Hirshleifer, Li and Yu (2015, JME)

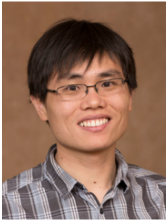
Asset pricing in production economies with extrapolative expectations

Junyong Kim

University of Wisconsin–Milwaukee

May 10, 2017

Authors



David Hirshleifer
UC Irvine

Jun Li
UT Dallas

Jianfeng Yu
Minnesota

Summary

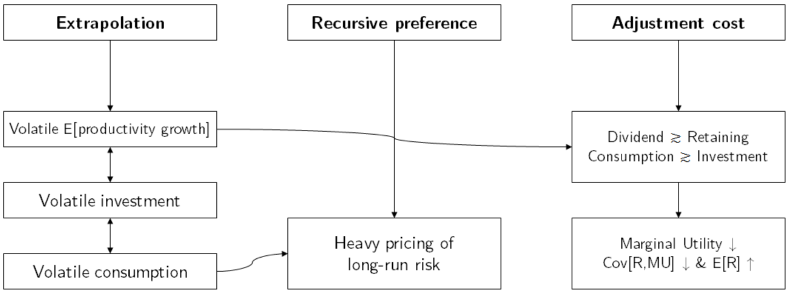
ABSTRACT

Introducing extrapolative bias into a standard production-based model with recursive preferences reconciles salient stylized facts about business cycles (low consumption volatility, high investment volatility relative to output) and financial markets (high equity premium, volatile stock returns, low and smooth risk-free rate) with plausible levels of risk aversion and intertemporal elasticity of substitution. Furthermore, the model captures return predictability based upon dividend yield, Q, and investment. Intuitively, extrapolative bias increases the variation in the wealth–consumption ratio, which is heavily priced under recursive preferences; adjustment costs decrease the covariance between marginal utility and asset returns. Empirical support for key implications of the model is also provided.

- This model includes
  1. Extrapolation bias
  2. Recursive preference (Epstein–Zin utility)
  3. Capital adjustment cost
- This model (theoretically & empirically) explains
  1. Business cycles (low consumption volatility, high investment volatility)
  2. Financial markets (equity premium puzzle, volatile r with smooth r_f)
  3. Return predictability (D/P, Q, I/K predicts r)

Trident

This paper relies on the production-based DSGE model equipped with. . .



Intros

- Extrapolative bias does exist (Hirshleifer (2001,JF), Tversky and Kahneman (1974, Science))
- And it does matter (Barberis et al. (1998,JFE) for overreaction anomalies, Fuster et al. (2010,JEP) for macroeconomic fluctuations)
- Production-based models are ill-matched to realities due to endogenous consumption & dividend smoothing (Jermann (1998,JME), Boldrin et al. (2001,AER), Barlevy (2004,AER))
- This paper introduces the "trident" and this better mimics both asset prices (r, r_f, $\ldots$) and macroeconomic quantities (c, y, i, $\ldots$)
  1. Realities are exaggerated because of extrapolation (distorted perception)
  2. Exaggerated realities are heavily priced owing to recursive preference
  3. Bypass through investment channel is unavailable due to adjustment cost
- Extrapolation has been widely adopted by previous trials
  - Barsky and de Long (1993,QJE): It makes P/D ratios more volatile
  - Bansal and Shaliastovich (2010,AER): Extrapolation in exchange economy
  - Bansal and Yaron (2004,JF): Endowment economy w/ EZ preference
  - Kaltenbrunner and Lochstoer (2010,RFS): Production economy w/o extrapolative bias (the nearest paper)

Ingredients

1. EZ utility (where $\hat{E}$ is subjective)

$$V_t = \left((1-\beta) C_t^{(1-\gamma)/\theta} + \beta \left(\hat{E}_t \left[V_{t+1}^{1-\gamma} \right]^{1/\theta} \right) \right)^{\theta/(1-\gamma)}, \quad \theta = \frac{1-\gamma}{1-1/\psi}$$

2. CRS production with convex adjustment (Jermann (1998,JME))

$$Y_t = (A_t L_t)^{1-\alpha} K_t^{\alpha}, \quad K_{t+1} = (1-\delta_K) K_t + \phi(I_t/K_t) K_t$$
$$\phi(I_t/K_t) = a_1 + \frac{a_2}{1-1/\xi} (I_t/K_t)^{1-1/\xi}, \quad \xi > 0$$

3. Real DGP vs. extrapolative bias

$$\begin{aligned} g_{A,t} = \Delta \ln A_t &= \mu_A + \sigma_A \varepsilon_{A,t}, \quad \text{DGP} \\ &= \hat{\mu}_t + \sigma_A \hat{\varepsilon}_{A,t}, \quad \text{perception} \\ \hat{\mu}_t &= (1-\rho-\tilde{\rho}) \bar{\mu} + \rho \hat{\mu}_{t-1} + \tilde{\rho} g_{A,t}, \quad \text{extrapolation} \\ \tilde{\rho} &= 1-\rho, \quad \text{Degree of extrapolation} \end{aligned}$$

Several solutions

- Perceived productivity growth

$$\begin{aligned}\hat{\mu}_t &= (1-\rho-\tilde{\rho})\,\mu_A + \rho\hat{\mu}_{t-1} + \tilde{\rho} g_{A,t}, \quad \text{objective} \\ &= (1-\rho-\tilde{\rho})\,\mu_A + (\rho+\tilde{\rho})\,\hat{\mu}_{t-1} + \tilde{\rho}\sigma_A\hat{\varepsilon}_{A,t}, \quad \text{subjective}\end{aligned}$$

- Log wealth-consumption ratio

$$wc_t = \log\left(W_t/C_t\right) = \log\left(\frac{1}{1-\beta}\right) + (1-1/\psi)\log\left(V_t/C_t\right)$$

- Return on investment (Cochrane (1991,JF))

$$R_{I,t} = \phi'\left(I_{t-1}/K_{t-1}\right)\left(\alpha\left(A_t/K_t\right)^{1-\alpha} + \frac{1-\delta_K+\phi\left(I_t/K_t\right)}{\phi'\left(I_t/K_t\right)} - I_t/K_t\right)$$

- Risk-free rate (Epstein and Zin (1989,EMA))

$$r_{f,t} = -\log\left(\hat{E}_t\left[\beta\left(\frac{C_{t+1}}{C_t}\right)^{\frac{1}{\phi}}\left(\frac{V_{t+1}\left(K_{t+1},\hat{\mu}_{t+1},A_{t+1}\right)}{\hat{E}_t\left[V_{t+1}^{1-\gamma}\left(K_{t+1},\hat{\mu}_{t+1},\hat{A}_{t+1}\right)\right]^{\frac{1}{1-\gamma}}}\right)\right]^{\frac{1}{\psi}-\gamma}\right)$$

Core idea

The pricing kernel is

$$m_t \approx \hat{E}_{t-1}[m_t] - \underbrace{\gamma \hat{\varepsilon}_{c,t}}_{\text{short-run risk}} - \underbrace{\frac{\gamma - 1/\psi}{1 - 1/\psi} \hat{\varepsilon}_{wc,t}}_{\text{long-run risk}}$$

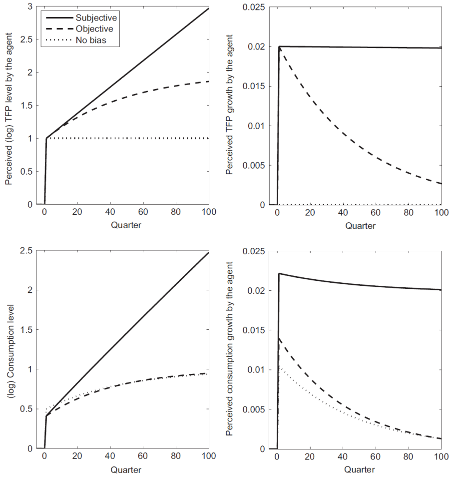
where $\hat{\varepsilon}_{c,t}$ is the short-run consumption growth shock, and $\hat{\varepsilon}_{wc,t}$ is the log wealth-consumption ratio shock, i.e.

$$\hat{\varepsilon}_{wc,t} \approx \Delta E_t \left[\sum_{j=1}^{\infty} \kappa_1^j (1 - 1/\psi) \Delta c_{t+j} \right]$$

where $\kappa_1 = \frac{W/C-1}{W/C}$ and W/C is the unconditional mean of wealth-consumption ratio. Since the kernel reflects the long-run risk, one can make the kernel more volatile by making (perceived) consumption growth more volatile.

Impulse response function

Figure 1: TFP level (upper-left), TFP growth (upper-right), consumption level (lower-left), consumption growth (lower-right)



Shocks will have a long-lasting impact (if consumers are extrapolative)

Calibration

Table 1: Extrapolation (ρ) 0.98, risk aversion (γ) 4.00, IES (ψ) 2.00, capital adjustment cost (ξ) 1.50 and subjective discount factor (β) 0.991

Statistics	Variable	B.I
Fixed parameter:		
Mean technology growth (%)	μ_A	0.4
Volatility of the innovation in technology growth (%)	σ_A	4.11
Share of capital	α	0.36
Depreciation (%)	δ_K	0.021
Leverage	B/E	2/3
Varying parameter:		
Extrapolation parameter	ρ	0.98
Risk aversion	γ	4.00
IES	ψ	2.00
Capital adjustment cost	ξ	1.50
Subjective discount factor	β	0.991

All parameters for simulations are chosen reasonably based on previous papers.

- $\gamma = 4$: Mehra and Prescott (1985,JME)
- $\psi = 2$: Ai (2010,JF), Croce (2014,JME)
- $\rho = 0.98$: Malmendier and Nagel (2016,QJE)
- $\xi = 1.50$: Kaltenbrunner and Lochstoer (2010,RFS)

Key table

Table 2: Data versus simulated results (400 quarters×1,000 times)

Parameter	Data	B.I	II	III	IV	V	VI
Risk aversion (γ)	NA	4.00	2.00	4.00	4.00	4.00	4.00
IES (ψ)	NA	2.00	2.00	2.00	2.00	2.00	2.00
Time discount (β)	NA	0.991	0.991	0.9945	0.9945	0.991	0.993
Adjustment cost (ξ)	NA	1.50	1.50	10.00	1.50	15.00	0.85
Extrapolation (ρ)	NA	0.98	0.95	1.00	1.00	0.98	0.95
TFP volatility (σ_A) (%)	NA	4.11	4.11	4.11	4.11	4.11	1.93
$\sigma(\Delta c_t)$	2.93	3.80	2.43	2.42	4.57	1.43	1.46
$\sigma(\Delta c_t)/\sigma(\Delta y_t)$	0.52	0.72	0.46	0.46	0.87	0.27	0.59
$\sigma(\Delta i_t)/\sigma(\Delta y_t)$	3.32	1.72	2.41	2.18	1.29	2.79	2.04
Adj. cost/output (%)	NA	0.37	0.48	0.08	0.30	0.07	0.14
$E(R_{f,t})$	0.86	1.29	0.87	2.22	1.89	2.26	1.17
$\sigma(R_{f,t})$	0.97	0.28	0.31	0.36	0.16	0.41	0.16
$E(R_{E,t} - R_{f,t})$	6.33	5.75	6.12	0.60	2.20	0.94	5.30
$\sigma(R_{E,t} - R_{f,t})$	19.42	10.42	14.55	2.15	7.81	1.89	10.14
Sharpe ratio	0.33	0.55	0.42	0.28	0.28	0.50	0.52

- Data column: The data are from 1929 to 1998. $\sigma(\Delta c_t)$ is about a half of $\sigma(\Delta y_t)$ and $\sigma(\Delta i_t)$ is about three times more volatile than $\sigma(\Delta y_t)$. Also $E\left[R_{E,t} - R_{f,t}\right]$ and $\sigma\left[R_{E,t} - R_{f,t}\right]$ are about to 6% and 19% (0.52, 3.32, 6.33, 19.42)
- B.I column: Baseline simulation with 2% extrapolation. Overall tendencies are matching with Data column (0.72, 1.72, 5.75, 10.42)
- II column: Simulation with 5% extrapolation. Mimicking performance is improved (0.46, 2.41, 6.12, 14.55)

Key table (continued)

Table 2: Data versus simulated results (400 quarters×1,000 times) (continued)

Parameter	Data	B.I	II	III	IV	V	VI
Risk aversion (γ)	NA	4.00	2.00	4.00	4.00	4.00	4.00
IES (ψ)	NA	2.00	2.00	2.00	2.00	2.00	2.00
Time discount (β)	NA	0.991	0.991	0.9945	0.9945	0.991	0.993
Adjustment cost (ξ)	NA	1.50	1.50	10.00	1.50	15.00	0.85
Extrapolation (ρ)	NA	0.98	0.95	1.00	1.00	0.98	0.95
TFP volatility (σ_A) (%)	NA	4.11	4.11	4.11	4.11	4.11	1.93
$\sigma(\Delta c_t)$	2.93	3.80	2.43	2.42	4.57	1.43	1.46
$\sigma(\Delta c_t)/\sigma(\Delta y_t)$	0.52	0.72	0.46	0.46	0.87	0.27	0.59
$\sigma(\Delta i_t)/\sigma(\Delta y_t)$	3.32	1.72	2.41	2.18	1.29	2.79	2.04
Adj. cost/output (%)	NA	0.37	0.48	0.08	0.30	0.07	0.14
$E(R_{f,t})$	0.86	1.29	0.87	2.22	1.89	2.26	1.17
$\sigma(R_{f,t})$	0.97	0.28	0.31	0.36	0.16	0.41	0.16
$E(R_{E,t} - R_{f,t})$	6.33	5.75	6.12	0.60	2.20	0.94	5.30
$\sigma(R_{E,t} - R_{f,t})$	19.42	10.42	14.55	2.15	7.81	1.89	10.14
Sharpe ratio	0.33	0.55	0.42	0.28	0.28	0.50	0.52

- III column: No extrapolation and cheap adjustment costs. Excess returns are too poor and smooth ($\sigma_{\Delta c}/\sigma_{\Delta y} = 0.46$, $\sigma_{\Delta i}/\sigma_{\Delta y} = 2.18$, $E = 0.60$, $\sigma = 2.15$)
- IV column: No extrapolation but reasonable adjustment costs. Consumptions are too volatile and investments are too smooth ($\sigma_{\Delta c}/\sigma_{\Delta y} = 0.87$, $\sigma_{\Delta i}/\sigma_{\Delta y} = 1.29$, $E = 2.20$, $\sigma = 7.81$)
- V column: Extrapolation but cheap adjustment costs. Consumptions are too smooth and investments are too volatile ($\sigma_{\Delta c}/\sigma_{\Delta y} = 0.27$, $\sigma_{\Delta i}/\sigma_{\Delta y} = 2.79$, $E = 0.94$, $\sigma = 1.89$)
- VI column: Simulations that match with post-WWII data. Both $\sigma_{\Delta c}$ and $\sigma_{\Delta y}$ are lower, but the equity premium is still sizeable

Return predictability

Table 3: Simulation results and predictive regressions

Statistics	Horizon	DP		IK		Q	
		50%	data	50%	data	50%	data
Panel A: benchmark calibration I: $\rho = 0.98$							
Coef	1	5.95	13.06	−2.63	−4.12	−0.10	−0.04
	3	16.35	32.67	−7.22	−7.99	−0.27	−0.11
	5	25.33	50.28	−11.11	−8.06	−0.42	−0.15
R^2	1	3.99	5.48	3.77	1.33	3.74	2.58
	3	11.21	13.51	10.22	3.66	10.35	9.68
	5	17.64	23.49	16.21	2.20	16.32	13.68
Panel B: calibration II: $\rho = 0: 95$							
Coef	1	7.49	13.06	−4.59	−4.12	−0.18	−0.04
	3	18.42	32.67	−11.30	−7.99	−0.43	−0.11
	5	25.79	50.28	−15.80	−8.06	−0.61	−0.15
R^2	1	8.28	5.48	8.32	1.33	8.39	2.58
	3	20.13	13.51	20.54	3.66	20.58	9.68
	5	28.35	23.49	28.98	2.20	29.05	13.68
Panel C: calibration III: $\rho = 1$							
Coef	1	0.35	13.06	−0.18	−4.12	−0.04	−0.04
	3	0.99	32.67	−0.49	−7.99	−0.13	−0.11
	5	1.58	50.28	−0.79	−8.06	−0.20	−0.15
R^2	1	0.62	5.48	0.62	1.33	0.67	2.58
	3	1.93	13.51	1.92	3.66	1.95	9.68
	5	3.07	23.49	3.09	2.20	3.07	13.68

- Signs of regression coefficients ($DP > 0$, $IK < 0$, $q < 0$) are matching
- Predictive horizon$\uparrow$ $\Rightarrow$ Predictability$\uparrow$
- Extrapolation$\uparrow$ $\Rightarrow$ Predictability$\uparrow$
- Extrapolation$\rightarrow 0$ $\Rightarrow$ Predictability$\rightarrow 0$

Are consumptions autocorrelated?

Table 4: Autocorrelations from data and simulations

Horizon	Data	Calibration			
		I	II	III	IV
1	0.26	0.04	0.18	0.14	0.02
4	0.15	0.03	0.16	0.13	0.01
8	−0.03	0.03	0.13	0.11	0.01
12	0.03	0.02	0.10	0.09	0.01
16	0.07	0.02	0.08	0.08	0.01
20	−0.04	0.02	0.06	0.06	0.01

- Consumption predictability$\uparrow$ $\Rightarrow$ Consumption volatility$\uparrow$
- Adjustment cost$\uparrow$ $\Rightarrow$ Consumption predictability$\downarrow$
- First order autocorrelation from data=0.26
- First order autocorrelation from simulations=0.04 (I) or 0.18 (II)
- High equity premium is not due to autocorrelated consumptions

Expectations versus reversal

Table 5: Predictability of return, GDP growth and TFP growth

Panel A: return predictability by $\hat{\mu}$ calculated from GDP growth and TFP growth

Horizon	$\hat{\mu}(GDP)$	t_{NW}	t_{HD}	R^2	$\hat{\mu}(TFP)$	t_{NW}	t_{HD}	R^2
1-year	−23.08	−1.71	−1.64	0.04	−13.84	−1.38	−1.23	0.02
2-year	−38.45	−1.91	−1.42	0.06	−18.69	−1.26	−0.89	0.02
3-year	−67.70	−3.35	−1.83	0.16	−31.77	−1.91	−1.04	0.05
4-year	−92.32	−4.46	−1.98	0.26	−46.13	−2.21	−1.15	0.08
5-year	−111.68	−4.52	−1.98	0.31	−61.07	−2.39	−1.20	0.12

Panel B: GDP growth and TFP growth predictability by calculated from GDP growth $\hat{\mu}$

Horizon	GDP growth				TFP growth			
	$\hat{\mu}(GDP)$	t_{NW}	t_{HD}	R^2	$\hat{\mu}(GDP)$	t_{NW}	t_{HD}	R^2
1-year	−0.61	−0.25	−0.36	0.00	−4.09	−2.35	−2.37	0.09
2-year	−4.18	−1.02	−1.31	0.03	−5.94	−2.29	−1.90	0.10
3-year	−6.77	−1.39	−1.60	0.06	−6.83	−2.55	−1.59	0.09
4-year	−8.80	−1.69	−1.72	0.08	−6.75	−2.30	−1.29	0.07
5-year	−9.17	−1.90	−1.55	0.08	−6.02	−2.00	−0.97	0.05

- $\hat{\mu}$ is the byproduct (state variable) of extrapolation
- Because of its reverting characteristic, $\hat{\mu}$ will negatively predict both (i) its subsequent values and (ii) future stock returns
- Extrapolative GDP growth and TFP growth are calculated using EWMA and target variables are regressed on these variables
- By and large, the result is matching with the prior expectation

Misperception and objective components

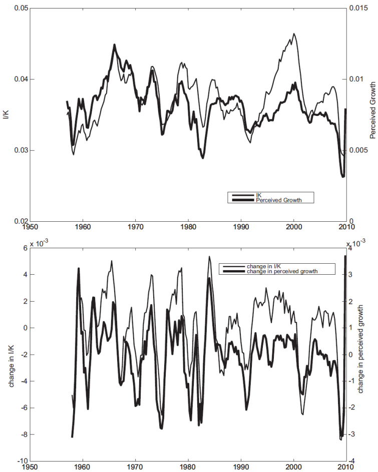
Table 6: Returns are regressed on both error and objective terms

Horizon	β_1	t_{NW}	t_{HD}	β_2	t_{NW}	t_{HD}	R^2
Panel A: empirical data							
1-year	−6.97	−2.84	−2.44	−1.56	−0.50	−0.26	0.07
2-year	−12.52	−2.69	−2.64	−6.83	−1.26	−0.73	0.12
3-year	−14.30	−2.62	−2.23	−6.94	−0.98	−0.61	0.13
4-year	−12.59	−2.74	−1.63	−4.62	−0.92	−0.35	0.09
5-year	−13.16	−2.27	−1.55	−5.94	−1.02	−0.41	0.08
Panel B: simulated data							
1-year	−4.38	−3.81	−2.86	−2.31	−1.38	−1.13	0.09
2-year	−7.68	−4.65	−2.67	−5.08	−2.20	−1.44	0.16
3-year	−10.32	−5.46	−2.52	−7.42	−2.81	−1.51	0.22
4-year	−12.43	−6.15	−2.39	−9.31	−3.29	−1.52	0.26
5-year	−14.10	−6.71	−2.27	−10.93	−3.73	−1.51	0.30

- The error term is $g_{forecasted} - g_{expected}$ and the objective term is $g_{expected}$
- Only coefficients with error terms are significant

Subjective perception and investment tendency

Figure 2: Comovement of I/K and $\hat{\mu}$. The comparison of two level variables (upper) and two flow variables (lower, change from year ago)



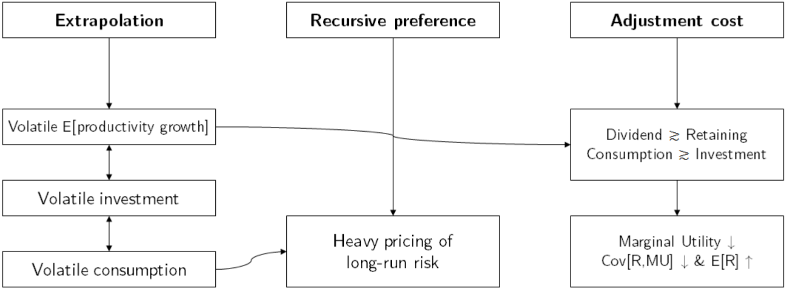
Investment predictability

Table 7: Regress investment rate on cash flow and perceived growth

	I	II	III	IV
$\hat{\mu}_A$ from GDP		1.81 (9.65)	1.86 (10.34)	
$\hat{\mu}_A$ from TFP				1.48 (5.00)
Cash flow	0.17 (6.43)	0.01 (0.50)		
R-sqr	0.30	0.66	0.66	0.29

- Empirical researches have shown that cash flow predicts investment rate
- Figure 2 exhibits the positive relation between I/K and $\hat{\mu}$ at a glance
- Before controlling anything, cash flow predicts investment rate significantly. However, the significance is disappeared when one includes $\hat{\mu}(GDP)$ or $\hat{\mu}(TFP)$ together
- Overall simulation results are consistent with many testable implications suggested by previous papers

Conclusion



- In the production-based economy, by intertwining (i) individual extrapolation, (ii) EZ preference and (iii) convex capital adjustment cost, one can better explain both macroeconomic quantities and asset prices
- Because there is only one shock (TFP) in this economy, there is a difficulty in matching the moments for the firm's payout claim and the aggregate consumption claim; one may be able to address this issue by introducing other productive sectors, sticky wages or equity market dividends