{Cov [\mathbb{F}_t[e_{t,t+h}], \log q_t]}{Var [\log q_t]}}_{\text{Cash Flow}} - \underbrace{\frac{Cov [\mathbb{F}_t[pe_{t,t+h}], \log q_t]}{Var [\log q_t]}}_{\text{Future Price-Earnings}}$$

- Estimate using OLS regression coefficients
  - Regress survey forecast  $\mathbb{F}_t[r_{t,t+h}]$ ,  $\mathbb{F}_t[e_{t,t+h}]$ ,  $\mathbb{F}_t[pe_{t,t+h}]$  on vacancy filling rate  $\log q_t$
  - Forecast horizons:  $h = 1, \dots, 5$  years
- Decomposition under objective belief:
  - Replace survey with machine forecast  $\mathbb{E}_t[\cdot]$
  - $\mathbb{F}_t - \mathbb{E}_t$  captures share that can be explained by belief distortion

# Variance Decomposition of the Vacancy Filling Rate

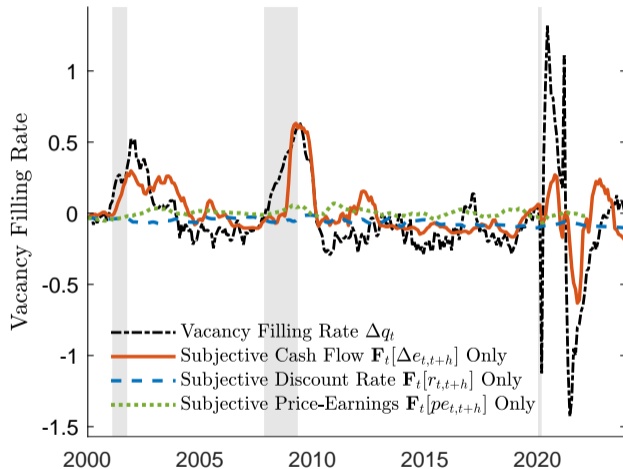
- Belief distortion  $\mathbb{F}_t - \mathbb{E}_t$  makes hiring sensitive to cash flow news



Notes: Sample: 2005Q1 to 2023Q4. Each bar shows Newey-West 95% confidence intervals with lags = 4 quarters.

# Role of Components in the Vacancy Filling Rate [► Details](#)

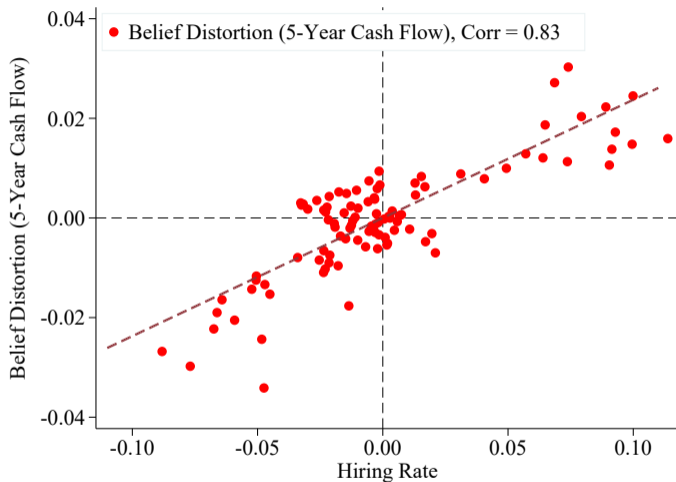
- ▶ Counterfactual series allowing one component to vary while holding others fixed
- ▶ Subjective cash flows play largest role in explaining vacancy filling rate variation



*Notes:* Counterfactual series are constructed by accumulating fitted values from regressions of vacancy filling rate growth on individual expectation measures at the  $h = 5$  year horizon, with all series initialized to the actual vacancy filling rate growth in 2001Q4.

# Firms with Pessimistic Belief Distortions Hire Less [► Details](#)

- ▶ Cross-sectional dispersion after removing time & firm fixed effect
- ▶ Hiring rate =  
New hires / employment
- ▶ Belief distortion:  
Expectational errors  
 $\mathbb{F}_t[\Delta e_{i,t,t+5}] - \mathbb{E}_t[\Delta e_{i,t,t+5}]$



Notes: y-axis: belief distortion measured as expectational errors  $\mathbb{F}_t[\Delta e_{i,t,t+5}] - \mathbb{E}_t[\Delta e_{i,t,t+5}]$  in 5-year IBES survey forecasts of annualized S&P 500 earnings growth. x-axis: hiring rate. Each dot is a bin scatter representing one percentile across all observations in the sample. Sample: 2005Q1 to 2023Q4.

# Why Do Some Firms Hire More Than Others?

- ▶ Define hiring rate at firm level:

$$hl_{i,t} \equiv \log \left( \frac{L_{i,t+1}}{L_{i,t}} - (1 - \delta_{i,t}) \right)$$

- $L_{i,t}$  employment (Compustat),  $\delta_{i,t}$  job separation rate from firm  $i$ 's industry (JOLTS)

- ▶ Decompose cross-sectional variance of hiring rate  $\text{Var}(\tilde{hl}_{i,t})$ :

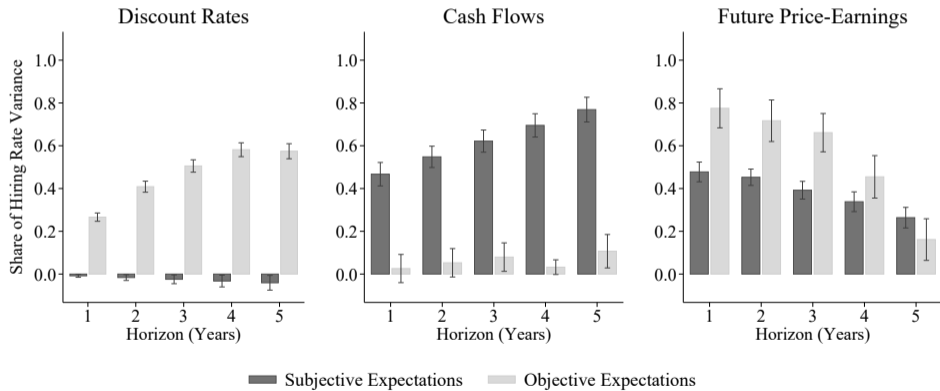
$$1 \approx - \underbrace{\frac{\text{Cov} \left( \mathbb{F}_t[\tilde{r}_{i,t,t+h}], \tilde{hl}_{i,t} \right)}{\text{Var}(\tilde{hl}_{i,t})}}_{\text{Discount Rate}} + \underbrace{\frac{\text{Cov} \left( \mathbb{F}_t[\tilde{e}_{i,t,t+h}], \tilde{hl}_{i,t} \right)}{\text{Var}(\tilde{hl}_{i,t})}}_{\text{Cash Flow}} + \underbrace{\frac{\text{Cov}(\mathbb{F}_t[\tilde{pe}_{i,t,t+h}], \tilde{hl}_{i,t})}{\text{Var}(\tilde{hl}_{i,t})}}_{\text{Future Price-Earnings}}$$

- $\tilde{x}_{i,t} = x_{i,t} - \sum_{i \in I} x_{i,t}$  cross-sectionally demeaned variable  $x_{i,t}$

- ▶ Estimate as coefficients from panel regressions with firm & time fixed effect

# Cross-Sectional Decomposition of Hiring Rate

- ▶ Belief distortion  $\mathbb{F}_t - \mathbb{E}_t$  makes hiring sensitive to cash flow news
  - Implies distortions can operate at firm level where actual hiring decisions are made



Notes: Sample: 2005Q1 to 2023Q4. Each bar shows 95% confidence intervals two-way clustered by firm and time.

- Firm-level ( $i$ ) local projection of profits per worker on forecast revisions:

$$\log \left( \frac{E_{i,t+h}}{L_{i,t+h}} \right) = \beta_h \text{Revision}_{i,t} + \alpha_i + \alpha_{s(i),t} + \varepsilon_{i,t+h}, \quad s(i) \in SIC2$$

⇒ Dispersion in  $\text{Revision}_{i,t}$  captures belief response to idiosyncratic shock

- Subjective: Survey cash flow forecast revision  $\text{Revision}_{i,t} = \mathbb{F}_t[\Delta e_{i,t+1}] - \mathbb{F}_{t-1}[\Delta e_{i,t+1}]$

⇒ Overreact to idiosyncratic shock, affect profits per worker by over- or under-hiring

- Objective: Machine cash flow forecast revision  $\text{Revision}_{i,t} = \mathbb{E}_t[\Delta e_{i,t+1}] - \mathbb{E}_{t-1}[\Delta e_{i,t+1}]$

⇒ No overreaction, stable profits per worker

► Objective forecast revision:

⇒ No overreaction

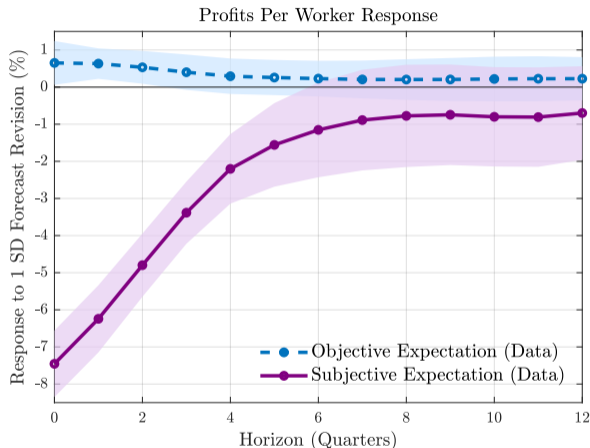
⇒ Stable profit per worker

► Subjective forecast revision:

⇒ Overreact (forecast revision)

⇒ Adjust hiring excessively

⇒ Profit per worker drop



Notes: Blue (purple) line: IRF under objective (subjective) expectations proxied by machine (survey) forecasts. Shaded area: 90% confidence intervals two-way clustered by firm and time. Sample: 1984Q1-2023Q4.

# Stock Returns React Only Under Subjective Beliefs

## ► Objective forecast revision:

⇒ Diversifiable shock not priced

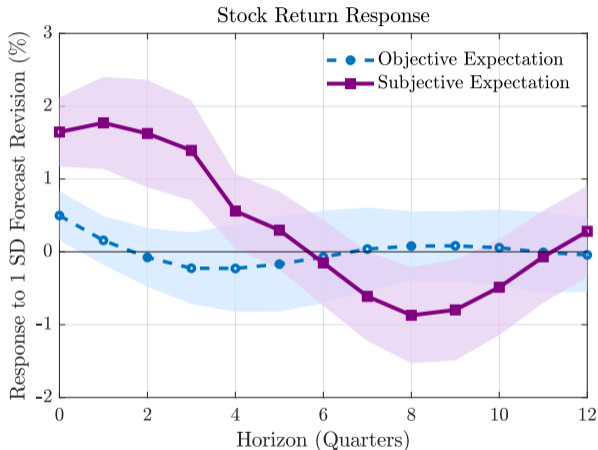
⇒ No return response

## ► Subjective forecast revision:

⇒ Overreact (forecast revision)

⇒ Initial overshoot  
(overoptimism)

⇒ Subsequent reversal  
(disappointment)



Notes: Blue (purple) line: IRF under objective (subjective) expectations proxied by machine (survey) forecasts. Shaded area: 90% confidence intervals two-way clustered by firm and time. Sample: 1984Q1-2023Q4.

# Model of Constant-Gain Learning: Environment

- ▶ True cash flow process has aggregate  $E_t$  and idiosyncratic  $\tilde{E}_{i,t}$  components

$$E_{i,t} = E_t \cdot \tilde{E}_{i,t} = \exp(e_t + \tilde{e}_{i,t})$$

- ▶ Log of each component follows an AR(1) process:

$$\begin{aligned} e_t &= \mu + \phi e_{t-1} + u_t, & u_t &\stackrel{iid}{\sim} \mathcal{N}(0, \sigma_u^2) \\ \tilde{e}_{i,t} &= \tilde{\mu}_i + \tilde{\phi} \tilde{e}_{i,t-1} + v_{i,t}, & v_{i,t} &\stackrel{iid}{\sim} \mathcal{N}(0, \sigma_v^2) \end{aligned}$$

- ▶ Log stochastic discount factor  $m_{t+1}$ :

$$m_{t+1} = -r_f - \frac{1}{2}\gamma^2\sigma_u^2 - \gamma u_{t+1}$$

with risk-free rate  $r_f$ , constant relative risk aversion  $\gamma$

- ▶ Objectively, long-run mean identical across firms:  $\mu = \tilde{\mu}_i = 0$ 
  - But firm does not know true  $\mu$  and  $\tilde{\mu}_i$  in cash flow process
- ▶ Update beliefs using constant-gain learning rule: Learn at rate  $\nu$

$$\begin{aligned}\mathbb{F}_t[\mu] &= \mathbb{F}_{t-1}[\mu] + \nu (\Delta e_t - \mathbb{F}_{t-1}[\Delta e_t]) \\ \mathbb{F}_t[\tilde{\mu}_i] &= \mathbb{F}_{t-1}[\tilde{\mu}_i] + \nu (\Delta \tilde{e}_{i,t} - \mathbb{F}_{t-1}[\Delta \tilde{e}_{i,t}])\end{aligned}$$

- Start with true value  $\mathbb{F}_0[\mu] = \mathbb{F}_0[\tilde{\mu}_i] = 0$  so that  $\nu = 0$  case nests rational expectation
- ▶ Fading memory: Assigns smaller decaying weight on older observations
  - Generates overreaction as beliefs over-extrapolate from recent observations
  - Can arise from Bayesian updating under suspected regime switches (Adam, Marcet, and Nicolini 2016) or experience-based learning (Nagel and Xu 2021)

- Firm valuation: Equilibrium stock price  $P_{i,t}$  under subjective beliefs

$$P_{i,t} = \sum_{h=1}^{\infty} P_{i,t}^{(h)} = \sum_{h=1}^{\infty} \exp \left\{ A_i^{(h)} + B^{(h)} \mathbb{F}_t[\mu] + \tilde{B}^{(h)} \mathbb{F}_t[\tilde{\mu}_i] + \phi^h e_t + \tilde{\phi}^h \tilde{e}_{i,t} \right\}$$

- $P_{i,t}$  driven by belief distortions in cash flows  $\mathbb{F}_t[\mu]$ ,  $\mathbb{F}_t[\tilde{\mu}_i]$  (from fading memory)
- $P_{i,t}^{(h)}$  strip prices with recursively defined coefficients  $A_i^{(h)}$ ,  $B^{(h)}$ ,  $\tilde{B}^{(h)}$
- Hiring condition: Firms post vacancies until marginal cost equals marginal value

$$\underbrace{\frac{\kappa}{q_t}}_{\text{Cost of Hiring}} = \underbrace{\frac{P_{i,t}}{L_{i,t+1}}}_{\text{Value of New Hire}}$$

- Partial equilibrium: Exogenous cash flows absorb wage setting and worker belief
- Subjective valuation  $P_{i,t}$  drives both stock returns  $R_{i,t} = \frac{P_{i,t+1} + E_{i,t}}{P_{i,t}}$  and hiring  $L_{i,t+1}$

Parameter	Value	Description/Moments
$\nu$	0.018	Constant-gain learning (Malmendier and Nagel 2015)
$\phi$	0.856	Autocorrelation aggregate earnings growth
$\sigma_u$	0.268	S.D. aggregate earnings growth
$\tilde{\phi}$	0.698	Autocorrelation firm-level earnings growth
$\sigma_v$	0.194	S.D. firm-level earnings growth
$r_f$	0.046	Risk-free rate (De La O, Han, and Myers 2022)
$\gamma$	1.586	Average aggregate return (De La O, Han, and Myers 2022)
$\rho$	0.980	Average price-earnings ratio
$B$	0.562	Matching function efficiency (Kehoe et al. 2023)
$\eta$	0.500	Matching function elasticity (Kehoe et al. 2023)
$\delta$	0.286	Separation rate (Kehoe et al. 2023)
$\kappa$	0.314	Per worker hiring cost (Elsby and Michaels 2013)

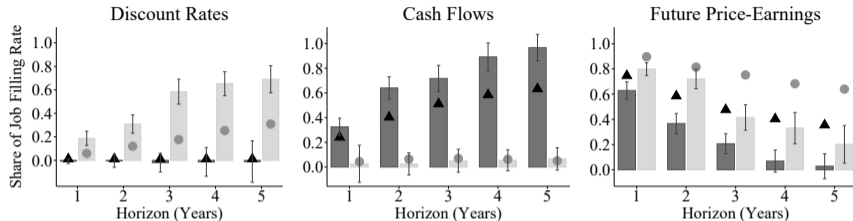
*Notes:* Table reports the parameter values used in the quantitative model along with the empirical moments they are calibrated to or sourced from. The model is calibrated at an annual frequency.

# Model vs. Data: Variance Decompositions

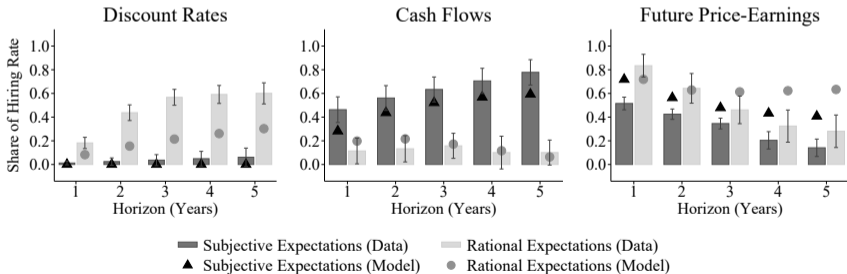
► Details (Labor Market)

► Model Parameters

(a) Time-Series  
Decomposition  
(Vacancy Filling Rate)



(b) Cross-Sectional  
Decomposition  
(Hiring Rate)



Notes: Circle and triangle dots show the values of rational and subjective expectations implied by the model, respectively, derived from a simulation of 300 firms over 500 periods, with the first 150 periods discarded as a burn-in.

# Model vs. Data: Moments

- Learning improves model's ability to match asset market and labor market moments

(a) Asset Market

Moment	Data	Learning Model	Rational Model
$SD(pe_t) \times 100$	<b>47.0</b>	<b>43.5</b>	<b>13.0</b>
$SD_i(pe_{i,t}) \times 100$	<b>22.6</b>	<b>21.1</b>	<b>4.2</b>
$SD(r_t) \times 100$	16.0	12.3	3.0
$SD(\mathbb{F}_t[r_{t+1}]) \times 100$	1.1	1.4	0.5
$SD(\mathbb{F}_t[\Delta e_{t+1}]) \times 100$	26.8	24.3	7.2
$SD_i(r_{i,t}) \times 100$	5.7	3.1	1.2
$SD_i(\mathbb{F}_t[r_{i,t+1}]) \times 100$	2.6	0.2	0.2
$SD_i(\mathbb{F}_t[\Delta e_{i,t+1}]) \times 100$	14.0	16.6	3.9

(b) Labor Market

Moment	Data	Learning Model	Rational Model
$SD(u_t) \times 100$	<b>2.10</b>	<b>1.28</b>	<b>0.34</b>
$SD_i(hl_{i,t}) \times 100$	<b>15.70</b>	<b>10.39</b>	<b>4.65</b>
$SD(q_t) \times 100$	8.70	6.16	0.91
$Corr(u_t, q_t)$	-0.82	-0.86	-0.99

Notes:  $SD(\cdot)$  = time-series standard deviation.  $SD_i(\cdot)$  = cross-sectional standard deviation.  $pe_t$  = log price-earnings ratio,  $r_t$  = log stock return,  $\Delta e_t$  = log earnings growth,  $q_t$  = job-filling rate,  $u_t$  = unemployment rate,  $hl_{i,t}$  = firm-level hiring rate.  $\mathbb{F}_t[\cdot]$  = subjective expectations formed at time  $t$ . Data = empirical moments. Model (Learning) = constant-gain learning model. Model (Rational) = rational expectations benchmark.

- ▶ Subjective beliefs are distorted as they overreact to news
  - Comparing survey vs. machine learning forecasts uncovers these distortions
- ▶ Overreaction to cash flow news drives asset prices and hiring
  - Both in the time-series and the cross-section
  - Results consistent with learning about cash flow with fading memory
- ▶ Offers new perspective on unemployment volatility puzzle
  - Belief distortions drive value of new hire, driving unemployment fluctuations

# Appendix

- ▶ **Unemployment Volatility Puzzle:** Shimer 2005; Hagedorn and Manovskii 2008; Hall and Milgrom 2008; Pissarides 2009; Elsby and Michaels 2013; Kudlyak 2014; Chodorow-Reich and Karabarbounis 2016; Ljungqvist and Sargent 2017; Hall 2017; Borovičková and Borovička 2017; Kilic and Wachter 2018; Mitra and Xu 2019; Kehoe, Midrigan, and Pastorino 2019; Kehoe et al. 2023; Meeuwis et al. 2023
  - This paper: Reframes unemployment volatility as belief-driven
- ▶ **Labor Market Frictions and Asset Prices:** Merz and Yashiv 2007; Donangelo 2014; Belo, Lin, and Bazdresch 2014; Favilukis and Lin 2015; Kuehn, Simutin, and Wang 2017; Petrosky-Nadeau, Zhang, and Kuehn 2018; Donangelo et al. 2019; Liu 2021; Belo et al. 2023
  - This paper: Introduce subjective beliefs to explain differences in hiring across firms
- ▶ **Non-Rational Expectations and Business Cycles:** Marcet and Sargent 1989; Evans and Honkapohja 2001; Woodford 2001; Mankiw and Reis 2002; Sims 2003; Venkateswaran 2014; Coibion and Gorodnichenko 2015; Gabaix 2019; Ma et al. 2020; Acharya and Wee 2020; Bordalo et al. 2021; Bianchi, Ludvigson, and Ma 2022; Bianchi, Ilut, and Saijo 2023; Menzio 2023; Bhandari, Borovička, and Ho 2024; Fukui, Gormsen, and Huber 2024; Du et al. 2025; Bigio, Silva, and Zilberman 2025; Bloom, Codreanu, and Fletcher 2025
  - This paper: Clarify that bias in expected cash flow drives unemployment fluctuations
- ▶ **Non-Rational Expectations and Asset Prices:** Timmermann 1993; Barberis, Shleifer, and Vishny 1998; Chen, Da, and Zhao 2013; Greenwood and Shleifer 2014; Greenwood and Hanson 2014; Adam, Marcet, and Nicolini 2016; Giglio et al. 2021; De La O and Myers 2021; Nagel and Xu 2022; Barrero 2022; Jin and Sui 2022; De La O, Han, and Myers 2022; Binsbergen, Han, and Lopez-Lira 2022; Adam and Nagel 2023; Bianchi, Ludvigson, and Ma 2024; Bordalo et al. 2024; Décaire and Graham 2024; Chaudhry 2025
  - This paper: Show that biases drive both asset prices and real hiring decisions

Time-series: Vacancy filling rate  $q_t$  for quarter  $t$  (Source: JOLTS, BLS)

$$q_t = \frac{f_t U_t}{V_t}$$

- ▶  $V_t$  and  $U_t$ : U.S. job openings and unemployment level
- ▶  $f_t = 1 - \frac{U_t - U_t^s}{U_{t-1}}$ : Job finding rate, where  $U_t^s$  short-term unemployed

Cross-section: Hiring rate  $hl_{i,t}$  for firm  $i$  quarter  $t$  (Source: Compustat, JOLTS)

$$hl_{i,t} = \log \left( \frac{L_{i,t+1}}{L_{i,t}} - (1 - \delta_{i,t}) \right)$$

- ▶  $L_{i,t}$ : Annual employees, interpolate to quarterly using latest value
- ▶  $\delta_{i,t}$ : Job separation rate of firm  $i$ 's NAICS2 industry
- ▶ Sample: All common stocks (share codes 10, 11) on NYSE/AMEX/NASDAQ with IBES analyst coverage of earnings and stock price targets

- ▶ Realized return  $r_t$ : Annual log return on CRSP value-weighted index with dividend
- ▶ Expected return  $\mathbb{F}_t[r_{t+h}]$ :
  - Source: CFO survey median consensus forecast (2001Q4-2023Q4)
  - Respondents: CFOs, VPs of finance, directors (1,600 members as of 2022)
  - Prediction target: Aggregate S&P 500 stock returns
  - Horizon  $h$ : 1 and 10 years ahead; interpolate intermediate horizons linearly

- ▶ Realized return  $r_{i,t}$ : Annual log return on firm  $i$ 's stock with dividend
- ▶ Expected return  $\mathbb{F}_t[r_{i,t+h}]$ :
  - Source: IBES (1-year) and Value Line (3-5 years) median consensus price target
  - Respondents: Equity research analysts
  - Prediction target: Firm  $i$ 's stock price level  $\mathbb{F}_t[P_{i,t+h}]$
  - Horizon  $h$ : 1 year (IBES) and 5 years (Value Line), interpolate intermediate horizons
  - Construct return forecasts (with dividends) from price level forecasts using

$$\mathbb{F}_t[r_{i,t+h}] \approx \log \left( \frac{\mathbb{F}_t[P_{i,t+h}]}{P_{i,t}} + \frac{D_{i,t}}{P_{i,t}} \frac{\mathbb{F}_t[D_{i,t+h}]}{D_{i,t}} \right)$$

- ▶ Expected dividend growth  $\frac{\mathbb{F}_t[D_{i,t+h}]}{D_{i,t}} \approx 1.064$  equal post war average (Nagel and Xu 2022)
- ▶ Dividend-price ratio  $\frac{D_{i,t}}{P_{i,t}}$  from Compustat/CRSP

- ▶ Firm-level earnings  $E_{i,t}^*$ : Street earnings for firm  $i$  (Source: IBES)
  - “Street”: Exclude discontinued operation, extraordinary charge, non-operating item
  - Construct from earnings per share:  $E_{i,t}^* = EPS_{i,t}^* \cdot S_{i,t}$  where  $S_{i,t}$  shares outstanding
  - Transformation to ensure positive earnings (Vuolteenaho 2002):

$$E_{i,t} = (1 - \lambda)E_{i,t}^* + \lambda r_t^f P_{i,t-1} > 0, \quad \lambda = 0.10$$

- ▶ Define firm as a portfolio of 90% equity & 10% 1-year T-bills (with rate  $r_t^f$ )
  - ▶ Allows  $\log(E_{i,t})$  to be well-defined when reported earnings negative  $E_{i,t}^* \leq 0$
- ▶ Firm-level expected log earnings growth  $\mathbb{F}_t[\Delta e_{i,t+h}]$ :
  - Source: IBES median consensus forecast (1983Q4-2023Q4)
  - Respondents: Equity research analysts

► Years  $h = 1, 2$  from level forecasts

- Prediction target: Street earnings per share ( $EPS_{i,t}^*$ ) over next 1, 2, 3 fiscal years
- Interpolate 1, 2, 3 fiscal year horizons to 1, 2 calendar year horizons
- Construct earnings level forecast using  $\mathbb{F}_t[E_{i,t+h}^*] = \mathbb{F}_t[EPS_{i,t+h}^*] \cdot S_{i,t}$
- Transformation to ensure positive earnings (Vuolteenaho 2002):

$$\mathbb{F}_t[E_{i,t+h}] = (1 - \lambda)\mathbb{F}_t[E_{i,t+h}^*] + \lambda r_t^f \mathbb{F}_t[P_{i,t+h-1}] > 0, \quad \lambda = 0.10$$

- Approximate log growth forecast using  $\mathbb{F}_t[\Delta e_{i,t+h}] \approx \log(\mathbb{F}_t[E_{i,t+h}]/\mathbb{F}_t[E_{i,t+h-1}])$

► Years  $h = 3, 4, 5$  from long-term growth (LTG): Interpret as  $\mathbb{F}_t[\Delta e_{i,t+h}]$

- LTG: Forecast of annualized growth over the next “three-to-five years”

- ▶ Aggregate S&P 500 earnings:  $x_t$  set of S&P 500 firms with IBES forecasts,  $\Omega_t$  adjusts for incomplete IBES coverage,  $Divisor_t$  S&P 500 divisor

$$E_t = \Omega_t \sum_{i \in x_t} EPS_{i,t}^* \cdot S_{i,t} / Divisor_t$$

- ▶ Aggregate S&P 500 expected log earnings growth  $\mathbb{F}_t[\Delta e_{t+h}]$ :

- Years  $h = 1, 2$ :  $\mathbb{F}_t[\Delta e_{t+h}] \approx \log(\mathbb{F}_t[E_{t+h}] / \mathbb{F}_t[E_{t+h-1}])$

$$\mathbb{F}_t[E_{t+h}] = \Omega_t \sum_{i \in x_t} \mathbb{F}_t[EPS_{i,t+h}^*] \cdot S_{i,t} / Divisor_t$$

- Years  $h = 3, 4, 5$ : Value-weighted aggregate of firm-level *LTG* forecasts

$$\mathbb{F}_t[\Delta e_{t+h}] = LTG_t = \sum_{i=1}^S LTG_{i,t} \frac{P_{i,t} S_{i,t}}{\sum_{i=1}^S P_{i,t} S_{i,t}}$$

where  $S$  is the number of firms in the S&P 500 index

Time-series: Log price-earnings ratio for the aggregate S&P 500

- ▶ Realized values:  $pe_t = \log(P_t/E_t)$
- ▶ Expected values: Use Campbell and Shiller 1988 present value identity

$$\mathbb{F}_t[pe_{t+h}] = \frac{1}{\rho^h} pe_t - \frac{1}{\rho^h} \sum_{j=1}^h \rho^{j-1} (c_{pe} + \underbrace{\mathbb{F}_t[\Delta e_{t+j}]}_{\text{IBES}} - \underbrace{\mathbb{F}_t[r_{t+j}]}_{\text{CFO}})$$

- $c_{pe}$  constant,  $\rho = \frac{\exp(\overline{pe})}{(1+\exp(\overline{pe}))}$  time discount factor from log-linearization

Cross-section: Log price-earnings ratio at firm level

- ▶ Realized values:  $pe_{i,t} = \log(P_{i,t}/E_{i,t})$
- ▶ Expected values: Use Campbell and Shiller 1988 present value identity

$$\mathbb{F}_t[pe_{i,t+h}] = \frac{1}{\rho^h} pe_{i,t} - \frac{1}{\rho^h} \sum_{j=1}^h \rho^{j-1} (c_{pe} + \underbrace{\mathbb{F}_t[\Delta e_{i,t+j}]}_{\text{IBES}} - \underbrace{\mathbb{F}_t[r_{i,t+j}]}_{\text{IBES}})$$

Long Short-Term Memory (LSTM) neural network (Bianchi et al. 2022, 2024, 2025)

$$\mathbb{E}_t[y_{t+h}] = G(\mathcal{X}_t, \beta_t; \lambda_t)$$

- ▶ Target:  $y_{t+h} \in \{r_{t+h}, \Delta e_{t+h}\}$  predicted  $h = 1, 2, \dots, 5$  years ahead
- ▶ Estimation:
  - Training: Rolling samples, parameters  $\beta_t$  re-estimated quarterly in real-time
  - Validation: Pseudo out-of-sample for hyperparameters  $\lambda_t$
  - Regularization:  $L_1/L_2$  penalties, dropout, early stopping, ensemble averaging
  - Architecture selection: Layers, neurons, training/validation window lengths
- ▶ Input data  $\mathcal{X}_t$ :
  - Macro/financial data, text (LDA factors from WSJ), macro data & FOMC surprises
  - Lagged survey forecast  $\mathbb{F}_{t-1}[y_{t+h-1}]$

Estimate using pooled panel firm level data

$$\mathbb{E}_t[y_{i,t+h}] = G(\mathcal{X}_{i,t}, \beta_t; \lambda_t)$$

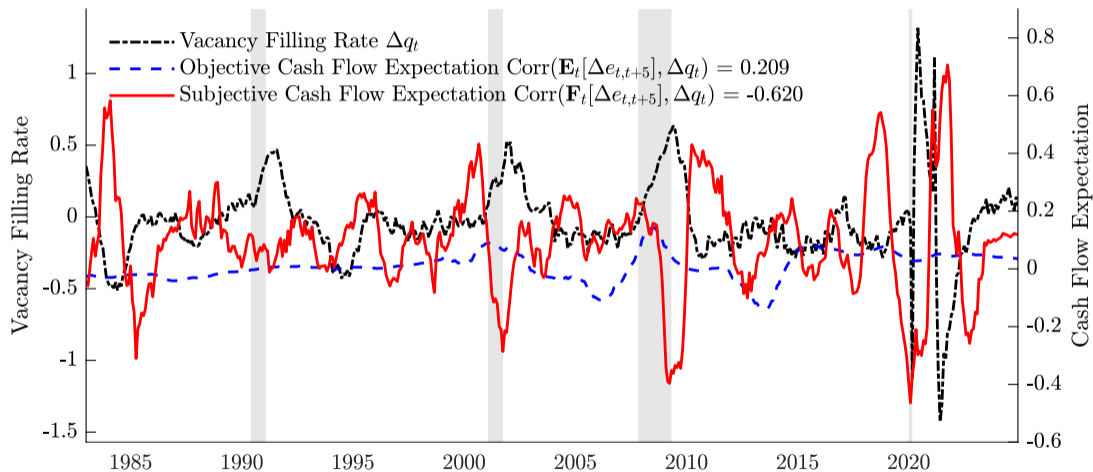
- ▶ Input data: Interaction of macro and firm characteristics

$$\mathcal{X}_{i,t} = \mathcal{X}_t \otimes \mathcal{C}_{i,t}$$

- $\mathcal{X}_t$ : Aggregate macro/financial variables (same as time-series)
- $\mathcal{C}_{i,t}$ : Firm characteristics (94 variables)
  - ▶ Valuation, profitability, size, momentum, volatility
  - ▶ Industry dummies (74 industries, 2-digit SIC codes)
- ▶ Re-estimation: Parameters and hyperparameters updated every 4 quarters

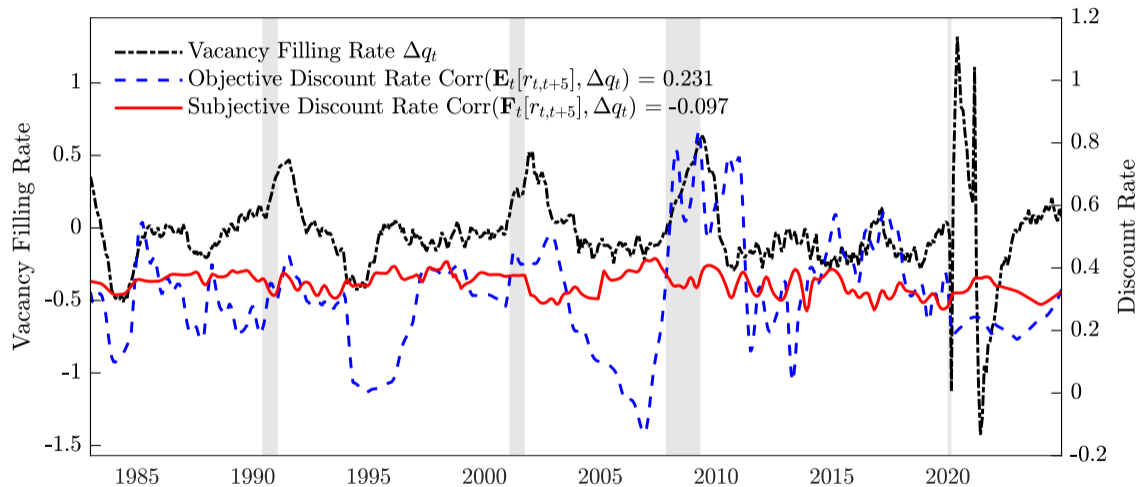
# Vacancy Filling Rate Tracks Belief Distortions in Cash Flows [▶ Return](#)

► Belief distortion: Expectational errors  $\mathbb{F}_t[\Delta e_{t,t+h}] - \mathbb{E}_t[\Delta e_{t,t+h}]$



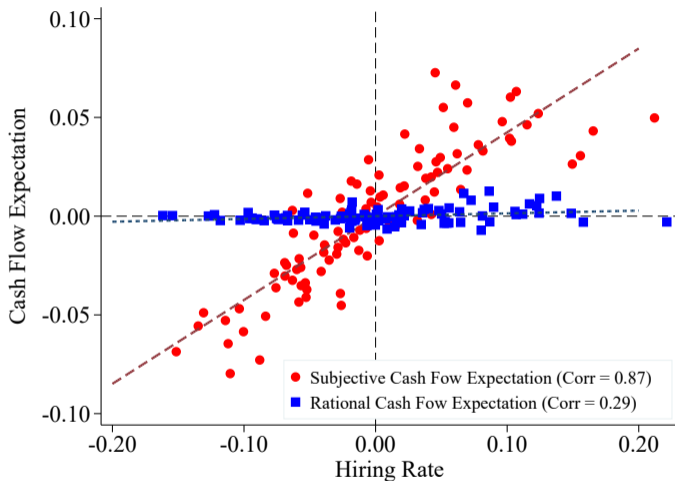
Notes: Left axis: Annual log change in the U.S. vacancy filling rate. Right axis: 5-year forecasts of annualized S&P 500 earnings growth. Subjective expectation: IBES median analyst projections for the next four fiscal years and long-term growth (LTG). Objective expectation: Machine learning forecasts from Long Short-Term Memory (LSTM) neural networks. Gray shaded areas indicate NBER recessions.

# Vacancy Filling Rate Tracks Objective Discount Rates

[Return](#)

# Firms with Pessimistic Belief Distortions Hire Less [▶ Return](#)

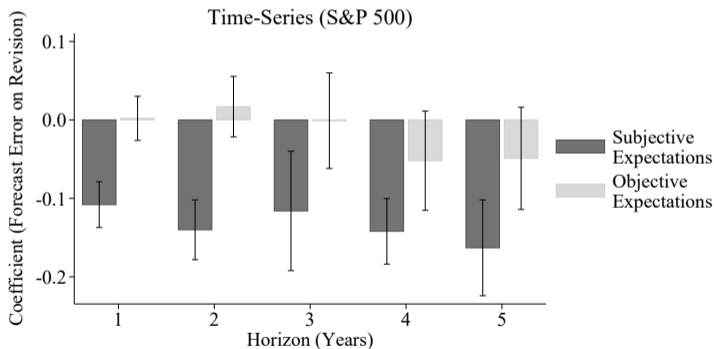
- ▶ Cross-sectional dispersion net of time & portfolio fixed effect
- ▶ Hiring rate =  
New hires / employment
- ▶ Belief distortion:  
Expectational errors  
 $\mathbb{F}_t[\Delta \tilde{e}_{i,t,t+h}] - \mathbb{E}_t[\Delta \tilde{e}_{i,t,t+h}]$



Notes: x-axis: Cross-sectionally demeaned real-time expectation of future earnings. Subjective Expectation:  $\mathbb{F}_t[\tilde{e}_{i,t,t+j}]$  based on IBES survey forecasts. Objective Expectation:  $\mathbb{E}_t[\tilde{e}_{i,t,t+j}]$  based on machine learning forecasts. y-axis: Cross-sectionally demeaned hiring rate. Each dot is a bin scatter representing one percentile across all observations in the sample. Sample: 2005Q1 to 2023Q4.

$$\overbrace{r_{t,t+h} - \mathbb{F}_t[r_{t,t+h}]}^{\text{Forecast Error}} = \beta \cdot \overbrace{[\mathbb{F}_t[r_{t,t+h}] - \mathbb{F}_{t-1}[r_{t,t+h}]]}^{\text{Forecast Revision}} + \varepsilon_t$$

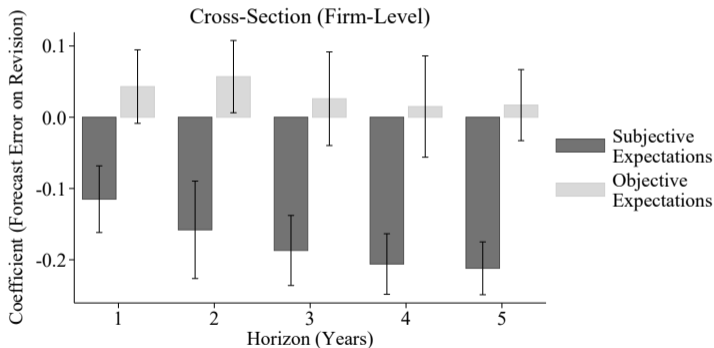
- ▶ Survey:  
(+) forecast revision  
predicts (-) forecast error  
⇒ Overreaction
- ▶ Machine:  
Forecast errors not  
predictable  
⇒ No overreaction



Notes: Figure reports  $\beta$  from time-series Coibion and Gorodnichenko 2015 regressions of survey and machine forecast errors on forecast revisions for aggregate S&P 500 cash flows. Sample: 2005Q1-2023Q4. Whiskers: 95% confidence intervals (Newey-West, 4 lags).

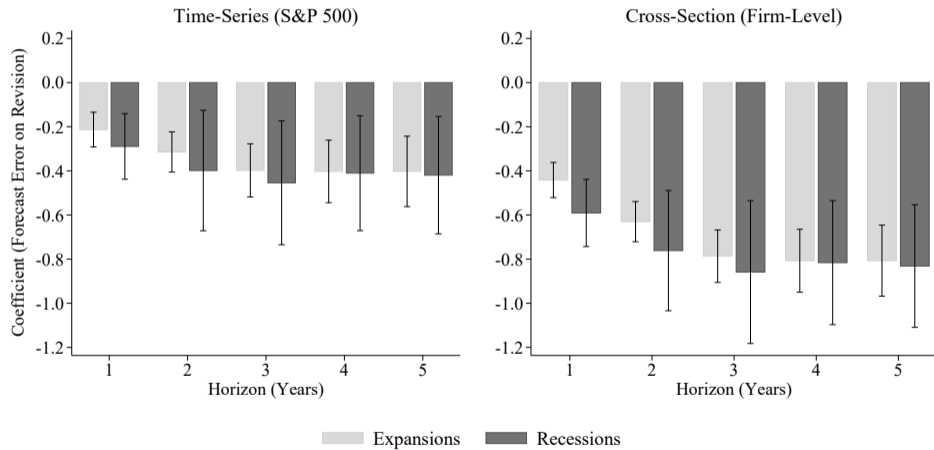
$$\overbrace{r_{i,t,t+h} - \mathbb{F}_t[r_{i,t,t+h}]}^{\text{Forecast Error}} = \beta \cdot \overbrace{[\mathbb{F}_t[r_{i,t,t+h}] - \mathbb{F}_{t-1}[r_{i,t,t+h}]]}^{\text{Forecast Revision}} + \overbrace{\alpha_i + \alpha_t}^{\text{Firm \& Time FE}} + \varepsilon_{i,t}$$

- ▶ Survey:  
(+) forecast revision  
predicts (-) forecast error  
⇒ Overreaction
- ▶ Machine:  
Forecast errors not  
predictable  
⇒ No overreaction



Notes: Figure reports  $\beta$  from firm-level Coibion and Gorodnichenko 2015 regressions of survey and machine forecast errors on forecast revisions with firm & time fixed effects. Sample: 2005Q1-2023Q4. Whiskers: 95% confidence intervals (two-way clustered by firm & time).

- ▶ Overreaction present in both during and outside of NBER recessions



*Notes:* Figure reports  $\beta$  from Coibion and Gorodnichenko 2015 regressions of survey forecast errors on forecast revisions, estimated separately for NBER expansions and recessions. Left: S&P 500 time-series. Right: firm-level with firm & time FE. Sample: 2001Q1-2020Q4. Whiskers: 95% CI (Newey-West for TS; clustered by firm for CS).

- Log-linearize log price-dividend  $pd_t \equiv \ln(P_t/D_t)$  around long-term average  $\overline{pd}$

$$pd_t = c_{pd} + \Delta d_{t+1} - r_{t+1} + \rho pd_{t+1}$$

where  $c_{pd}$  constant,  $r_{t+1} \equiv \log(\frac{P_{t+1}+D_{t+1}}{P_t})$  stock returns,  $\rho \equiv \frac{\exp(\overline{pd})}{1+\exp(\overline{pd})} = 0.98$

- Substitute in log price-earnings  $pe_t = pd_t + de_t$  where  $de_t$  log payout ratio

$$pe_t = c_{pd} + \Delta e_{t+1} - r_{t+1} + \rho pe_{t+1} + (1 - \rho)de_{t+1}$$

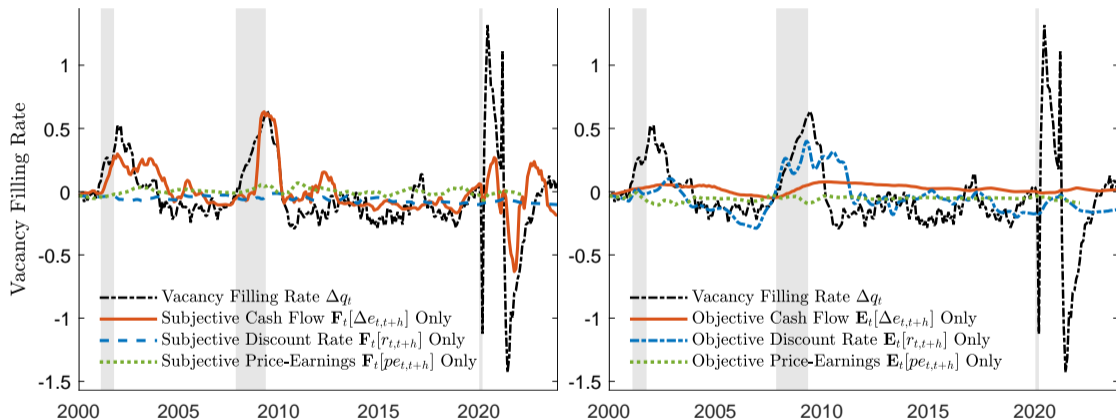
- Since  $1 - \rho \approx 0$  and  $de_t$  bounded, approximate  $(1 - \rho)de_{t+1}$  as a constant

$$pe_t \approx c_{pe} + \Delta e_{t+1} - r_{t+1} + \rho pe_{t+1}, \quad c_{pe} \approx c_{pd} + (1 - \rho)de_{t+1}$$

- Recursively substitute for the next  $h$  periods

$$pe_t = \sum_{j=1}^h \rho^{j-1} (c_{pe} + \Delta e_{t+j} - r_{t+j}) + \rho^h pe_{t+h}$$

# Role of Components in the Vacancy Filling Rate: $\mathbb{F}_t$ vs. $\mathbb{E}_t$ [Return](#)



Notes: Counterfactual series are constructed by accumulating fitted values from regressions of vacancy filling rate growth on individual expectation measures at the  $h = 5$  year horizon, with all series initialized to the actual vacancy filling rate growth in 2001Q4. Gray shaded areas indicate NBER recessions. Sample period: 2000Q4 to 2023Q4.

- ▶ Allow for a residual  $v_{t,h}$  in the decomposition:

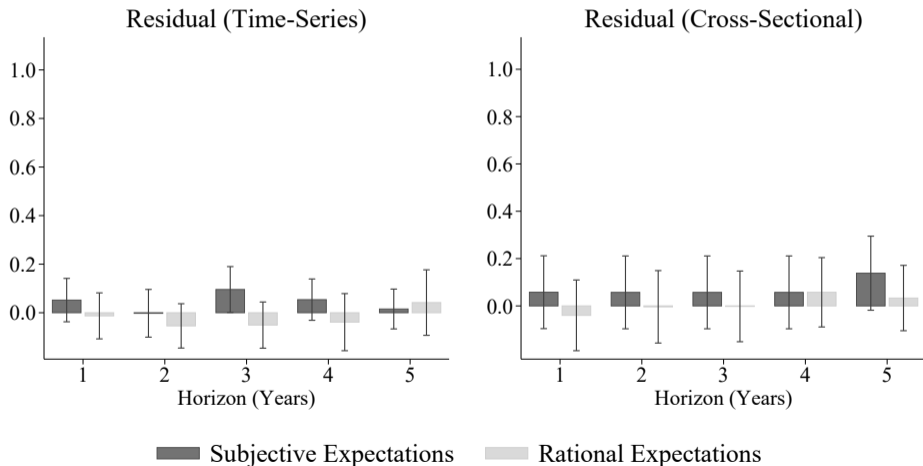
$$\log q_t = c_q + \mathbb{F}_t[r_{t,t+h}] - \mathbb{F}_t[\Delta e_{t,t+h}] - \mathbb{F}_t[pe_{t,t+h}] + v_{t,h}$$

- ▶ Residual  $v_{t,h}$  approximately unrelated to dependent variables and components

Component	Time-Series	Cross-Sectional
Dependent Variables		
Vacancy Filling Rate	0.015	—
Hiring Rate	—	0.015
Decomposition Components		
Discount Rate $\mathbb{F}_t[r_{t,t+5}]$	0.026	0.032
Cash Flow $\mathbb{F}_t[\Delta e_{t,t+5}]$	0.078	0.089
Future Price-Earnings $\mathbb{F}_t[pe_{t,t+5}]$	−0.001	−0.033

Notes: This table reports correlations between residuals and each component. Cross-sectional correlations use firm-level deviations from the corresponding time  $t$  means. Sample: 2005Q1 to 2023Q4.

- ▶ Residual  $v_{t,h}$  contributes up to 13.8% in variance decompositions



Notes: Each bar shows Newey-West 95% confidence intervals with lags = 4 quarters. Sample: 2005Q1 to 2023Q4.

► At the 5-year horizon:

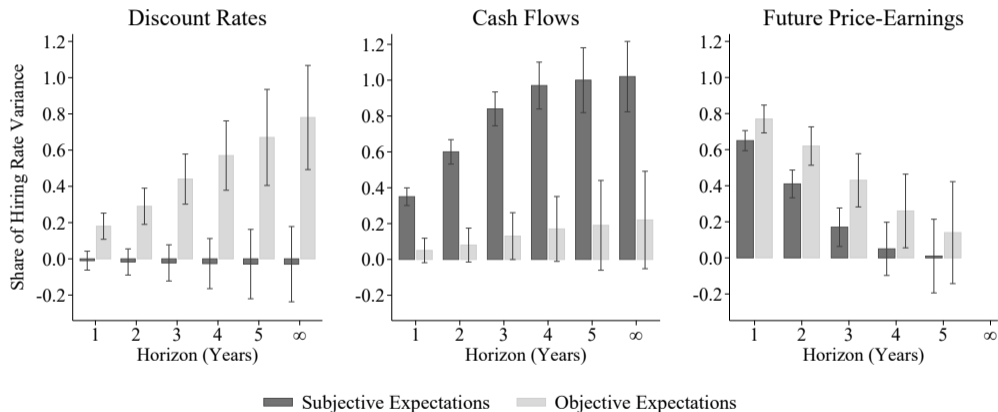
- Cash flow bias leads to over-attribution of hiring variation to earnings
- Discount rate bias offsets this by under-attributing to discount rates

Horizon $h$ (Years)	1	2	3	4	5
Biases in Subjective Expectations					
$\mathbb{E}_t[y_{t,t+h}] - \mathbb{E}_t[y_{t,t+h}] = \beta_{0,B} + \beta_{1,B} \log q_t + \varepsilon_{t,B}, \quad y = r, e, pe$					
Discount Rate	-0.194	-0.313**	-0.604***	-0.667***	-0.701***
$t$ -stat	(-1.574)	(-2.167)	(-2.896)	(-2.918)	(-2.740)
(-) Cash Flow	0.299	0.615***	0.666***	0.837***	0.901***
$t$ -stat	(1.421)	(5.476)	(5.703)	(7.365)	(6.665)
(-) Price-Earnings	-0.170	-0.354**	-0.209	-0.262	-0.174
$t$ -stat	(-0.464)	(-2.373)	(-0.503)	(-0.479)	(-0.292)
Residual	-0.065	-0.052	-0.147	-0.093	0.026
$t$ -stat	(-0.148)	(-0.219)	(-0.306)	(-0.154)	(0.040)

Notes: Newey-West  $t$ -statistics with lags = 4 in parentheses: \* sig. at 10%. \*\* sig. at 5%. \*\*\* sig. at 1%.

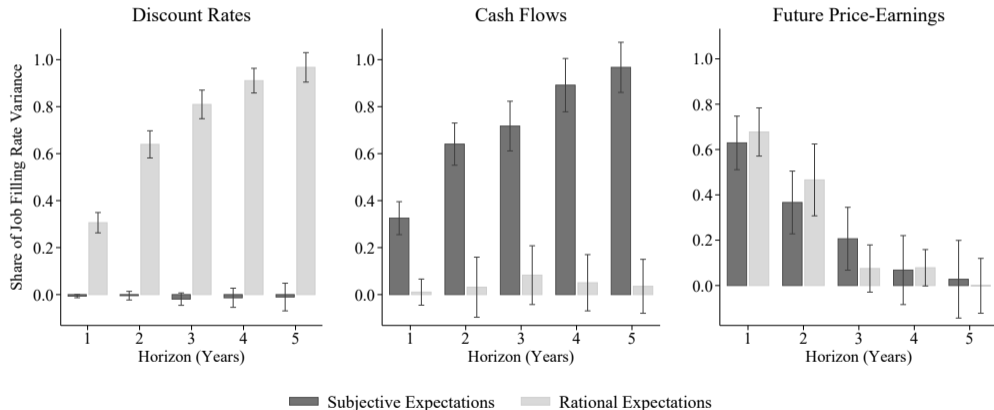
# Time-Series Decomposition of Vacancy Filling Rate: VAR(1) [Return](#)

$$X_{t+1} = AX_t + \varepsilon_{t+1}, \quad X_t = [\mathbb{F}_t[r_{t,t+1}] \quad \mathbb{F}_t[e_{t,t+1}] \quad \mathbb{F}_t[pe_{t,t+1}] \quad \log q_t]'$$



*Notes:* Figure reports variance decompositions of the aggregate vacancy filling rate based on a Vector Autoregression (VAR). Light (dark) bars show the contribution under objective (subjective) expectations. Subjective expectations  $\mathbb{F}_t$  are based on survey forecasts of CFOs and IBES financial analysts. Objective expectations  $\mathbb{E}_t$  are based on machine learning forecasts from Long Short-Term Memory (LSTM) neural networks. The sample is quarterly from 2005Q1 to 2023Q4. Each bar shows bootstrapped 95% confidence intervals.

- Replace machine learning forecast  $\mathbb{E}_t[x_{t,t+h}]$  with ex-post realized value  $x_{t,t+h}$



*Notes:* Figure illustrates the discount rate, cash flow, and future price-earnings components of the time-series decomposition of the aggregate vacancy filling rate. Light bars show the contribution under objective expectations. Dark bars show the contribution under subjective expectations. The Sample: 2005Q1 to 2023Q4. Each bar shows Newey-West 95% confidence intervals with lags = 4.

- ▶ Start with ex-post decomposition of vacancy filling rate:

$$\log q_t = c_q + \underbrace{\sum_{j=1}^h \rho^{j-1} r_{t+j}}_{r_{t,t+h}} - \underbrace{\left[ dl_t + \sum_{j=1}^h \rho^{j-1} \Delta d_{t+j} \right]}_{d_{t,t+h}} - \underbrace{\rho^h p d_{t+h}}_{p d_{t,t+h}}$$

where  $d_t$  denotes log S&P 500 dividends

- ▶ Evaluate under risk-neutral measure  $\mathbb{E}_t^Q[\cdot]$ :

$$\log q_t = c_q + \mathbb{E}_t^Q[r_{t,t+h}] - \mathbb{E}_t^Q[d_{t,t+h}] - \mathbb{E}_t^Q[p d_{t,t+h}]$$

- ▶ Under no arbitrage, futures price = expected future spot price under  $\mathbb{E}_t^Q[\cdot]$  (Ait-Sahalia, Wang, and Yared 2001)

► Risk-neutral discount rates:

$$\mathbb{E}_t^Q[r_{t,t+h}] = \sum_{j=1}^h \rho^{j-1} (f_{t,t+j}^{sp500} - f_{t,t+j-1}^{sp500}), \quad f_{t,t}^{sp500} \equiv p_t$$

- Measure  $\mathbb{E}_t^Q[r_{t,t+j}] = f_{t,t+j}^{sp500} - f_{t,t+j-1}^{sp500}$  assuming  $f_{t,t+j}^{sp500} \approx \log \mathbb{E}_t^Q[P_{t+j}]$
- $f_{t,t+j}^{sp500}$  time  $t$  log S&P 500 futures price (CME E-mini) for maturity  $t+j$

► Risk-neutral cash flow expectations:

$$\mathbb{E}_t^Q[d_{t,t+h}] = dl_t + \sum_{j=1}^h \rho^{j-1} (f_{t,t+j}^{div} - f_{t,t+j-1}^{div}), \quad f_{t,t}^{div} \equiv d_t$$

- Measure  $\mathbb{E}_t^Q[\Delta d_{t+j}] = f_{t,t+j}^{div} - f_{t,t+j-1}^{div}$  assuming  $f_{t,t+j}^{div} \approx \log \mathbb{E}_t^Q[D_{t+j}]$
- $f_{t,t+j}^{div}$  time  $t$  log S&P 500 dividend futures price (Bloomberg) for maturity  $t+j$

► Risk-neutral  $\mathbb{E}_t^Q[pd_{t+h}]$ : Use Campbell and Shiller 1988 identity

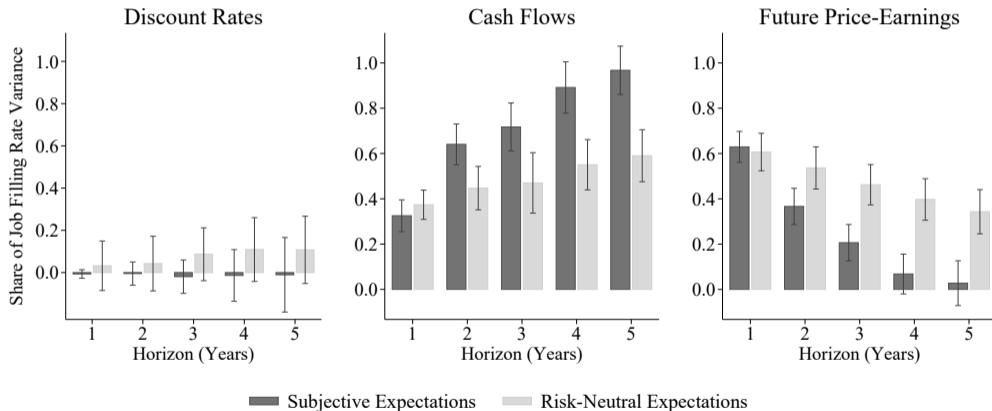
- ▶ Futures price growth for  $j > 1$  years ahead: Use estimates from AR(1) model

$$\begin{aligned}f_{t,t+1}^{sp500} - p_t &= \mu_{sp500} + \rho_{sp500}(p_t - p_{t-1}) + \varepsilon_{sp500,t} \\f_{t,t+1}^{div} - d_t &= \mu_{div} + \rho_{div}(d_t - d_{t-1}) + \varepsilon_{div,t}\end{aligned}$$

- ▶ Implies predicted values

$$\begin{aligned}f_{t,t+j}^{sp500} - f_{t,t+j-1}^{sp500} &= \frac{\mu_{sp500}(1 - \rho_{sp500}^{j-1})}{1 - \rho_{sp500}} + \rho_{sp500}^{j-1}(f_{t,t+1}^{sp500} - p_t) \\f_{t,t+j}^{div} - f_{t,t+j-1}^{div} &= \frac{\mu_{div}(1 - \rho_{div}^{j-1})}{1 - \rho_{div}} + \rho_{div}^{j-1}(f_{t,t+1}^{div} - d_t)\end{aligned}$$

- ▶ Subjective beliefs more sensitive to cash flow news than risk-neutral beliefs



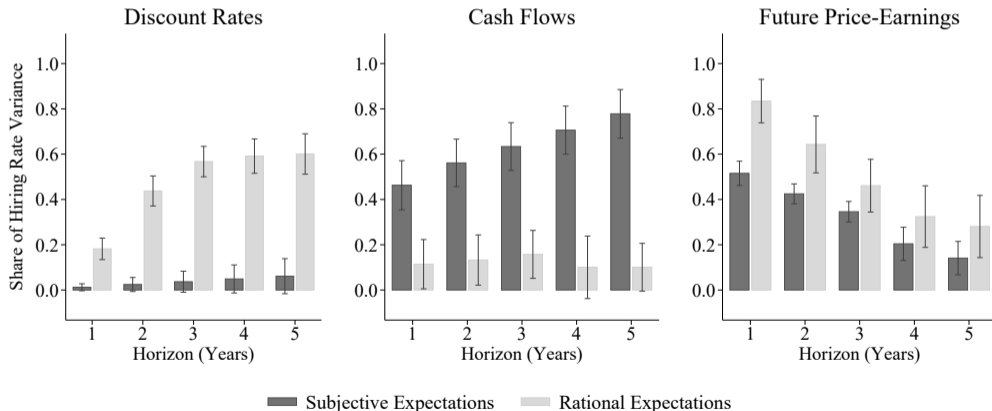
Notes: Light bars show the contribution under risk-neutral expectations implied by S&P 500 and dividend futures. Dark bars show the contribution under subjective expectations. The Sample: 2005Q1 to 2023Q4. Each bar shows Newey-West 95% confidence intervals with lags = 4.

- ▶ Results are robust to using alternative surveys for earnings growth forecasts:
  - IBES, Bloomberg (BBG), CFO survey
  - Kalman-filtered (KF) composite of IBES, BBG, and CFO

Horizon $h$ (Years)	1	2	3	4	5
Subjective Expectations: $\log q_t = c_q + \mathbb{F}_t[r_{t,t+h}] - \mathbb{F}_t[e_{t,t+h}] - \mathbb{F}_t[pe_{t,t+h}]$					
(-) Cash Flow (KF)	0.578***	0.625***	0.684***	0.887***	0.933***
$t$ -stat	(3.046)	(4.275)	(4.894)	(6.019)	(7.612)
(-) Cash Flow (BBG)	0.586***	0.830***	0.851***	0.896***	0.949***
$t$ -stat	(8.476)	(8.317)	(7.213)	(5.288)	(4.541)
(-) Cash Flow (CFO)	0.637*				
$t$ -stat	(1.934)				

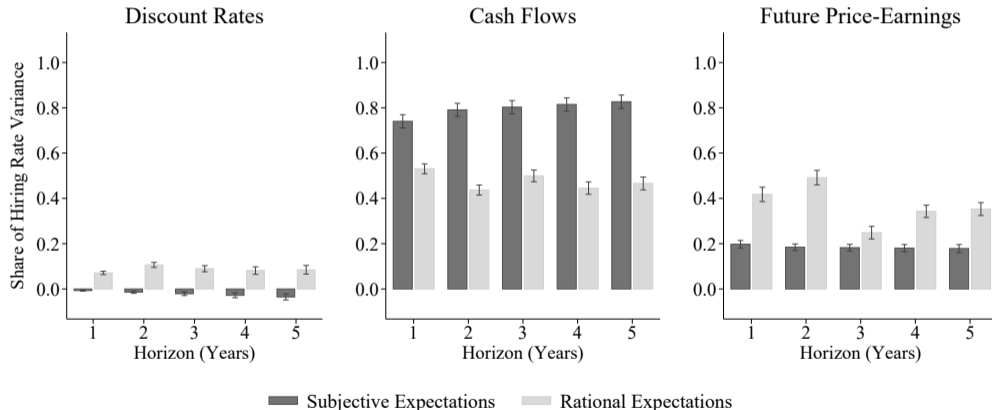
Notes: KF summarizes the alternative survey measures into a single series using a Kalman filter. The sample for BBG and KF is quarterly from 2006Q1 to 2023Q4. The sample for CFO is quarterly from 2005Q1 to 2019Q3. Newey-West  $t$ -statistics with lags = 4 in parentheses: \*sig. at 10%. \*\*sig. at 5%. \*\*\*sig. at 1%.

- ▶ Cash flow belief distortion  $\mathbb{F}_t - \mathbb{E}_t$  accounts for most of hiring variation
  - Implies distortions can operate at firm level where actual hiring decisions are made



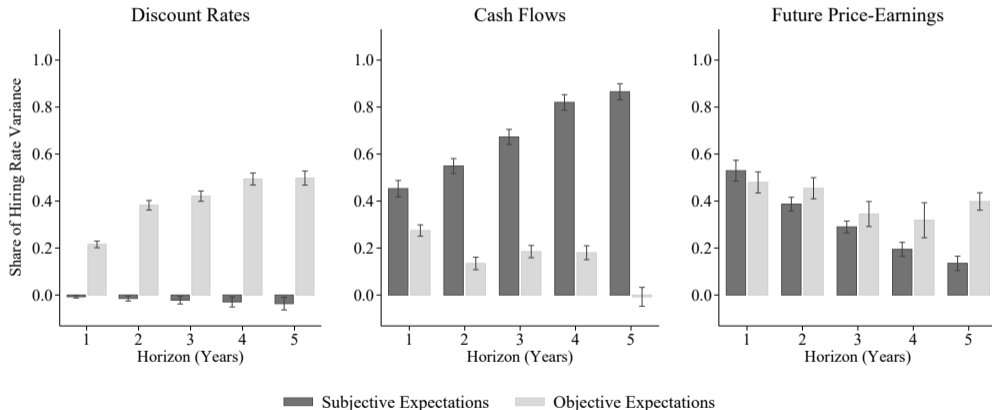
Notes: Firms have been sorted into five value-weighted portfolios by book-to-market ratio. Light (dark) bars show the contribution under objective (subjective) expectations. Sample: 2005Q1 to 2023Q4. Each bar shows two-way clustered 95% confidence intervals by portfolio and time.

## ► Idiosyncratic shock: Earnings AR(1) residual (firm & time fixed effects)



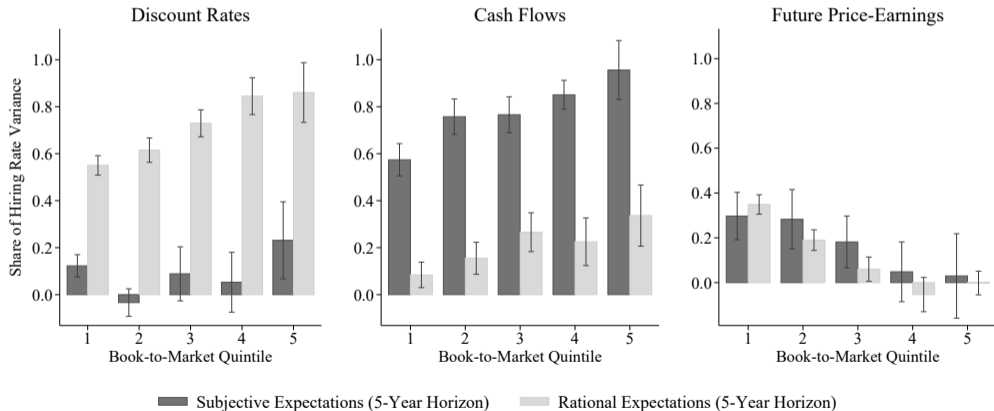
Notes: Firms have been sorted into 10 value-weighted portfolios by idiosyncratic shock. Light (dark) bars show the contribution under objective (subjective) expectations. Sample: 2005Q1 to 2023Q4. Each bar shows two-way clustered 95% confidence intervals by portfolio and time.

## ► Subjective beliefs over-weight cash flows



Notes: Firms have been sorted into Fama-French 49 industry portfolios. Light bars show the contribution under objective expectations. Dark bars show the contribution under subjective expectations. The Sample: 2005Q1 to 2023Q4. Each bar shows Newey-West 95% confidence intervals with lags = 4.

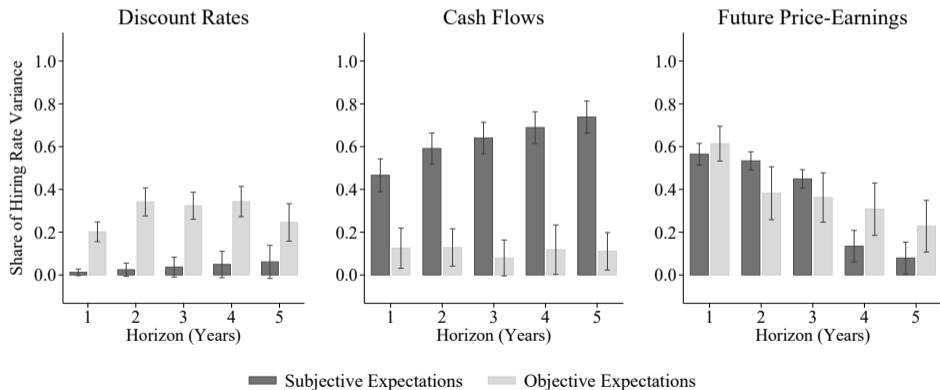
- ▶ Subjective beliefs over-weight cash flows across all portfolios
- ▶ Terminal value (future price-earnings) more important for low B/M (growth)



Notes: Firms have been sorted into five value-weighted portfolios by book-to-market ratio. Light bars show the contribution under objective expectations. Dark bars show the contribution under subjective expectations. The Sample: 2005Q1 to 2023Q4. Each bar shows Newey-West 95% confidence intervals with lags  $\bar{=}$  4.

## ► Financial constraint proxies:

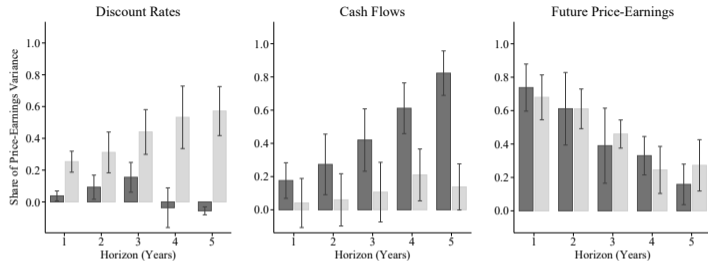
- Size, payout ratio, SA index (size and age), expected free cash flow (size, leverage, profitability, growth), Whited-Wu index (leverage, payout, size, growth)



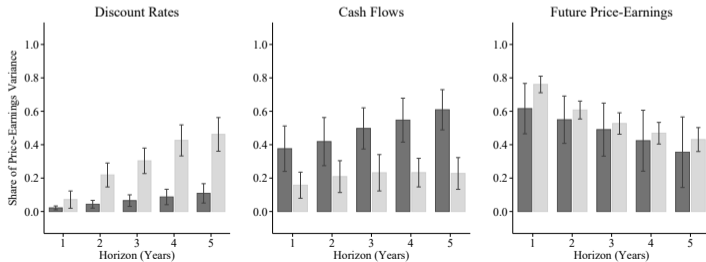
*Notes:* Figure estimates cross-sectional decomposition of hiring rate, controlling for measures of financial constraints. Financial constraint controls include firm size, payout ratio, SA index, expected free cash flow, and the Whited-Wu index. The sample is quarterly from 2005Q1 to 2023Q4. Each bar shows 95% confidence intervals clustered by portfolio and time.

# Variance Decomposition of the Price-Earnings Ratio [▶ Return](#)

(a) Time-Series  
Decomposition  
(Price-Earnings  
Ratio)



(b) Cross-Sectional  
Decomposition  
(Price-Earnings  
Ratio)



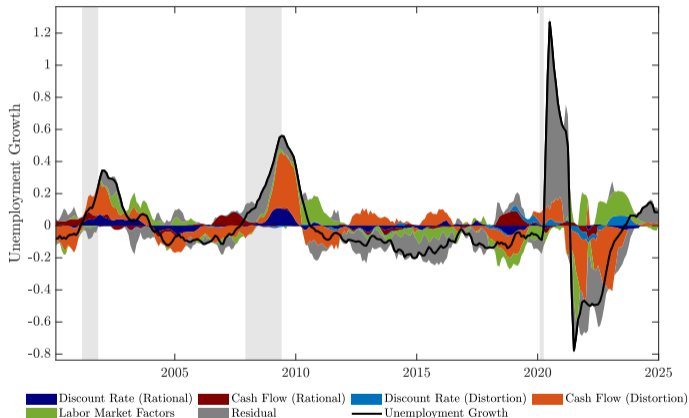
■ Subjective Expectations    ■ Objective Expectations

- Distortion in cash flow expectation strongest predictor, raises Adj.  $R^2$  and OOS  $R^2$

Forecast Target: Unemployment Growth $\Delta u_{t+1}$			Forecast Target: Employment Growth $\Delta \tilde{l}_{i,t+1}$		
	(1)	(2)		(3)	(4)
$\mathbb{E}_t[r_{t,t+h}]$	0.551***	0.236	$\mathbb{E}_t[\tilde{r}_{i,t,t+h}]$	-0.498***	-0.119
$t$ -stat	(5.046)	(0.893)	$t$ -stat	(-3.058)	(-0.734)
$\mathbb{E}_t[e_{t,t+h}]$	-0.041	-0.018	$\mathbb{E}_t[\tilde{e}_{i,t,t+h}]$	0.154	0.053
$t$ -stat	(-0.108)	(-0.050)	$t$ -stat	(1.304)	(0.754)
$\mathbb{F}_t[r_{t,t+h}] - \mathbb{E}_t[r_{t,t+h}]$		-0.006	$\mathbb{F}_t[\tilde{r}_{i,t,t+h}] - \mathbb{E}_t[\tilde{r}_{i,t,t+h}]$		-0.043
$t$ -stat		(-0.033)	$t$ -stat		(-0.410)
$\mathbb{F}_t[e_{t,t+h}] - \mathbb{E}_t[e_{t,t+h}]$		-0.701***	$\mathbb{F}_t[\tilde{e}_{i,t,t+h}] - \mathbb{E}_t[\tilde{e}_{i,t,t+h}]$		0.759***
$t$ -stat		(-5.584)	$t$ -stat		(6.412)
Adj. $R^2$	0.528	0.745	Adj. $R^2$	0.135	0.253
OOS $R^2$	0.149	0.254	OOS $R^2$	0.207	0.447

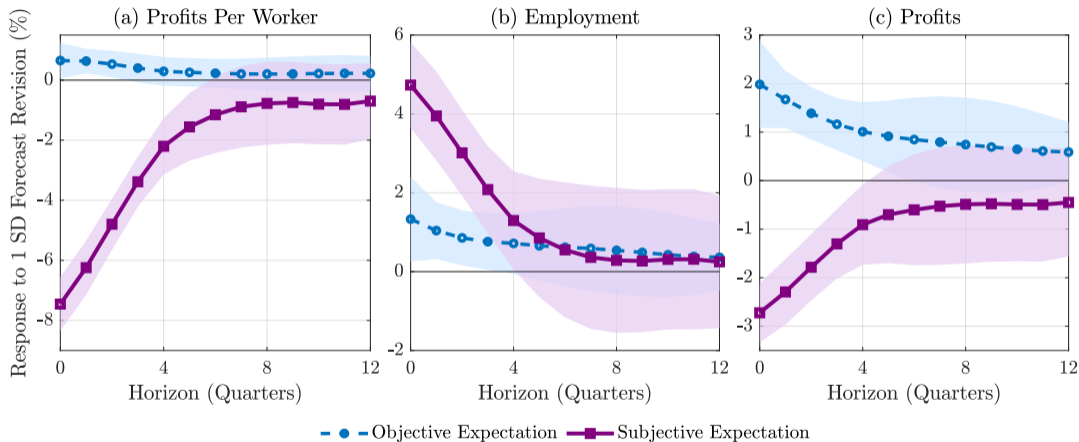
Notes: The sample is quarterly from 2005Q1 to 2023Q4. OOS  $R^2$  is defined as  $1 - MSE_{\text{Model}}/MSE_{\text{Benchmark}}$ . Out-of-sample forecasts are constructed as 1-year-ahead predictions using model parameters estimated over a rolling 10-year window.  $MSE_{\text{Model}}/MSE_{\text{Benchmark}}$  denotes the ratio of each model's out-of-sample mean squared forecast error to that of a benchmark, which is the Survey of Professional Forecasters (SPF) consensus for time-series predictions and an AR(1) model for cross-sectional predictions. Newey-West corrected (time-series) and two-way clustering by portfolio and quarter (cross-sectional)  $t$ -statistics with lags = 4 are reported in parentheses: \* sig. at 10%. \*\* sig. at 5%. \*\*\* sig. at 1%.

- Unemployment tracks the cash flow distortion component closely



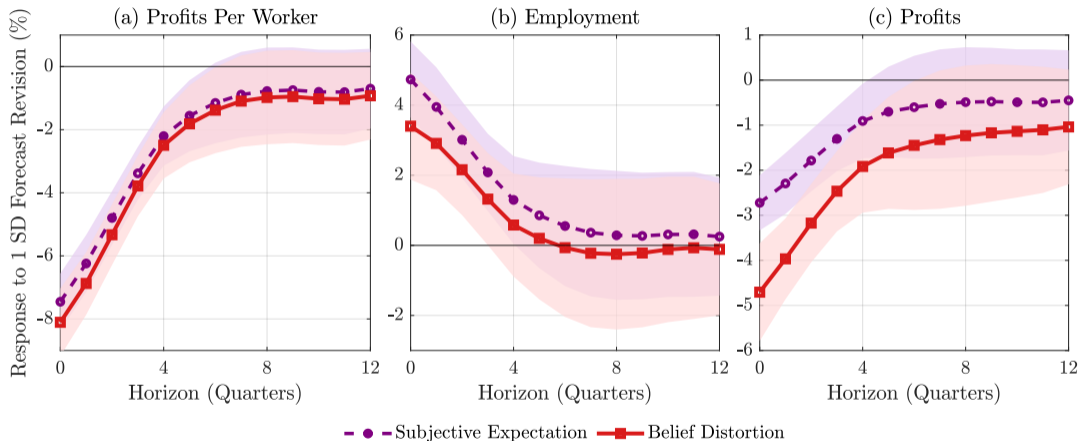
*Notes:* Figure plots decompositions of log annual growth in the unemployment rate, using objective expectations  $\mathbb{E}_t$  and belief distortions  $\mathbb{F}_t - \mathbb{E}_t$  of expected cash flows and discount rates. Labor market factors include the log annual growth of lagged unemployment  $\Delta u_t$ , labor market tightness  $\Delta \theta_t$  and job separations  $\Delta \delta_t$ . Residual (dark gray) represents the variation in vacancy filling rates that are not captured by the other components. NBER recessions are shown with light gray shaded bars.

# Employment Rise, Profits Fall Under Subjective Beliefs

[Return](#)

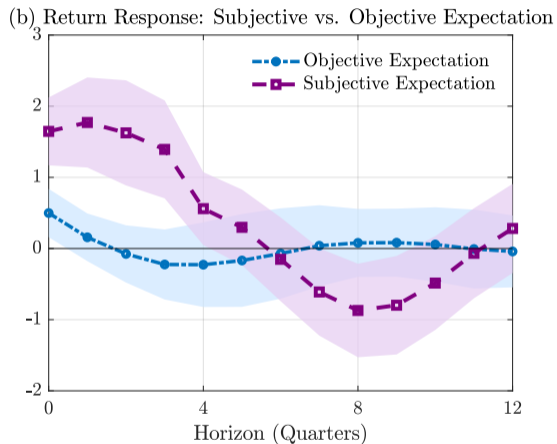
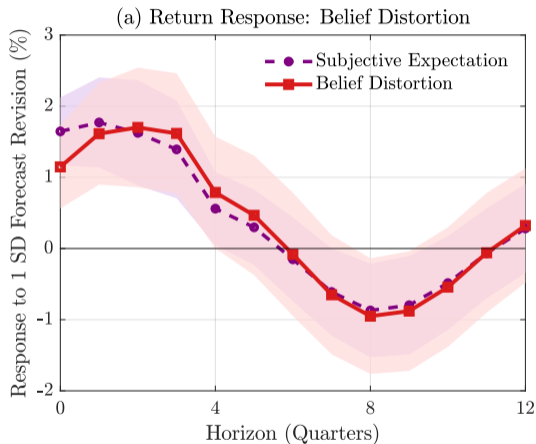
Notes: Blue (violet) line: IRF from revisions in objective (subjective) expectation. Shaded area: 90% confidence intervals two-way clustered by firm and time. Sample: 1984Q1-2023Q4.

# Subjective Belief Response Driven by Belief Distortion: Hiring

[Return](#)

Notes: Red (violet) line: IRF from revisions in belief distortion (subjective expectation). Shaded area: 90% confidence intervals two-way clustered by firm and time. Sample: 1984Q1-2023Q4.

# Subjective Belief Response Driven by Belief Distortion: Returns ► Return



Notes: Red (violet) line: IRF from revisions in belief distortion (subjective expectation). Shaded area: 90% confidence intervals two-way clustered by firm and time. Sample: 1984Q1-2023Q4.

- ▶ Earnings surprises only lead to small revisions in subjective cash flow expectation
  - Consistent with constant gain learning (Nagel Xu 2021, De La O, Han, Myers 2024)

Regression: $\mathbb{F}_{t+j}[\tilde{x}_{i,t+h}] - \mathbb{F}_{t+j-1}[\tilde{x}_{i,t+h}] = \alpha_{h,j} + \gamma_{h,j}(\tilde{x}_{i,t+1} - \mathbb{F}_t[\tilde{x}_{i,t+1}]) + \eta_{h,t+j}$				
Target Horizon $h$ (Years)	5	5	5	5
Revision Horizon $j$ (Years)	1	2	3	4
(a) Earnings Growth	0.0929 (0.0734)	0.0934 (0.0455)	0.1121 (0.0776)	0.1245 (0.0743)
(b) Earnings to Employment	0.0600 (0.1281)	0.0508 (0.0725)	0.0697 (0.0321)	0.0745 (0.0419)

Notes: Table shows the gradual adjustment of expectations about future earnings  $\tilde{x}_{i,t+h}$  after an earnings surprise at  $t + 1$ . The sample period is 1999 to 2023. Newey-West  $t$ -statistics with lags 12 in parentheses. \* sig. at 10%. \*\* sig. at 5%. \*\*\* sig. at 1%.

- ▶ Aggregate strip price ( $h$ -period): Guess and verify recursive form

$$P_t^{(h)} = \mathbb{F}_t[M_{t+1}P_{t+1}^{(h-1)}] = \exp\{A^{(h)} + B^{(h)}\mathbb{F}_t[\mu] + \phi^h e_t\}$$

with coefficients:

$$A^{(h)} = A^{(h-1)} - r_f + \frac{1}{2}C^{(h)}[(1 + \nu^2)C^{(h)} - 2\gamma]\sigma_u^2$$

$$B^{(h)} = B^{(h-1)} + \phi^{h-1}, \quad C^{(h)} = \nu B^{(h-1)} + \phi^{h-1}, \quad A^{(0)} = B^{(0)} = C^{(0)} = 0$$

- ▶ Realized return on strip:

$$R_{t+1}^{(h)} = \frac{P_{t+1}^{(h-1)}}{P_t^{(h)}} = \exp\{[A^{(h-1)} - A^{(h)}] + C^{(h)}(\mu - \mathbb{F}_t[\mu] + u_{t+1})\}$$

- ▶ Subjective expected return on strip:

$$\mathbb{F}_t \left[ R_{t+1}^{(h)} \right] = \exp \{ r_f + C^{(h)} \gamma \sigma_u^2 \}$$

- Realized stock price: Sum of strip prices

$$P_t = \sum_{h=1}^{\infty} P_t^{(h)}$$

- Realized return: Weighted average of strip returns

$$R_{t+j} = \frac{\sum_{h=1}^{\infty} P_{t+j}^{(h-1)}}{\sum_{h=1}^{\infty} P_{t+j-1}^{(h)}} = \sum_{h=1}^{\infty} w_{t+j-1,h} R_{t+j}^{(h)}, \quad w_{t+j-1,h} = \frac{P_{t+j-1}^{(h)}}{\sum_{h=1}^{\infty} P_{t+j-1}^{(h)}}, \quad j \geq 1$$

- Subjective expected return: Assume agents use current weights  $w_{t+j-1,h} \approx w_{t,h}$

$$\mathbb{F}_t[R_{t+j}] \approx \sum_{h=1}^{\infty} w_{t+j-1,h} \mathbb{F}_t[\mathbb{F}_{t+1}[\dots \mathbb{F}_{t+j-1}[R_{t+j}^{(h)}]]] = \sum_{h=1}^{\infty} w_{t,h} \exp \{ r_f + C^{(h)} \gamma \sigma_u^2 \}$$

- ▶ Realized strip price: Apply independence of aggregate and idiosyncratic shocks:

$$\begin{aligned} P_{i,t}^{(h)} &= \mathbb{F}_t[M_{t+1} \dots \mathbb{F}_{t+h-1}[M_{t+h} E_{t+h} \tilde{E}_{i,t+h}]] \\ &= P_t^{(h)} \cdot \mathbb{F}_t[\dots \mathbb{F}_{t+h-1}[\tilde{E}_{i,t+h}]] \end{aligned}$$

- ▶ Realized return on strip:

$$R_{i,t+1}^{(h)} = \frac{P_{i,t+1}^{(h-1)}}{P_{i,t}^{(h)}} = R_{t+1}^{(h)} \frac{\mathbb{F}_{t+1}[\dots \mathbb{F}_{t+h-1}[\tilde{E}_{i,t+h}]]}{\mathbb{F}_t[\dots \mathbb{F}_{t+h-1}[\tilde{E}_{i,t+h}]]}$$

- ▶ Subjective expected return on strip (where  $\tilde{C}^{(h)} \equiv \tilde{\phi}^{h-1} + \nu \frac{1-\tilde{\phi}^{h-1}}{1-\tilde{\phi}}$ ):

$$\mathbb{F}_t[R_{i,t+1}^{(h)}] = \exp \left\{ r_f + C^{(h)} \gamma \sigma_u^2 + \frac{1}{2} ((\tilde{C}^{(h)})^2 - \tilde{\phi}^{2(h-1)}) \sigma_v^2 \right\}$$

- Realized stock price: Sum of strip prices

$$P_{i,t} = \sum_{h=1}^{\infty} P_{i,t}^{(h)} = \sum_{h=1}^{\infty} \exp \left\{ A_i^{(h)} + B^{(h)} \mathbb{F}_t[\mu] + \tilde{B}^{(h)} \mathbb{F}_t[\tilde{\mu}_i] + \phi^h e_t + \tilde{\phi}^h \tilde{e}_{i,t} \right\}$$

- Realized return: Weighted average of strip returns

$$R_{i,t+1} = \frac{\sum_{h=1}^{\infty} P_{i,t+1}^{(h-1)}}{\sum_{h=1}^{\infty} P_{i,t}^{(h)}} = \sum_{h=1}^{\infty} w_{i,t,h} R_{i,t+1}^{(h)}, \quad w_{i,t,h} = \frac{P_{i,t}^{(h)}}{\sum_{h=1}^{\infty} P_{i,t}^{(h)}}$$

- Subjective expected return: Assume agents use current weights  $w_{i,t+j-1,h} \approx w_{i,t,h}$

$$\begin{aligned} \mathbb{F}_t[R_{i,t+j}] &\approx \sum_{h=1}^{\infty} w_{i,t+j-1,h} \mathbb{F}_t[\mathbb{F}_{t+1}[\dots \mathbb{F}_{t+j-1}[R_{i,t+j}^{(h)}]]] \\ &= \sum_{h=1}^{\infty} w_{i,t,h} \exp \left\{ r_f + C^{(h)} \gamma \sigma_u^2 + \frac{1}{2} ((\tilde{C}^{(h)})^2 - \tilde{\phi}^{2(h-1)}) \sigma_v^2 \right\} \end{aligned}$$

- Solve for  $q_t$  and  $L_{i,t+1}$  by iterating on labor market tightness  $\theta_t$  until convergence:

1. Initialize labor market tightness:  $\theta_t^{(0)} = 1$
2. Construct vacancy filling rate using Cobb-Douglas matching:  $q_t^{(s)} = B(\theta_t^{(s)})^{-\eta}$
3. Update each firm's employment policy using the hiring equation:

$$L_{i,t+1}^{(s)} = \frac{P_{i,t} q_t^{(s)}}{\kappa}$$

4. Update each firm's vacancy posting using the employment accumulation equation:

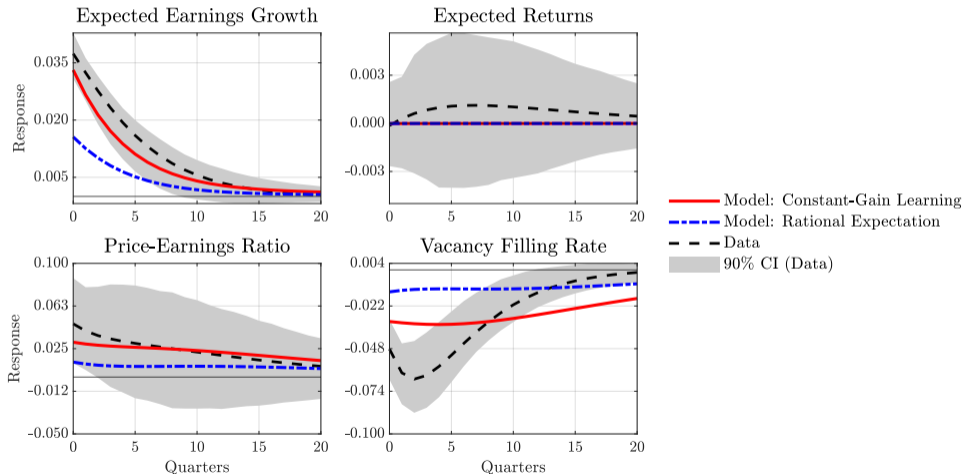
$$V_{i,t}^{(s)} = \frac{1}{q_t^{(s)}} (L_{i,t+1}^{(s)} - (1 - \delta) L_{i,t})$$

5. Aggregate firm-level variables over the set of firms  $I$ :

$$V_t^{(s)} = \sum_{i \in I} V_{i,t}^{(s)}, \quad L_{t+1}^{(s)} = \sum_{i \in I} L_{i,t+1}^{(s)}, \quad U_t^{(s)} = 1 - \sum_{i \in I} L_{i,t}$$

6. Update labor market tightness:  $\theta_t^{(s+1)} = \frac{V_t^{(s)}}{U_t^{(s)}}$ . Check convergence:  $|\theta_t^{(s+1)} - \theta_t^{(s)}| < \varepsilon$

- VAR(1):  $X_t = [\mathbb{F}_t[\Delta e_{t+1}], \mathbb{F}_t[r_{t+1}], pe_t, \log q_t]'$ , Cholesky identification



Notes: Red solid line: model-based IRFs from simulated series under constant-gain learning. Blue solid line: model-based IRFs from simulated series under rational expectations. Black dashed line: data-based IRFs. Shaded area: 90% bootstrap confidence interval for the data VAR. Sample: 1984Q1-2023Q4.

**Estimated parameters:**  $\theta = (\nu, \phi, \sigma_u, r_f, \gamma)$

- ▶  $\nu$ : Constant gain in belief updating
- ▶  $(\phi, \sigma_u)$ : Persistence and volatility of earnings process
- ▶  $(r_f, \gamma)$ : Risk-free rate and risk aversion

**Key empirical moments to match:**

- ▶ Earnings: Variance and autocorrelation of  $\Delta e_t$
- ▶ Returns: Mean, equity premium, volatility of stock returns
- ▶ Valuations: Volatility and persistence of price-earnings ratio
- ▶ Learning: Coibion-Gorodnichenko regression slopes at multiple horizons

**MSM criterion:**  $\hat{\theta}_N = \arg \min_{\theta} (S_N - S(\theta))' W_N^{-1} (S_N - S(\theta))$

- ▶ Earnings follow AR(1):  $e_t = \mu + \phi e_{t-1} + u_t$ ,  $\Delta e_t = (\phi - 1)e_{t-1} + u_t$
- ▶ Belief updating:  $\mathbb{F}_t[\mu] - \mathbb{F}_{t-1}[\mu] = \nu(\Delta e_t - \mathbb{F}_{t-1}[\Delta e_t])$
- ▶ Forecast error and revision:

$$\text{FE}_{t,1} = u_t - \mathbb{F}_{t-1}[\mu], \quad \text{Rev}_{t,h} = \phi^{h-1} \nu \text{FE}_{t,1} + \phi^{h-1}(\phi - 1)\Delta e_t.$$

- ▶ Coibion-Gorodnichenko regression slope:

$$\beta^{\text{CG}}(h) = \phi^{h-1} \left[ \nu + (\phi - 1) \frac{\text{Cov}(\Delta e_t, \text{FE}_{t,1})}{\text{Var}(\text{FE}_{t,1})} \right] = \phi^{h-1} \left[ \nu + (\phi - 1) \frac{2-\nu}{2} \cdot \frac{1-\phi+\nu}{1-\phi+\phi\nu} \right]$$

- ▶  $\beta^{\text{CG}}(h)$  increases with  $\nu$ ; negative at low  $\nu$ , positive at high  $\nu$

Moment or parameter	Data	Model	$t$ statistic
Panel A: Moments			
Mean log stock return	0.072	0.088	-0.510
SD log stock return	0.160	0.118	0.568
Mean log risk free rate	0.046	0.045	0.144
Mean of log price earnings	2.980	2.392	0.424
SD of log price earnings	0.285	0.293	-0.084
AC of log price earnings	0.750	0.798	-0.457
SD of aggregate earnings growth	0.268	0.294	-0.455
AC of aggregate earnings growth	-0.144	-0.142	-0.045
CG slope $h$ equals 4 aggregate	-0.263	-0.266	0.063
CG slope $h$ equals 8 aggregate	-0.463	-0.454	-0.040
Panel B: Estimated Parameters			
Gain coefficient $\nu$		0.013	
AR coefficient aggregate $\phi$		0.854	
Aggregate shock standard deviation $\sigma_u$		0.271	
Risk free rate $r_f$		0.045	
Risk aversion $\gamma$		1.647	

- ▶ Aggregate results suggest belief distortions matter, but causality is unclear
- ▶ Use state-level variation to test whether distorted beliefs drive unemployment:

$$u_{s,t+1} = \beta_r \mathbb{F}_t[r_{s,t,t+h}] + \beta_e \mathbb{F}_t[e_{s,t,t+h}] + \gamma' X_{s,t} + \alpha_s + \alpha_t + \varepsilon_{s,t+1}$$

- Subjective expectations:  $\mathbb{F}_t[r_{s,t,t+h}]$  discount rate,  $\mathbb{F}_t[e_{s,t,t+h}]$  cash flow
  - ▶ Aggregate across firms with headquarters in state  $s$
- $X_{s,t} = [u_{s,t}, \theta_{s,t}, \delta_{s,t}]'$  labor market factors,  $\alpha_s$  state fixed effect,  $\alpha_t$  time fixed effect
- ▶ Bartik shift-share instrument: Replace state-level forecast  $\mathbb{F}_t[y_{s,t,t+h}]$  with

$$\widehat{\mathbb{F}}_t[y_{s,t,t+h}] = \sum_{i \in I} s_{s,i,t-1} \mathbb{F}_t[y_{i,t,t+h}], \quad y = r, e$$

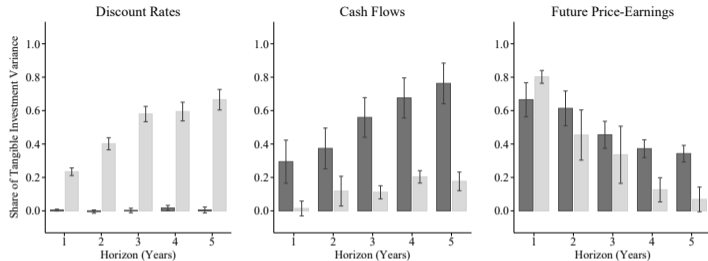
- $s_{s,i,t-1}$ : Industry  $i$ 's (2-digit NAICS) employment share in state  $s$
- Instrument isolates variation in beliefs from national trends, not local conditions

► Shift-share estimates confirm causal impact of belief distortions

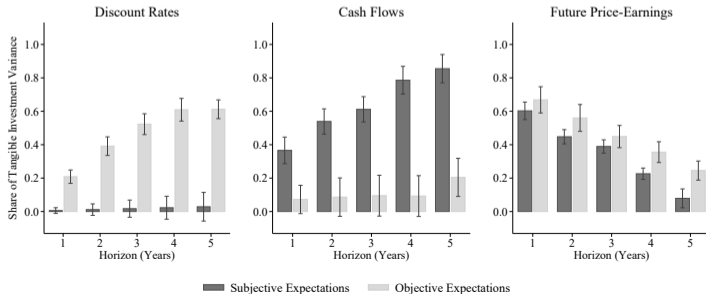
	OLS			Shift-Share Instrument		
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbb{E}_t[r_{s,t,t+h}]$	0.725*** (0.235)		0.470 (0.780)	0.572*** (0.222)		0.207 (0.240)
$\mathbb{E}_t[e_{s,t,t+h}]$	-0.247 (0.499)		-0.065 (0.182)	-0.064 (0.075)		0.005 (0.168)
$\mathbb{F}_t[r_{s,t,t+h}]$		0.248 (0.297)	0.233 (0.300)		0.052 (0.228)	0.052 (0.228)
$\mathbb{F}_t[e_{s,t,t+h}]$		-0.817*** (0.236)	-0.791*** (0.242)		-0.690*** (0.160)	-0.708*** (0.200)
$R^2$	0.414	0.558	0.558	0.414	0.549	0.549
State FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Labor Market Factors	Yes	Yes	Yes	Yes	Yes	Yes

# Variance Decomposition of the Tangible Investment Rate [▶ Return](#)

(a) Time-Series  
Decomposition

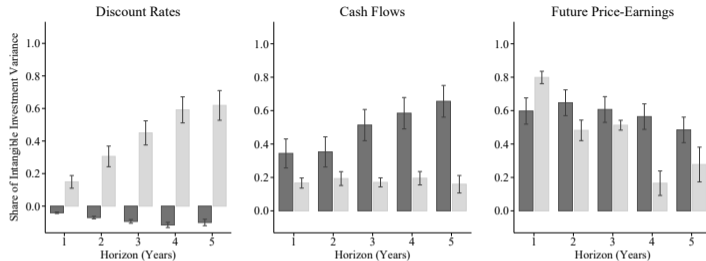


(b) Cross-Sectional  
Decomposition

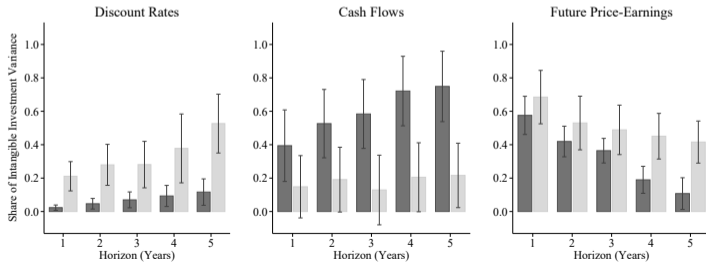


# Variance Decomposition of the Intangible Investment Rate [▶ Return](#)

(a) Time-Series  
Decomposition



(b) Cross-Sectional  
Decomposition



■ Subjective Expectations    ■ Objective Expectations

- ▶ Measured earnings  $E_t$  reflect contribution from all new hires
  - Introduce model accounting for job-to-job transitions
  - Kuhn, Manovskii, and Qiu 2021; Faberman et al. 2022
- ▶ Assume fraction  $\phi$  of employed workers search for a job each period
  - Total searchers:  $S_t \equiv U_t + \phi L_t = U_t + \phi(1 - U_t)$
  - Matches formed under CRS matching function  $\mathcal{M}(S_t, V_t)$
- ▶ Assume only fraction  $\chi$  of on-the-job searchers accept offers
  - Hiring efficiency:  $\varphi_t \equiv \frac{U_t + \chi\phi(1 - U_t)}{U_t + \phi(1 - U_t)}$
- ▶ Firm's value satisfies Bellman equation:

$$\mathcal{V}(A_t, L_t) = \max_{V_t, L_{t+1}} \{E_t + (1 - \phi\chi f_t)\mathbb{E}_t[M_{t+1}\mathcal{V}(A_{t+1}, L_{t+1})]\}$$

$$\text{s.t. } L_{t+1} = (1 - \delta_t)L_t + q_t\varphi_t V_t$$

- Employee retention rate  $1 - \phi\chi f_t$ , efficiency-adjusted Vacancy Filling Rate  $q_t\varphi_t$

- ▶ First-order condition under constant returns to scale:

$$\frac{\kappa}{q_t \varphi_t} = (1 - \phi \chi f_t) \frac{P_t}{L_{t+1}}$$

- Ex-dividend firm value:  $P_t \equiv \mathbb{F}_t [M_{t+1} \mathcal{V}(A_{t+1}, L_{t+1})]$
- ▶ Take logs, combine with Campbell and Shiller 1988 identity for price-earnings:

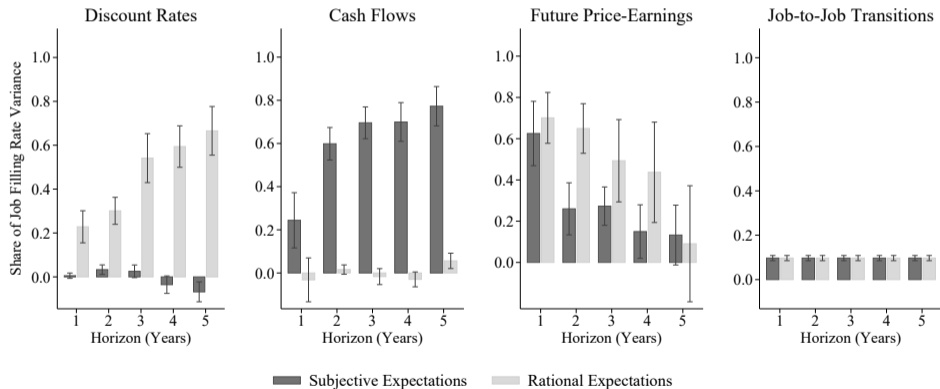
$$\log q_t = c_q - \underbrace{\log(1 - \phi \chi f_t)}_{\text{Job-to-Job Transitions}} + \underbrace{\mathbb{F}_t[r_{t,t+h}]}_{\text{Discount Rate}} - \underbrace{\mathbb{F}_t[e_{t,t+h}]}_{\text{Cash Flow}} - \underbrace{\mathbb{F}_t[pe_{t,t+h}]}_{\text{Future Price-Earnings}}$$

- Constant  $c_q = \log \kappa - \frac{c_{pe}(1-\rho^h)}{1-\rho} - \log \varphi_t$  with  $\log \varphi_t \approx \log \varphi$
- Estimate by regressing each component on  $\log q_t$

- ▶ Parameters based on Kuhn, Manovskii, and Qiu 2021; Faberman et al. 2022
  - Fraction of on-the-job searchers  $\phi = 0.12$
  - Fraction of on-the-job searchers accepting offered job  $\chi = 0.75$
- ▶ Subjective expectations: IBES earnings forecasts
  - Analysts forecast total earnings, which pools contribution from all new hires
- ▶ Vacancy Filling Rate: Hires over vacancies  $q_t = \frac{H_t}{V_t}$ 
  - JOLTS hires  $H_t$  (includes UE and J2J) / JOLTS job openings  $V_t$
- ▶ Labor market tightness: Vacancies over job searchers  $\theta_t = \frac{V_t}{S_t} = \frac{V_t}{U_t + \phi(1 - U_t)}$ 
  - JOLTS job openings  $V_t$ , BLS unemployment level  $U_t$
- ▶ Job finding rate: Infer from CRS matching function  $f_t = \frac{\mathcal{M}(S_t, V_t)}{S_t} = q_t \theta_t$

## Extension with On-the-Job Search: Results [▶ Return](#)

- ▶ Cash flow belief distortion  $\mathbb{F}_t - \mathbb{E}_t$  accounts for most of hiring variation
- ▶ Job-to-job transitions  $\log(1 - \phi\chi f_t)$  account for 8.9% of  $\log q_t$  variation



Notes: Light bars show the contribution under objective expectations. Dark bars show the contribution under subjective expectations. The Sample: 2005Q1 to 2024Q4. Each bar shows Newey-West 95% confidence intervals with lags = 4.

- ▶ Assume decreasing returns to scale production:  $Y_{i,t} = A_{i,t} L_{i,t}^\alpha$ ,  $0 < \alpha < 1$
- ▶ Earnings  $E_{i,t}$  defined as profits  $\Pi_{i,t}$  after vacancy posting cost:

$$E_{i,t} = \Pi_{i,t} - \kappa V_{i,t}, \quad \Pi_{i,t} = Y_{i,t} - W_{i,t} L_{i,t}$$

$A_{i,t}$  productivity,  $L_{i,t}$  employment,  $W_{i,t}$  wages,  $\kappa V_{i,t}$  vacancy posting cost

- ▶ After recursive substitution, first-order condition implies:

$$\frac{\kappa}{q_t} = \sum_{j=1}^{\infty} \mathbb{F}_t \left[ \frac{1}{R_{i,t,t+j}} \frac{(\pi_{i,t+j} L_{i,t+j} - \kappa V_{i,t+j})}{L_{i,t+j}} \right]$$

$\pi_{i,t+j} = \frac{\partial \Pi_{i,t+j}}{\partial L_{i,t+j}}$  marginal profit,  $\frac{1}{R_{i,t,t+j}} = \prod_{k=1}^j \frac{1}{R_{i,t+k}}$  cumulative discount rate

- ▶ DRS introduces wedge between marginal vs. average profit:  $(1 - \alpha)Y_{i,t}$

$$\pi_{i,t}L_{i,t} - \kappa V_{i,t} = \alpha A_{i,t}L_{i,t}^\alpha - W_{i,t}L_{i,t} - \kappa V_{i,t} = E_{i,t} - (1 - \alpha)Y_{i,t}$$

- ▶ Substitute DRS wedge into the hiring equation

- ▶ Aggregate into averages weighted by employment share  $S_{i,t+1} \equiv \frac{L_{i,t+1}}{\sum_{i \in I} L_{i,t+1}}$

$$\frac{\kappa}{q_t} = \sum_{i \in I} \sum_{j=1}^{\infty} \mathbb{F}_t \left[ \frac{1}{R_{i,t,t+j}} \left( \underbrace{\frac{E_{i,t+j}}{L_{i,t+1}}}_{EL_{i,t+j}} - (1 - \alpha) \underbrace{\frac{Y_{i,t+j}}{L_{i,t+1}}}_{YL_{i,t+j}} \right) \right] \underbrace{\frac{L_{i,t+1}}{L_{t+1}}}_{S_{i,t+1}}$$

- ▶ Log linearize around steady state

$$\log q_t = \sum_{i \in I} \sum_{j=1}^{\infty} \left[ \mathbb{F}_t [\rho_{i,j}^r r_{i,t,t+j}] - \mathbb{F}_t [\rho_{i,j}^{el} el_{i,t+j}] + (1 - \alpha) \mathbb{F}_t [\rho_{i,j}^{yl} yl_{i,t+j}] - \rho_{i,j}^s s_{i,t+1} \right]$$

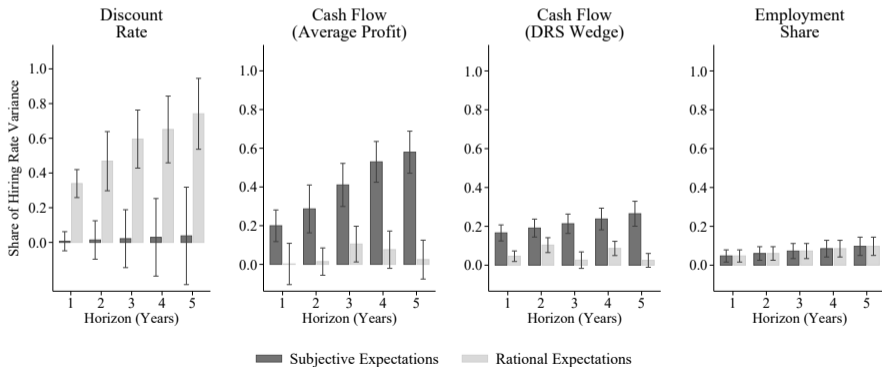
- $\rho_{i,j}^{el} = \frac{\bar{q}}{\kappa} \cdot \frac{\bar{EL}_i \cdot \bar{S}_i}{\bar{R}^j}$ ,  $\rho_{i,j}^{yl} = \frac{\bar{q}}{\kappa} \cdot \frac{\bar{YL}_i \cdot \bar{S}_i}{\bar{R}^j}$ ,  $\rho_{i,j}^s = \rho_{i,j}^r = \frac{\bar{q}}{\kappa} \cdot \frac{(\bar{EL}_i + (1 - \alpha)\bar{YL}_i) \cdot \bar{S}_i}{\bar{R}^j}$
- $s_{i,t+1}$  captures shifts in firm size distribution (composition effect)

- ▶ Time-series decomposition of aggregate Vacancy Filling Rate:

$$\log q_t = \sum_{j=1}^{\infty} \left[ \underbrace{\mathbb{F}_t[r_{t,t+j}]}_{\text{Discount Rate}} - \underbrace{\mathbb{F}_t[e_{t,t+j}]}_{\text{Cash Flow (Earnings)}} + \underbrace{(1-\alpha)\mathbb{F}_t[y_{t,t+j}]}_{\text{Cash Flow (DRS Wedge)}} - \underbrace{s_{t+1}}_{\text{Composition Effect}} \right]$$

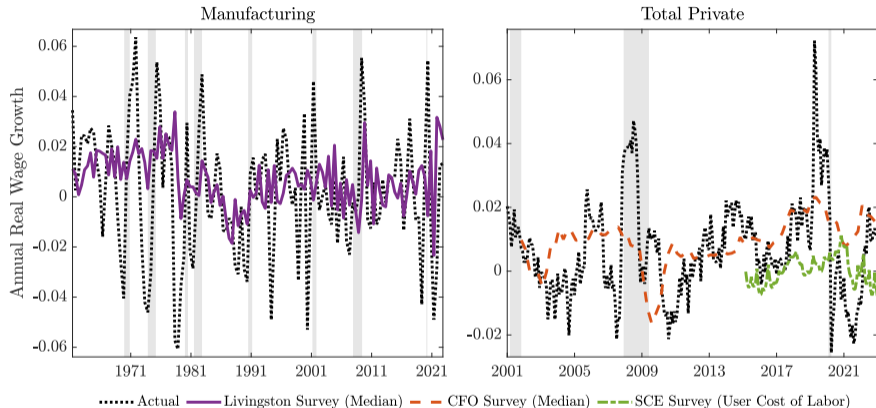
- $x_t = \sum_{i \in I} \rho_{i,j}^x x_{i,t}$  aggregates firm-level variable  $x_{i,t}$
- ▶ Data and measurement
  - Sort firms into 5 value-weighted portfolios by employee count
  - Measure expected output  $\mathbb{F}_t[y_{i,t+j}]$  using IBES sales forecasts
  - $\alpha = 0.72$  labor share,  $\kappa = 0.133$  flow vacancy cost (Elsby and Michaels 2013)
  - $\bar{q}$ ,  $\bar{R}$ ,  $\bar{EL}_i$ ,  $\bar{YL}_i$ ,  $\bar{S}_i$  long-run sample averages
  - Approximate the infinite sum by truncating up to  $h \leq 5$  years

- Cash flow belief distortion  $\mathbb{F}_t - \mathbb{E}_t$  accounts for most of hiring variation
  - DRS wedge (output-employment) about 1/3 of total weight on cash flow
  - Composition effect (employment share) accounts for less than 10%



Notes: The sample is quarterly from 2005Q1 to 2023Q4. Each bar shows Newey-West 95% confidence intervals with lags = 4.

# Real Wage Growth: Actual vs. Subjective Expectations



**Notes:** This figure plots ex-post realized outcomes (Actual) and 1-year ahead subjective expectations (Survey) of real wage growth. x axis denotes the date on which actual values were realized and the period on which the survey forecast is made, making the vertical distance between the actual and survey lines the forecast error. Actual values are deflated using the Consumer Price Index (CPIAUCSL). Livingston, CFO, and SCE survey expectations of nominal wage growth are deflated using median consensus forecasts of CPI inflation from the Livingston, SPF, and SCE surveys, respectively. The sample period for Livingston is semi-annual spanning 1961S1 to 2022S2, CFO survey is quarterly spanning 2001Q4 to 2023Q4, SCE is monthly spanning 2015M5 to 2022M12. NBER recessions are shown with gray shaded bars.

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