Heterogeneous Beliefs, Asset Prices, and Business Cycles

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Waves of optimism/pessimism and business cycles

What drives business cycles fluctuations?

- A prominent narrative attributes it to *waves of optimism and pessimism*
  - See, e.g., Minsky (1977), Kindleberger (1978), Shiller (2000)

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- But how does waves of optimism spillover to the real economy?

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Heterogeneous beliefs, Asset Prices, and Business Cycles

- This paper: production-based asset pricing model with belief heterogeneity
- Two ingredients: heterogeneous beliefs about growth and labor set one-period in advance
    - Enough to match key business-cycle, beliefs, and asset-pricing moments
    - e.g., equity premium, volatility, and return predictability (under objective and subjective beliefs)

Motivating evidence

Three facts about expectations

Fact 1: Subjective expectations are volatile

- Share of cash-flow variance explained by movements in expectations
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Fact 3: Expectations predict hiring

- Lagged I/B/E/S earnings expectations predict subsequent payroll and worker growth
- This remains true controlling for past and contemporaneous returns

Model

Firms

Productivity growth.

$$\frac{A_{t+1}}{A_t} = x_{t+1},$$

where $x_{t+1} \in \{x_L, x_H\}$ with objective transition probability from s to s' $p_{ss'}$

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Firm's problem.

$$Q_t = \max_{h_{t+1}} \mathbb{E}_t \left[\Lambda_{t,t+1}(A_{t+1} h_{t+1}^{\alpha} - w_{t+1} h_{t+1} + Q_{t+1})\right],$$

where $\Lambda_{t,t+1}$ is the economy's SDF.

Labor as risky investment

- Workers hired one-period in advance, so hiring is risky for the firm
- Reminiscent of search models, where employment is predetermined

Preferences and beliefs

Preferences.

$$V_{i,t} = (1-\beta)U\left(C_{i,t} - \xi_t h_{i,t}\right) + \beta U(\mathcal{V}_{i,t}),$$

where $\mathcal{V}_{i,t} = \Psi^{-1}\left(\mathbb{E}_{i,t}[\Psi(U^{-1}(V_{i,t+1}))]\right)$ and $\xi_t = \xi A_{t-1}$.

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Beliefs.

$$p^i_{HH} = \underbrace{\frac{1+\rho_i}{2}}_{\text{extrapolation}} + \underbrace{\Delta_i}_{\text{optimism/pessimism}}, \qquad p^i_{LL} = \frac{1+\rho_i}{2} - \Delta_i,$$

Equilibrium characterization

Households' and firms' problems

Euler equations:

$$\Lambda_i(X, s, s') = \frac{p_{ss'}}{p^i_{ss'}} \Lambda(X, s, s')$$

where $\Lambda_i(X, s, s')$ is the subjective SDF for investor i.

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Labor demand:

$$\alpha \times \underbrace{\mathbb{E}_t \left[\frac{\Lambda_{t,t+1}}{\mathbb{E}_t[\Lambda_{t,t+1}]} x_{t+1} \right]}_{\mathcal{L}_t} \times h_{t+1}^{\alpha-1} = w_{t+1},$$

where $w_{t+1} = W_{t+1} / A_t$.

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where $w_{t+1} = W_{t+1}/A_t$.

Hours and wages:

$$h(\mathcal{L}) = \left(\frac{\alpha \mathcal{L}}{\xi} \right)^{\frac{1}{1-\alpha}}, \qquad w(\mathcal{L}) = \xi,$$

Step I: Price of risk affects hiring

Risk-neutral expected productivity growth:

$$\mathcal{L}'(X,s) = \underbrace{\mathbb{E}_s[x_{s'}]}_{\text{objective expectation}} - \underbrace{\frac{\mathbb{E}_s[R_r^e(X,s,s')]}{\sigma_s[R_r^e(X,s,s')]}}_{\text{price of risk}} \times \underbrace{\sigma_s[x_{s'}]}_{\text{quantity of risk}},$$

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Equity premium and labor volatility:

- Price of risk $\propto$ volatility of SDF
- Fluctuations in compensation for risk $\Rightarrow$ fluctuations in labor demand

In a nutshell, labor-volatility puzzle and equity-volatility puzzle are tightly connected

- Shimer (2010): search model where $\mathcal{L}$ is constant $\Rightarrow$ no employment fluctuations

Step II: Hiring affects risk

The labor friction amplifies the volatility of dividends

- Revenue falls after a productivity drop, but the wage bill is sticky
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This effect is known as the *operating leverage channel*:

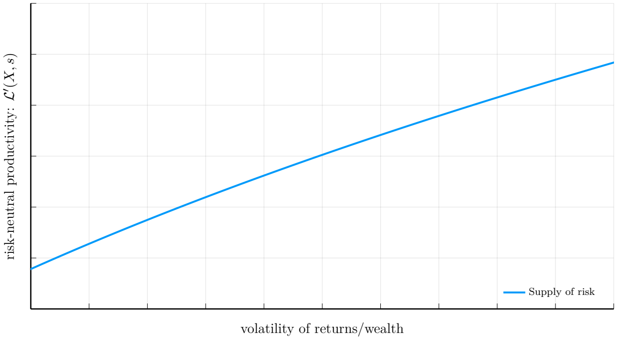
$$\underbrace{\sigma_s\left[\frac{\pi_{t+1}}{\pi_t}\right]}_{\substack{\text{volatility of}\\ \text{dividend growth}}} = \underbrace{\frac{x_t}{x_t - \alpha\mathcal{L}_{t-1}}}_{\text{operating leverage}} \times \underbrace{\sigma_s\left[\frac{Y_{t+1}}{Y_t}\right]}_{\substack{\text{volatility of}\\ \text{output growth}}}$$

Special case: Log utility

The supply of risk

With log utility, the price-dividend ratio is constant:

$$\frac{P_t}{D_t} = \frac{1}{1-\beta} \qquad \Rightarrow \qquad \sigma_s\left[\log R_{p,t+1}\right] = \sigma_s\left[\log D_{t+1}\right].$$



Return volatility = Dividend volatility

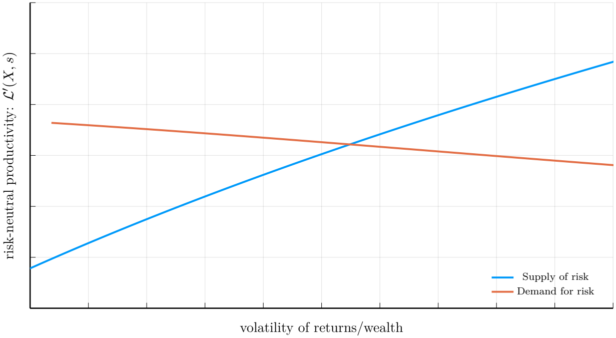
- Volatility increases with $\mathcal{L}'$
- Operating leverage channel in action

The demand for risk

From portfolio choice, we have the demand for risk in the economy

$$\sum_{i=1}^{I} \eta_i \sigma_s[R_{i,n}(X,s,s')] = \beta \frac{x_s}{x_s - \frac{\alpha}{1+\nu}\mathcal{L}} \left[\frac{p_{sH}(X)}{\mathcal{L}'(X,s) - x_L} - \frac{p_{sL}(X)}{x_H - \mathcal{L}'(X,s)} \right].$$

where $p_{ss'}(X) = \sum_{i=1}^{I} \eta_i p^i_{ss'}$.



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- Beliefs as a demand shifter

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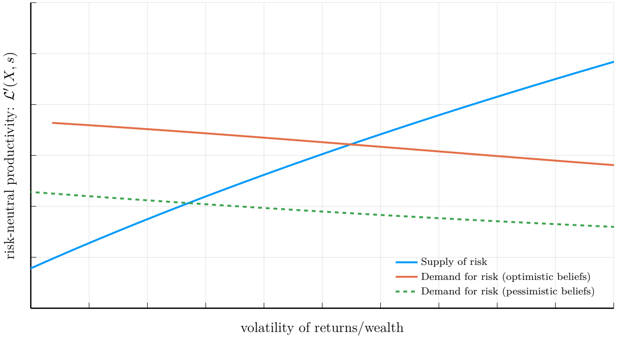

Demand for risk:

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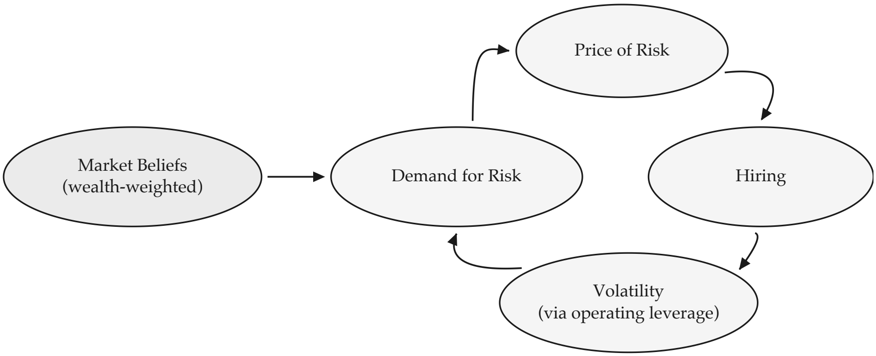
Risk build-up + 'frothy' markets

- Consistent with evidence
- Challenging for standard models

Belief-Driven Equilibrium Feedback



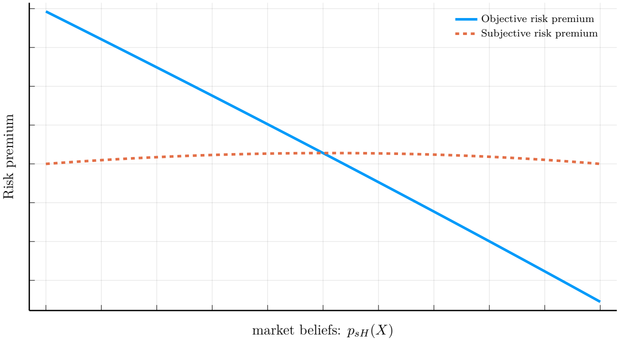
No macro-finance separation in this setting (Tallarini, 2000)

- Labor demand and price of risk are jointly determined
- Separation holds if firms could adjust labor after productivity is realized

Objective vs. subjective risk premia

Objective risk premium:

$$\mathbb{E}_s\left[R^e_r(X,s,s')\right] = \underbrace{\mathbb{E}_{i,s}\left[R^e_r(X,s,s')\right]}_{\text{subjective risk premium}} - \underbrace{\frac{\mathbb{E}_{i,s}[x_{s'}] - \mathbb{E}_s[x_{s'}]}{(1-\alpha)\mathcal{L}'(X,s)}}_{\text{optimism effect}}.$$



Optimism leads to changes in risk premia

- Muted effect on subjective risk premium
- Consistent with evidence
  - De La O & Meyer (2021); Nagel and Xu (2023)

A Taxonomy of Beliefs

Definition (Taxonomy of beliefs)

We classify beliefs into two categories:

(i) **Rank-preserving beliefs:** $p^i_{HH} > p^j_{HH}$ implies $p^i_{LH} > p^j_{LH}$

- Relative optimism (or pessimism) is preserved in all states

(ii) **Rank-alternating beliefs:** $p^i_{HH} > p^j_{HH}$ implies $p^i_{LH} < p^j_{LH}$

- Investors alternate in their degree of relative optimism across states.

Dynamics with heterogeneous beliefs

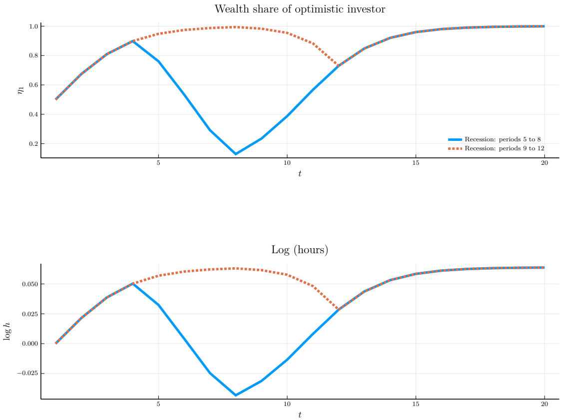


Figure: Optimistic vs pessimistic

Dynamics with heterogeneous beliefs

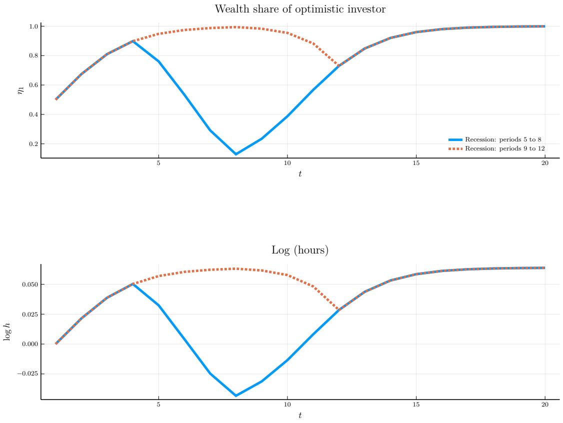


Figure: Optimistic vs pessimistic

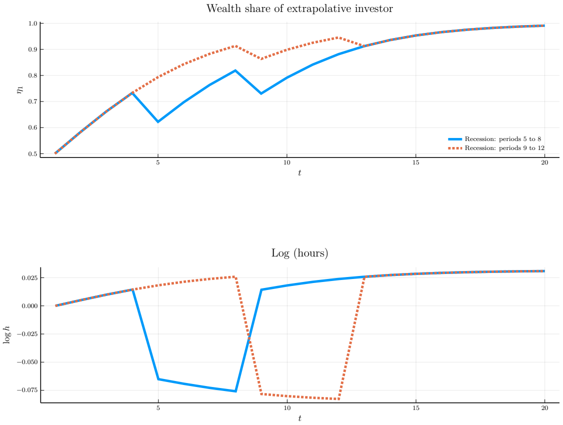


Figure: Rational vs extrapolative

Turnover and disagreement

Turnover vs. disagreement:

$$\tau(X, s, s') = \underbrace{\frac{\zeta(s, s')}{2}}_{\text{multiplier}} \times \underbrace{\sum_{i=1}^{I} \eta_i |\rho_i - \rho(X)|}_{\text{belief dispersion}}.$$

Predictions with rank-alternating beliefs:

- Multiplier is state-dependent
- Amplified in transitions to downturns

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	Baseline (1)	Recession (2)	Early Rec. (4)
Disagreement (z-score)	0.075	0.054	0.069
	(0.047)	(0.039)	(0.047)
Recession		0.051	
		(0.048)	
Disagreement × Recession		0.176***	
		(0.058)	
Early rec.			0.014
			(0.035)
Disagreement × Early rec.			0.095*
			(0.051)
Marginal effect of DI in recession		0.230	0.164
Constant	0.311***	0.301***	0.309***
	(0.023)	(0.022)	(0.023)
Observations	158	158	158
R^2	0.212	0.352	0.235

Sample 1982Q2–2021Q3; disagreement standardized within sample; Newey–West (4 lags) s.e.

Quantitative implications

Model with continuous states

To study the quantitative implications of the model, it is useful to go beyond two states

Objective beliefs:

$$\hat{x}_{t+1} = \mu_x + \sigma_x \epsilon_{x,t+1},$$

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Objective beliefs:

$$\hat{x}_{t+1} = \mu_x + \sigma_x \epsilon_{x,t+1},$$

Subjective beliefs:

$$\hat{x}_{t+1} = \mu_{x,i} + \rho_{x,i}(\hat{x}_t - \mu_{x,i}) + v_{i,t} + \sigma_{x,i}\epsilon_{i,t+1},$$
$$v_{i,t+1} = \rho_{v,i} v_{i,t} + \sigma_{v,i} \upsilon_{i,t+1}.$$

where $v_{i,t}$ is a **sentiment shock**.

Calibration:

- Choose $(\rho_{v,1}, \sigma_{v,1})$ to match persistence and variance share of subjective expectations
- Choose $\rho_{x,1}$ to match the correlation between beliefs and productivity

Forecast biases in productivity expectations

Coibion–Gorodnichenko regressions:

$$\text{FE}_t = c + \beta_{CG}\,\text{Revision}_t + u_t$$

- Under FIRE, $\beta_{CG} = 0$
- Negative β_{CG} indicates over-extrapolation

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Model implication

- $\hat{\beta}_{CG}^{model} = -0.695$
- Close to labor and within one s.e. of TFP

	Labor productivity	TFP proxy
Forecast revision coefficient β_{CG}	-0.63***	-0.50**
	(0.030)	(0.198)
Constant	-0.15	-0.25
	(0.289)	(0.259)
Observations	86	86
R^2	0.3697	0.0579

Newey–West HAC standard errors. Sample: 2004Q1–2025Q2.

Unconditional moments

	Rational Beliefs			Subjective Beliefs				
	Endowment						Data ($\pm$2 s.e.)	
Variables	Mean	Std					Mean	Std
Interest rate	10.2	0.0					[0.6, 3.0]	[3.7, 6.0]
Excess returns (equity)	0.7	2.7					[3.5, 9.3]	[15.6, 21.4]
Consumption growth	2.1	2.7					[1.2, 3.1]	[2.0, 3.4]
Dividend growth	2.1	2.7					[-0.3, 3.4]	[6.9, 11.2]
Log hours	0.0	0.0					–	[1.7, 2.7]

Alternative version with light row shading to direct attention during the reveal.

Column 1: the red shading highlights the key failure in the benchmark: zero labor volatility.

Unconditional moments

	Rational Beliefs				Subjective Beliefs				
	Endowment		Production					Data (±2 s.e.)	
Variables	Mean	Std	Mean	Std				Mean	Std
Interest rate	10.2	0.0	10.0	0.7				[0.6, 3.0]	[3.7, 6.0]
Excess returns (equity)	0.7	2.7	1.2	7.2				[3.5, 9.3]	[15.6, 21.4]
Consumption growth	2.1	2.7	2.1	2.7				[1.2, 3.1]	[2.0, 3.4]
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Log hours	0.0	0.0	0.2	0.0				–	[1.7, 2.7]

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Column 2: the blue shading highlights dividend volatility, which improves sharply once labor is chosen in advance.

Unconditional moments

	Rational Beliefs				Subjective Beliefs						
	Endowment		Production		Homogeneous					Data (±2 s.e.)	
Variables	Mean	Std	Mean	Std	Mean	Std				Mean	Std
Interest rate	10.2	0.0	10.0	0.7	10.1	1.3				[0.6, 3.0]	[3.7, 6.0]
Excess returns (equity)	0.7	2.7	1.2	7.2	1.2	8.3				[3.5, 9.3]	[15.6, 21.4]
Consumption growth	2.1	2.7	2.1	2.7	2.1	2.8				[1.2, 3.1]	[2.0, 3.4]
Dividend growth	2.1	2.7	2.1	9.3	2.1	10.0				[-0.3, 3.4]	[6.9, 11.2]
Log hours	0.0	0.0	0.2	0.0	0.2	1.3				–	[1.7, 2.7]

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Column 3: the blue shading returns to hours, which start to move once beliefs become subjective.

Unconditional moments

	Rational Beliefs				Subjective Beliefs				Data (± 2 s.e.)	
	Endowment		Production		Homogeneous		Heterogeneous			
Variables	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
Interest rate	10.2	0.0	10.0	0.7	10.1	1.3	1.7	6.1	[0.6, 3.0]	[3.7, 6.0]
Excess returns (equity)	0.7	2.7	1.2	7.2	1.2	8.3	5.2	15.8	[3.5, 9.3]	[15.6, 21.4]
Consumption growth	2.1	2.7	2.1	2.7	2.1	2.8	2.1	2.8	[1.2, 3.1]	[2.0, 3.4]
Dividend growth	2.1	2.7	2.1	9.3	2.1	10.0	2.1	10.0	[-0.3, 3.4]	[6.9, 11.2]
Log hours	0.0	0.0	0.2	0.0	0.2	1.3	0.2	1.2	–	[1.7, 2.7]

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Column 4: the blue shading highlights the row where heterogeneous beliefs close the gap on equity premium and return volatility.

Unconditional moments

	Rational Beliefs				Subjective Beliefs							
	Endowment		Production		Homogeneous		Heterogeneous		High elast.		Data ($\pm$2 s.e.)	
Variables	**Mean**	**Std**	**Mean**	**Std**	**Mean**	**Std**	**Mean**	**Std**	**Mean**	**Std**	**Mean**	**Std**
Interest rate	10.2	0.0	10.0	0.7	10.1	1.3	1.7	6.1	1.6	6.1	[0.6, 3.0]	[3.7, 6.0]
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Log hours	0.0	0.0	0.2	0.0	0.2	1.3	0.2	1.2	0.6	1.9	–	[1.7, 2.7]

Alternative version with light row shading to direct attention during the reveal.

Column 5: the blue shading returns to hours, which improve further with higher labor elasticity.

Return predictability: objective vs. subjective beliefs

Fraction of variance of returns explained by discount rates:

- Heterogeneous beliefs: nearly 90% explained by discount rates
- Homogeneous beliefs: -15% for rational and 26% for subjective

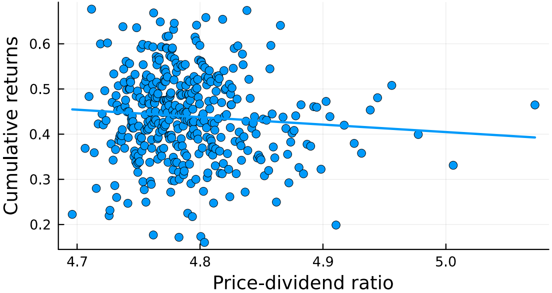

Figure: Return predictability

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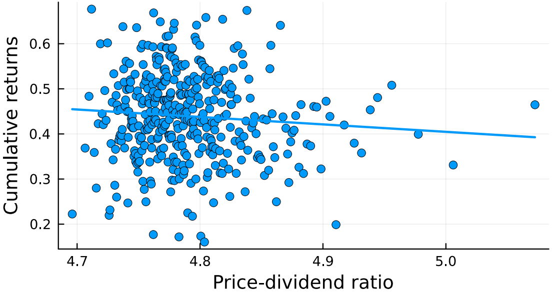

Figure: Return predictability

Dependent Variable:	cum_ex_returns			
Model:	(1)	(2)	(3)	(4)
Variables				
labor_income	-2.07		0.33	
	(0.94)		(1.31)	
p/d		-0.29		-0.04
		(0.12)		(0.17)
Observations	4,000	4,000	4,000	4,000

Table: Labor and p/d ratio regressions

Left panel: binscatter of the price-dividend ratio against future cumulative returns for $T = 60$ quarters.
Right panel: Monte Carlo mean coefficients under the objective measure (cols. 1–2) and under subjective beliefs (cols. 3–4).

Conclusion

Production model with heterogeneous beliefs

- Two ingredients: heterogeneous beliefs and labor chosen one period in advance
- Model is disciplined with survey expectations of cash flows

Main lessons

- Waves of optimism compress risk premia and raise labor demand
- Rank-alternating beliefs amplify business cycles

Quantitative implications

- Model matches key beliefs, asset prices, and business cycles facts
- Heterogeneity is essential for matching excess volatility and return predictability