Investor Heuristics and Biases: Quantitative Effects on the U.S. Business Cycle

Job Market Paper

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Overview

Introduction

Case for Anchoring

- Kahneman and Tversky (1974, 1979):

  “The location of the reference point . . . emerge as critical factors in the analysis of decisions.”

- Thaler and Johnson (1990):

  “real decision makers are influenced by prior outcomes . . . increased risk seeking in the presence of a prior gain.”

Case for Confidence

- Pigou (1927): waves of optimism and pessimism may cause business cycles
- Keynes (1936): “animal spirits” regarding investing decisions may cause business cycles

Case for Confidence

Malmendier and Tate (2005):

"Overconfident managers overestimate the returns to their investment projects . . . overinvest when they have abundant internal funds, but curtail investment when they require external financing."

Behavior to Business Cycles

- Malmendier and Tate (2005, 2008, 2015)
- Ho et. al. (2016): "overconfident [CEOs] likely to weaken lending standards and increase leverage... more vulnerable to the shock of the crisis."
- Jlassi et. al. (2014): "overconfidence is the main incentive that triggered and prolonged the global financial crisis in the US market."
- Abbes (2013): "volatility is positively related to... overconfidence bias... contributes to the exceptional financial instability that erupted in 2008."

Research Question

Do investors exhibit behavioral biases and/or heuristics?
Does this have an effect on the US business cycle?

Method: Gertler and Karadi (2011) + subjective expectation formation + MCMC estimation.

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Summary of Findings

- Theoretical model shows that behavioral features may cause investors to maintain sub-optimal leverage ratios.
- Estimation shows that investors form 18% to 31% of their expectations subjectively.
- Subjectivity amplifies the recession caused by capital quality shocks, but reduces its duration.
- Confidence shocks have a large dual effect on macro variables which is amplified by subjectivity.

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Baseline Theoretical Model

Gertler and Karadi (JME 2011)

Standard CEE (2005) + Financial Frictions

Agent Features

- CRRA utility
- Variable capital utilization/depreciation
- Retailers with monopolistic markup
- Investment adjustment costs
- Shocks to capital quality
- Taylor Rule

Financial Intermediaries/Banks

$N_{j,t}$: Net worth of bank j at end of t

$B_{j,t+1}$: Deposits from households into bank j at t (paid in $t+1$)

$S_{j,t}$: shares of nonfinancial firms held by bank j with a corresponding share price Q_t and generates a return of R^k_{t+1} per share

Bank's balance sheet:

$$\underbrace{Q_t S_{j,t}}_{\text{Assets}} = \overbrace{B_{j,t+1}}^{\text{Liabilities}} + \underbrace{N_{j,t}}_{\text{Net Worth}}$$

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Financial Intermediaries/Banks

Banker's objective function:

$$V_{j,t} = \max \mathbb{E}_t \sum_{i=1}^{\infty} m_{t,t+i}[(R^k_{t+i} - R_{t+i})Q_{t+i}S_{j,t+i} + R_{t+i}N_{j,t+i-1}]$$

Introduce financial friction: Banker can divert fraction λ of assets. Depositors recover fraction $(1-\lambda)$.

Equilibrium incentive constraint:

$$V_{j,t} = \nu_t Q_t S_{j,t} + \eta_t N_{j,t} = \lambda Q_t S_{j,t}$$

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Financial Intermediaries/Banks

Convert to leverage ratio form:

$$Q_t S_{j,t} = \frac{\eta_t}{\lambda - \nu_t} N_{j,t} = \phi_t N_{j,t}$$

So net worth evolves:

$$N_{j,t+1} = [(R^k_{t+i} - R_{t+i})\phi_t + R_{t+1}] N_{j,t}$$

ϕ_t does not depend on firm-specific factors. So aggregate:

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Behavioral Modifications

Subjective Maximization Problem

Recall banker's net worth maximization problem:

$$V_{j,t} = \max \mathbb{E}_t \sum_{i=1}^{\infty} m_{t,t+i}[(R^k_{t+i} - R_{t+i})Q_{t+i}S_{j,t+i} + R_{t+i}N_{j,t+i-1}]$$

Investor's *subjective* expectations at time t: $\mathbb{E}^s_t$

Banker's subjective maximization problem:

$$V_{j,t} = \max \mathbb{E}^s_t \sum_{i=1}^{\infty} m_{t,t+i}[(R^k_{t+i} - R_{t+i})Q_{t+i}S_{j,t+i} + R_{t+i}N_{j,t+i-1}]$$

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Modeling Subjective Returns

Define ζ as the fraction of returns assessments that is derived from behavioral factors.

$$\mathbb{E}_t^s R_{t+1}^k = \zeta R_{t+1}^s + (1-\zeta)\mathbb{E}_t R_{t+1}^k$$

R_{t+1}^s contains all behavioral biases and/or heuristics.

Anchoring

Investors may be anchored to prior T period returns and fail to adjust appropriately.

$$R^s_{t+1} = \rho_1 R^k_t + \rho_2 R^k_{t-1} + \cdots + \rho_T R^k_{t+1-T}$$

where $\sum_{i=1}^{T} \rho_i = 1$.

$$\mathbb{E}^s_t R^k_{t+1} = \zeta R^s_{t+1} + (1-\zeta)\mathbb{E}_t R^k_{t+1}$$

Endogenous Confidence

Investors may be under- or over-confident of generating returns depending on the availability of internal funding (N_t).

$$R^s_{t+1} = f(N_t) R_{t+1}$$

where $f(0) = 1$, $f' > 0$, and $f'' < 0$.

$$\mathbb{E}^s_t R^k_{t+1} = \zeta R^s_{t+1} + (1 - \zeta) \mathbb{E}_t R^k_{t+1}$$

Endogenous Confidence

Example Functional Form:

$$f(N_t) = \chi \left(\frac{1}{\chi^{1+\zeta_c}} + N_t \right)^{\frac{1}{1+\zeta_c}}$$

where $\chi > 0$ and $\zeta_c > 0$.

Satisfies: $f(0) = 1$, $f' > 0$, and $f'' < 0$.

Note:

- χ is set so that $R^s = R^k$ at steady state.
- ζ_c is an estimated parameter.

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- ζ_c is an estimated parameter.

Exogenous Confidence

Investors may be subjected to a sudden wave of optimism or pessimism:

$$\mathbb{E}_t^s R_{t+1}^k = \zeta R_{t+1}^s + (1-\zeta)\mathbb{E}_t R_{t+1}^k + \varepsilon_t^s$$

where $\varepsilon_t^s \sim N(0, \sigma_s^2)$ i.i.d.

Effects of Subjective Expectations

Here, $\nu_t^s = f(\mathbb{E}_t^s R_{t+1}^k, \dots)$

Leverage ratio:

$$\phi_t^s = \frac{\eta_t}{\lambda - \nu_t^s}$$

$\implies$ ϕ_t^s depends on subjective returns expectations.

$\mathbb{E}_t^s R_{t+1}^k > \mathbb{E}_t R_{t+1}^k \implies \nu_t^s > \nu_t \implies \phi_t^s > \phi_t$

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Estimation and Results

Data

6 U.S. time series from Q1 1988 to Q4 2019:

- Gross Domestic Product
- Fixed Private Investment
- Personal Consumption Expenditures
- Inflation (GDP Deflator)
- Federal Funds Rate
- U.S. Financial Sector Net Worth

All data series are in real terms and converted to growth rates prior to estimation.

Expectations Data

AAII survey: "What Direction Do AAII Members Feel The Stock Market Will Be In The Next 6 Months?"

Greenwood and Shleifer (2014):

$$EXP_t = \%BULLISH_t - \%BEARISH_t$$

Observation Equation:

$$EXP_t = \beta_0 + \beta_1(R^s_{t+1} + R^s_{t+2}) + \varepsilon^{obs}_t$$

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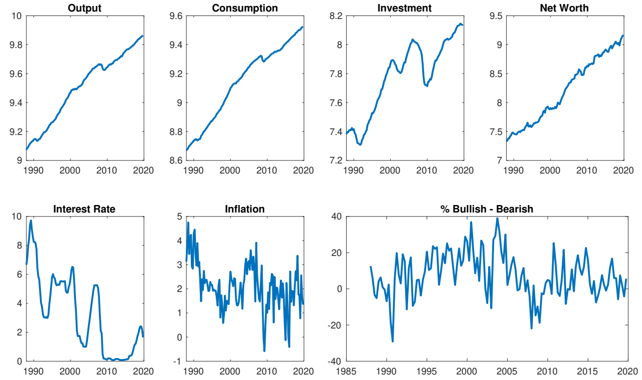
Raw Data Series



Calibrated Parameters

Parameter	Value	Details
β	0.99	Discount rate
φ	0.276	Inverse Frisch elasticity of labor supply
θ	0.972	Bankers' survival rate
α	0.33	Effective share of capital
υ	7.2	Elasticity of marginal depreciation wrt utilization rate
ε	4.167	Elasticity of goods substitution
$\bar{\delta}$	0.025	Steady state depreciation rate
$\bar{\phi}$	4	Steady state leverage ratio
$\bar{R}^k - \bar{R}$	0.0025	Steady state market premium
$\bar{L}$	1/3	Steady state labor supply
G/Y	0.2	Steady state government spending ratio

Parameters

Parameter	Description	Prior			Posterior Mean		
		Dist.	Mean	Dev.	Exo. Confidence	Anchoring ($T = 4$)	End. Confidence
h	Habit formation	Beta	0.70	0.10	0.8389	0.7915	0.8107
σ	IES	Gamma	1.50	1.00	0.5712	0.8369	0.7706
γ	Calvo factor	Beta	0.50	0.15	0.8172	0.9001	0.9009
γ_p	Price Indexation	Uniform	0.50	-	0.7720	0.0525	0.0578
η_i	Inv. Adjustment	Gamma	4.00	1.50	4.2032	0.1793	0.1765
κ_π	Taylor Rule	Normal	1.50	0.25	2.1320	1.8516	1.7866
κ_y	Taylor Rule	Normal	0.125	0.0625	0.3536	0.0547	0.0584
y^*	Trend	Normal	0.40	0.10	0.7426	0.9305	0.9360
π^*	Trend	Normal	0.60	0.10	0.5654	0.7707	0.7560
i^*	Trend	Normal	0.75	0.10	0.7043	0.7907	0.6725
β_0	Observation	Normal	0.00	0.30	0.0761	0.0747	0.0766
β_1	Observation	Normal	1.00	0.25	0.0167	0.0405	0.0393
ζ	Subjectivity	Uniform	0.50	-	-	0.1755	0.3144
ρ_1	Anchoring	Normal	0.90	0.25	-	0.6835	-
ρ_2	Anchoring	Normal	0.00	0.25	-	-0.2099	-
ρ_3	Anchoring	Normal	0.00	0.25	-	0.1219	-
ρ_4	Anchoring	-	-	-	-	0.4045	-
ζ_c	Confidence	Gamma	2.00	1.50	-	-	1.5549

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Shock Processes

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Persistence							
ρ_a	Technology	Beta	0.50	0.20	0.3929	0.5243	0.5161
ρ_g	Govt. Spending	Beta	0.50	0.20	0.9489	0.9642	0.9651
ρ_i	Monetary Policy	Beta	0.50	0.20	0.3973	0.0932	0.1105
ρ_ξ	Capital Quality	Beta	0.50	0.20	0.2643	0.0123	0.0124
ρ_s	Ex. Confidence	Beta	0.50	0.20	0.3344	-	-
Deviation							
σ_a	Technology	Inv. Gamma	0.30	1.00	0.0394	0.0513	0.0533
σ_g	Govt. Spending	Inv. Gamma	0.30	1.00	0.0419	0.0443	0.0440
σ_i	Monetary Policy	Inv. Gamma	0.30	1.00	0.0371	0.0371	0.0371
σ_ξ	Capital Quality	Inv. Gamma	0.30	1.00	0.0377	0.0387	0.0390
σ_{Ne}	Net Worth	Inv. Gamma	0.30	1.00	0.2172	0.0514	0.0516
σ_s	Ex. Confidence	Inv. Gamma	0.30	1.00	2.0011	0.9318	0.9424
σ_{obs}	Measurement Error	Inv. Gamma	0.30	1.00	0.1112	0.1199	0.1191

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Full Posterior

Shock Processes

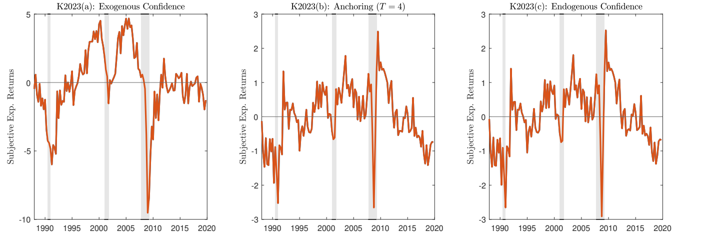
Parameter	Description	Prior			Posterior Mean		
		Dist.	Mean	Dev.	Exo. Confidence	Anchoring ($T = 4$)	End. Confidence
Persistence							
ρ_a	Technology	Beta	0.50	0.20	0.3929	0.5243	0.5161
ρ_g	Govt. Spending	Beta	0.50	0.20	0.9489	0.9642	0.9651
ρ_i	Monetary Policy	Beta	0.50	0.20	0.3973	0.0932	0.1105
ρ_ξ	Capital Quality	Beta	0.50	0.20	0.2643	0.0123	0.0124
ρ_s	Ex. Confidence	Beta	0.50	0.20	0.3344	-	-
Deviation							
σ_a	Technology	Inv. Gamma	0.30	1.00	0.0394	0.0513	0.0533
σ_g	Govt. Spending	Inv. Gamma	0.30	1.00	0.0419	0.0443	0.0440
σ_i	Monetary Policy	Inv. Gamma	0.30	1.00	0.0371	0.0371	0.0371
σ_ξ	Capital Quality	Inv. Gamma	0.30	1.00	0.0377	0.0387	0.0390
σ_{Ne}	Net Worth	Inv. Gamma	0.30	1.00	0.2172	0.0514	0.0516
σ_s	Ex. Confidence	Inv. Gamma	0.30	1.00	2.0011	0.9318	0.9424
σ_{obs}	Measurement Error	Inv. Gamma	0.30	1.00	0.1112	0.1199	0.1191

Full Posterior

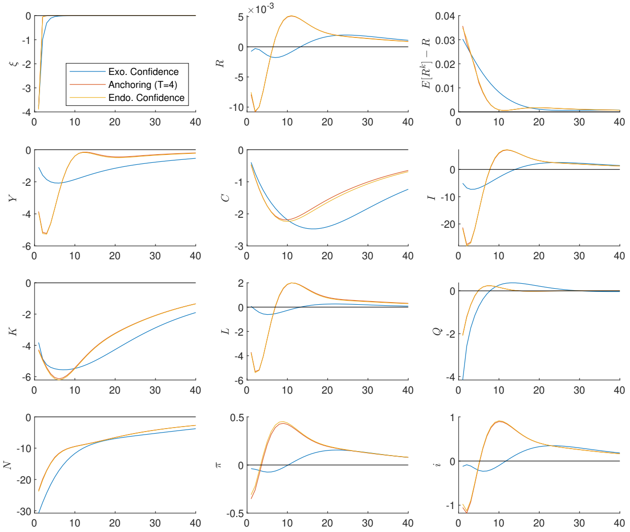
Model Comparison

	Exo. Confidence K2023(a)	Anchoring (T=4) K2023(b)	End. Confidence K2023(c)
Marginal Likelihood	-2531.47	-2426.31	-2422.43

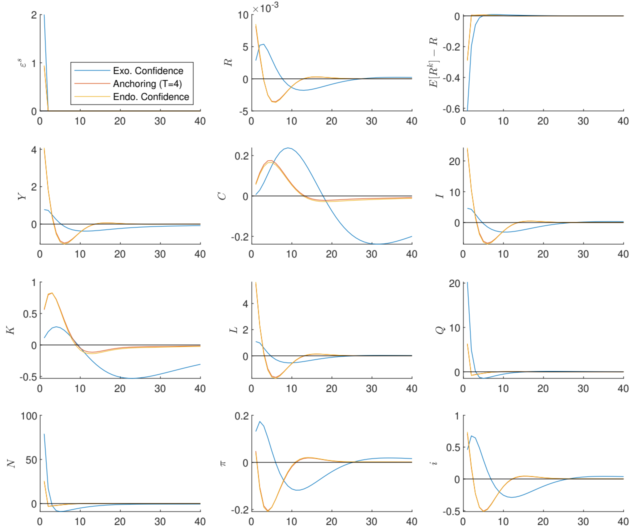
Implied $\mathbb{E}^s R^k_{t+1}$



IRFs to a Negative Capital Quality Shock



IRFs to an Overconfidence Shock



Thank you.

Questions?

Full Posterior - Parameters

		Prior			Exo. Confidence K2023(a)			Anchoring ($T=4$) K2023(b)			End. Confidence K2023(c)		
Parameter	Description	Dist.	Mean	Dev.	Mean	10%	90%	Mean	10%	90%	Mean	10%	90%
h	Habit formation	Beta	0.70	0.10	0.8389	0.8088	0.8707	0.7915	0.7636	0.8291	0.8107	0.7812	0.8401
σ	IES	Gamma	1.50	1.00	0.5712	0.3407	0.8691	0.8369	0.6978	0.9583	0.7706	0.6738	0.8748
γ	Calvo factor	Beta	0.50	0.15	0.8172	0.7992	0.8364	0.9001	0.8923	0.9080	0.9009	0.8927	0.9090
γ_p	Price Indexation	Uniform	0.50	-	0.7720	0.5250	1.0000	0.0525	0.0000	0.1113	0.0578	0.0000	0.1224
η_i	Inv. Adjustment	Gamma	4.00	1.50	4.2032	4.0251	4.5325	0.1793	0.1539	0.2041	0.1765	0.1517	0.2007
κ_π	Taylor Rule	Normal	1.50	0.25	2.1320	1.9625	2.2676	1.8516	1.6237	2.0699	1.7866	1.5986	1.9984
κ_y	Taylor Rule	Normal	0.125	0.0625	0.3536	0.2883	0.4152	0.0547	0.0466	0.0628	0.0584	0.0509	0.0657
y^*	Trend	Normal	0.40	0.10	0.7426	0.7049	0.7755	0.9305	0.8979	0.9629	0.9360	0.9021	0.9705
π^*	Trend	Normal	0.60	0.10	0.5654	0.4629	0.6800	0.7707	0.6428	0.8902	0.7560	0.6371	0.9277
i^*	Trend	Normal	0.75	0.10	0.7043	0.5973	0.8489	0.7907	0.6828	0.8956	0.6725	0.5480	0.8036
β_0	Exp. Observation	Normal	0.00	0.30	0.0761	0.0574	0.0945	0.0747	0.0573	0.0940	0.0766	0.0599	0.0942
β_1	Exp. Observation	Normal	1.00	0.25	0.0167	0.0117	0.0220	0.0405	0.0195	0.0610	0.0393	0.0211	0.0561
ζ	Subjectivity	Uniform	0.50	-	-	-	-	0.1755	0.0000	0.4226	0.3144	0.0000	0.7424
ρ_1	Anchoring	Normal	0.90	0.25	-	-	-	0.6835	0.3164	0.9908	-	-	-
ρ_2	Anchoring	Normal	0.00	0.25	-	-	-	-0.2099	-0.5414	0.1721	-	-	-
ρ_3	Anchoring	Normal	0.00	0.25	-	-	-	0.1219	-0.1108	0.3913	-	-	-
ρ_4	Anchoring	-	-	-	-	-	-	0.4045	-0.5542	1.3358	-	-	-
ζ_c	Confidence	Gamma	2.00	1.50	-	-	-	-	-	-	1.5549	0.2356	2.9252

Return

Full Posterior - Shocks

		Prior			Exo. Confidence K2023(a)			Anchoring ($T=4$) K2023(b)			End. Confidence K2023(c)		
Parameter	Description	Dist.	Mean	Dev.	Mean	10%	90%	Mean	10%	90%	Mean	10%	90%
Persistence													
ρ_a	Technology	Beta	0.50	0.20	0.3929	0.1454	0.6263	0.5243	0.4853	0.5617	0.5161	0.4726	0.5604
ρ_g	Govt. Spending	Beta	0.50	0.20	0.9489	0.9334	0.9644	0.9642	0.9528	0.9755	0.9651	0.9536	0.9767
ρ_i	Monetary Policy	Beta	0.50	0.20	0.3973	0.2254	0.5313	0.0932	0.0233	0.1577	0.1105	0.0218	0.1965
ρ_ξ	Capital Quality	Beta	0.50	0.20	0.2643	0.0766	0.4547	0.0123	0.0014	0.0227	0.0124	0.0015	0.0229
ρ_s	Ex. Confidence	Beta	0.50	0.20	0.3344	0.2639	0.3994	-	-	-	-	-	-
Deviation													
σ_a	Technology	Inv. Gamma	0.30	1.00	0.0394	0.0366	0.0425	0.0513	0.0426	0.0601	0.0533	0.0432	0.0631
σ_g	Govt. Spending	Inv. Gamma	0.30	1.00	0.0419	0.0377	0.0460	0.0443	0.0393	0.0490	0.0440	0.0392	0.0487
σ_i	Monetary Policy	Inv. Gamma	0.30	1.00	0.0371	0.0366	0.0378	0.0371	0.0366	0.0378	0.0371	0.0366	0.0378
σ_ξ	Capital Quality	Inv. Gamma	0.30	1.00	0.0377	0.0366	0.0392	0.0387	0.0366	0.0410	0.0390	0.0366	0.0415
σ_{Ne}	Net Worth	Inv. Gamma	0.30	1.00	0.2172	0.1716	0.2638	0.0514	0.0443	0.0587	0.0516	0.0442	0.0589
σ_s	Ex. Confidence	Inv. Gamma	0.30	1.00	2.0011	1.7211	2.1972	0.9318	0.8072	1.0532	0.9424	0.8179	1.0722
σ_{obs}	Measurement Error	Inv. Gamma	0.30	1.00	0.1112	0.0995	0.1225	0.1199	0.1070	0.1317	0.1191	0.1067	0.1305

Return

Banks

Evolution of net worth:

$$
\begin{aligned}
N_{j,t+1} &= R^k_{t+1} Q_t S_{j,t} - R_{t+1} B_{j,t+1} \\
&= (R^k_{t+1} - R_{t+1}) Q_t S_{j,t} + R_{t+1} N_{j,t}
\end{aligned}
$$

Bankers exit with probability $(1 - \theta)$

Banker's objective function:

$$
V_{j,t} = \max \mathbb{E}_t \sum_{i=1}^{\infty} m_{t,t+i} [(R^k_{t+i} - R_{t+i}) Q_{t+i} S_{j,t+i} + R_{t+i} N_{j,t+i-1}]
$$

$$
m_{t,t+i} = (1-\theta)\theta^{i-1}\beta^i \Lambda_{t,t+i}
$$

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$$m_{t,t+i} = (1-\theta)\theta^{i-1}\beta^i \Lambda_{t,t+i}$$

Banks

If $R^k_{t+i} > R_{t+i}$, banker wants to borrow from households and invest in stocks indefinitely.

Introduce financial friction: Banker can divert fraction λ of assets. Depositors recover fraction $(1-\lambda)$.

Incentive constraint: $V_{j,t} \geq \lambda Q_t S_{j,t}$

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Banks

Can solve for the value of the firm:

$$V_{j,t} = \nu_t Q_t S_{j,t} + \eta_t N_{j,t}$$

where ν_t and η_t are functions of parameters.

Note: ν_t depends on the rate of return the investor expects to receive R^k_{t+1}.

Incentive constraint binds at equilibrium:

$$\implies V_{j,t} = \nu_t Q_t S_{j,t} + \eta_t N_{j,t} = \lambda Q_t S_{j,t}$$

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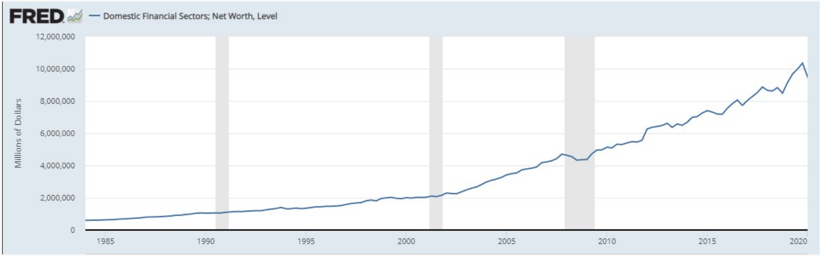
Combined Subjective Returns Assessment

$$R^s_{t+1} = \underbrace{\sum_{i=1}^{T} \rho_i R^k_{t+1-i}}_{\text{Anchoring}} + \left(1 - \sum_{i=1}^{T} \rho_i\right) \underbrace{f(N_t) R_{t+1}}_{\text{En. Confidence}}$$

$$\mathbb{E}^s_t R^k_{t+1} = \zeta R^s_{t+1} + (1-\zeta)\mathbb{E}_t R^k_{t+1} + \underbrace{\varepsilon^s_t}_{\text{Ex. Confidence}}$$

Net Worth

FRED Series: BOGZ1FL792090005Q



Conclusion

Future Work

- Model investor myopia
- Historical shock decomposition
- Forecast error variance decomposition