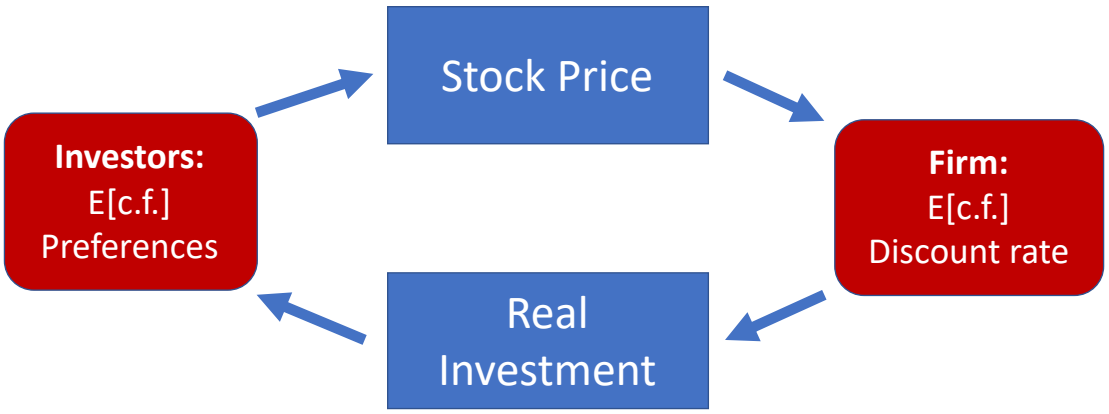
Investor expectations, asset prices, and corporate policies

Stefan Nagel

December 2019

Asset prices, firm investment, and beliefs



Can empirical relations between investment – cash flows – asset prices tell us about

- Beliefs of investors?
- Beliefs of firm managers?

Claims about what one can infer from empirical investment – cash flows – asset price relations

Investment policies aligned with cost of capital
⇒ Rational managers?
⇒ Rational investors?

> *... the body of evidence [...] suggests that managers of individual firms do a good job in aligning investment policies with their costs of capital [...]. If investors are psychologically biased, why would managers be less biased? (Zhang 2017)*

> *If people are rational at work, why irrational at home? (Cochrane 2004)*

Beliefs of relevant actors

- Important to keep distinct
  - Subjective beliefs of investors, $\tilde{\mathbb{E}}_{inv}[.]$
  - Subjective beliefs of firm managers, $\tilde{\mathbb{E}}_{firm}[.]$
  - Objective beliefs of econometrician studying data ex post, $\mathbb{E}[.]$
- Econometrician's beliefs are objective because they reflect data-generating process; e.g.,

$$\frac{1}{T}\sum_{t=1}^{T} x_t \approx \mathbb{E}[x_t]$$

- Rational expectations models assume economic actors
  - are rational
  - know the data-generating process (model, parameters)

⇒ $\tilde{\mathbb{E}}_{inv}[.] = \tilde{\mathbb{E}}_{firm}[.] = \mathbb{E}[.]$

Outline

1. Basic q-theory framework under rational expectations (RE)

Firm investment decisions: Two-period q-theory

- Investment of I_0 raises capital to $K_1 = K_0 + I_0$ and yields payoff
$$D = \Pi K_1$$
subject to stochastic shock Π. Paid out as dividend at $t = 1$.

- Quadratic investment cost: (negative) payout at $t = 0$
$$I_0 - \frac{\alpha}{2} I_0^2$$

- Investor valuation at $t = 0$, given investment decision of the firm
$$P_0 = \mathbb{E}[MD], \quad \text{or} \quad \frac{P_0}{K_1} = \mathbb{E}[M\Pi]$$
where M is investors' stochastic discount factor (SDF).

CAPM special case

- All arguments below go through with general SDF, but for simplicity let's specialize to CAPM

- With log-normal payoffs (see, e.g., Korteweg and Nagel 2019)
$$\mathbb{E}[MD] \approx \frac{\mathbb{E}[D]}{R_f + \beta\, \mathbb{E}[R_m - R_f]}$$

- Let
$$Y = R_f + \beta(\mathbb{E}[R_m - R_f])$$

- Investor valuation at $t = 0$, given investment decision of the firm:
$$\frac{P_0}{K_1} = \frac{\mathbb{E}[\Pi]}{Y}$$

Firm investment decisions in CAPM special case

- Firm objective

$$\max V_0(I_0) = -I_0 - \frac{\alpha}{2} I_0^2 + \frac{\mathbb{E}[\Pi K_1]}{Y} \qquad \text{s.t.} \quad K_1 = K_0 + I_0$$

  yields first-order condition (FOC)

$$\boxed{1 + \alpha I_0 = \frac{\mathbb{E}[\Pi]}{Y}}$$

- Post-investment valuation received by the firm

$$\frac{P_0}{K_1} = \frac{\mathbb{E}[\Pi]}{Y} = 1 + \alpha I_0$$

- Stock return

$$R \equiv \frac{\Pi}{P_0/K_1} = \frac{\Pi}{1 + \alpha I_0}$$

Expected stock returns: Investment "CAPM"

- Econometrician will find, in expectation

$$\mathbb{E}[R] = \frac{\mathbb{E}[\Pi]}{1 + \alpha I_0}$$

  i.e., everything else equal,
  - positive relation to profitability
  - negative relation to investment

- Empirically, relation can also be captured by factor models: investment "CAPM" (Hou, Xue, Zhang 2015)

$$\begin{aligned}\mathbb{E}[R] - R_f = &\beta\, \mathbb{E}[R_m - R_f] + \beta_{mcap}\, \mathbb{E}[R_{mcap} - R_f] \\ &+ \beta_{inv}\, \mathbb{E}[R_{inv} - R_f] + \beta_{roe}\, \mathbb{E}[R_{roe} - R_f]\end{aligned}$$

  where
  - Investment factor = high - low investment/assets
  - Profitability factor = high - low ROE

Interpretation: q-theory relations and beliefs

- Investment "CAPM" = "rational efficient markets explanation" for cross-sectional differences in expected returns?

  > *... behavioural finance relies on dysfunctional, inefficient markets for its mechanisms to work, but the investment CAPM relies on well functioning, efficient markets. (Zhang 2017)*

- No! As I will discuss now, investment "CAPM" relationships do not rely on rational investors, efficient markets

2. q-theory with subjective beliefs

q-theory with subjective beliefs

- Now we allow for $\tilde{\mathbb{E}}_{inv}[.] \neq \mathbb{E}[.]$ and/or $\tilde{\mathbb{E}}_{firm}[.] \neq \mathbb{E}[.]$
- Assumption (to focus on cross-sectional aspects): for aggregate variables like R_m expectations are RE
- Important if $\tilde{\mathbb{E}}_{inv}[.] \neq \tilde{\mathbb{E}}_{firm}[.]$: what do managers maximize, current stock price or long-run value?
- Various pieces of my discussion appear in Stein (1996), Gennaioli, Ma, Shleifer (2016), van Binsbergen and Opp (2019).

1. Homogeneous non-RE subjective beliefs of investors and managers

- Let $\tilde{\mathbb{E}}_{inv}[.] = \tilde{\mathbb{E}}_{firm}[.] = \tilde{\mathbb{E}}[.]$, but $\tilde{\mathbb{E}}[.] \neq \mathbb{E}[.]$.
- Investor valuation under subjective beliefs with CAPM

$$\frac{P_0}{K_1} = \frac{\tilde{\mathbb{E}}[\Pi]}{\tilde{Y}} \qquad \text{where} \quad \tilde{Y} = R_f + \beta(\mathbb{E}[R_m - R_f])$$

- Managers and investors agree on $\tilde{\mathbb{E}}[\Pi]$ and hence also on discount rate $\tilde{Y}$

1. Homogeneous non-RE subjective beliefs of investors and managers

- Firm FOC for investment

$$\boxed{1 + \alpha I_0 = \frac{\tilde{\mathbb{E}}[\Pi]}{\tilde{Y}}}$$

- Post-investment valuation received by the firm

$$\frac{P_0}{K_1} = \frac{\tilde{\mathbb{E}}[\Pi]}{\tilde{Y}} = 1 + \alpha I_0$$

- And so again

$$R = \frac{\Pi}{1 + \alpha I_0} \quad \text{and} \quad \mathbb{E}[R] = \frac{\mathbb{E}[\Pi]}{1 + \alpha I_0}$$

  i.e., econometrician finds that investment "CAPM" holds

2. Heterogeneous subjective beliefs of investors and managers

- Now $\tilde{\mathbb{E}}_{inv}[.] \neq \tilde{\mathbb{E}}_{firm}[.]$.
  - Special case included: RE managers $\tilde{\mathbb{E}}_{firm}[.] = \mathbb{E}[.]$
- Investor valuation

$$\frac{P_0}{K_1} = \frac{\tilde{\mathbb{E}}_{inv}\Pi}{\tilde{Y}_{inv}}, \qquad \tilde{Y}_{inv} = R_f + \beta(\mathbb{E}[R_m - R_f])$$

- Assumption: Managers maximize current stock price

2. Heterogeneous subjective beliefs of investors and managers

- To max. current stock price, managers extract discount rate that explains stock valuation under their beliefs

$$\frac{P_0}{K_1} = \frac{\tilde{\mathbb{E}}_{firm}[\Pi]}{\tilde{Y}_{firm}}, \qquad \tilde{Y}_{firm} = R_f + \beta(\mathbb{E}[R_m - R_f]) + \beta_G\, \mathbb{E}[G]$$

  that differs from CAPM discount rate used by investors under their subjective beliefs

- Example: Rational mangers ($\tilde{\mathbb{E}}_{firm}[.] = \mathbb{E}[.]$) interpret low return of high market-to-book stocks as low discount rate

2. Heterogeneous subjective beliefs of investors and managers

- Firm FOC for investment: To max. current stock price firm chooses

$$\boxed{1 + \alpha I_0 = \frac{\tilde{\mathbb{E}}_{firm}[\Pi]}{\tilde{Y}_{firm}}}$$

- Post-investment valuation received by the firm

$$\frac{P_0}{K_1} = \frac{\tilde{\mathbb{E}}_{inv}[\Pi]}{\tilde{Y}_{inv}} = \frac{\tilde{\mathbb{E}}_{firm}[\Pi]}{\tilde{Y}_{firm}} = 1 + \alpha I_0$$

- And so again

$$R = \frac{\Pi}{1 + \alpha I_0} \qquad \text{and} \quad \mathbb{E}[R] = \frac{\mathbb{E}[\Pi]}{1 + \alpha I_0}$$

  i.e., econometrician finds that investment "CAPM" holds

3. Non-RE investors and RE managers maximizing long-run value

- Now: Rational managers ignore investor misvaluation
- Therefore: FOC under rational cash flow expectations and discounting using investors' subjective SDF

$$\boxed{1 + \alpha I_0 = \frac{\mathbb{E}[\Pi]}{\tilde{Y}}}$$

- Post-investment valuation received by the firm

$$\frac{P_0}{K_1} = \frac{\tilde{\mathbb{E}}_{inv}[\Pi]}{\tilde{Y}_{inv}} \neq \frac{\mathbb{E}[\Pi]}{\tilde{Y}} = 1 + \alpha I_0$$

- Therefore, investment "CAPM" does not hold:

$$\mathbb{E}[R] \neq \frac{\mathbb{E}[\Pi]}{1 + \alpha I_0}$$

Beliefs, investment, asset prices: Summary

Investor beliefs	Manager beliefs	Manager objective	Inv. "CAPM"?	Market efficient?	Inv. efficient?*
$\tilde{\mathbb{E}}_{inv}[.] = \tilde{\mathbb{E}}_{firm}[.] = \mathbb{E}[.]$		SR = LR	✓	✓	✓
$\tilde{\mathbb{E}}_{inv}[.] = \tilde{\mathbb{E}}_{firm}[.] \neq \mathbb{E}[.]$		SR = LR	✓	✗	✗
$\tilde{\mathbb{E}}_{inv}[.] \neq \tilde{\mathbb{E}}_{firm}[.]$		SR	✓	✗	✗
$\tilde{\mathbb{E}}_{inv}[.] \neq \tilde{\mathbb{E}}_{firm}[.] = \mathbb{E}[.]$		SR	✓	✗	✗
$\tilde{\mathbb{E}}_{inv}[.] \neq \tilde{\mathbb{E}}_{firm}[.]$		LR	✗	✗	✗
$\tilde{\mathbb{E}}_{inv}[.] \neq \tilde{\mathbb{E}}_{firm}[.] = \mathbb{E}[.]$		LR	✗	✗	✓

* in the sense of max. long-run objective firm owner welfare.

Beliefs, investment, asset prices: Summary

- Bottom line: Empirical investment "CAPM" and investment-q relation
  - says nothing about investor belief rationality, market efficiency, relevance of behavioral finance
  - says nothing about managerial beliefs: does not imply managers are rational
- But different theories of beliefs imply very different conclusions regarding
  - efficiency of real investment
  - asset market efficiency
- How do disentangle? Empirical study of beliefs!

3. Empirical research on beliefs and investment

Example: Aggregate investment and expectations

- Suppose
  - Homogeneous non-RE beliefs $\tilde{\mathbb{E}}_{inv}[.] = \tilde{\mathbb{E}}_{firm}[.]$
  - Investors demand $R_f +$ risk premium $=$ constant $\tilde{Y}_{inv}$
- Predictions
  1. Asset price variation driven by subjective beliefs $\tilde{\mathbb{E}}_{inv}[\Pi]$
  2. Firm applies constant discount rate $\tilde{Y}_{inv}$
  3. Investment driven by beliefs:

$$I_0 = \frac{1}{\alpha}\left(\frac{\tilde{\mathbb{E}}_{inv}[\Pi]}{\tilde{Y}_{inv}} - 1\right)$$

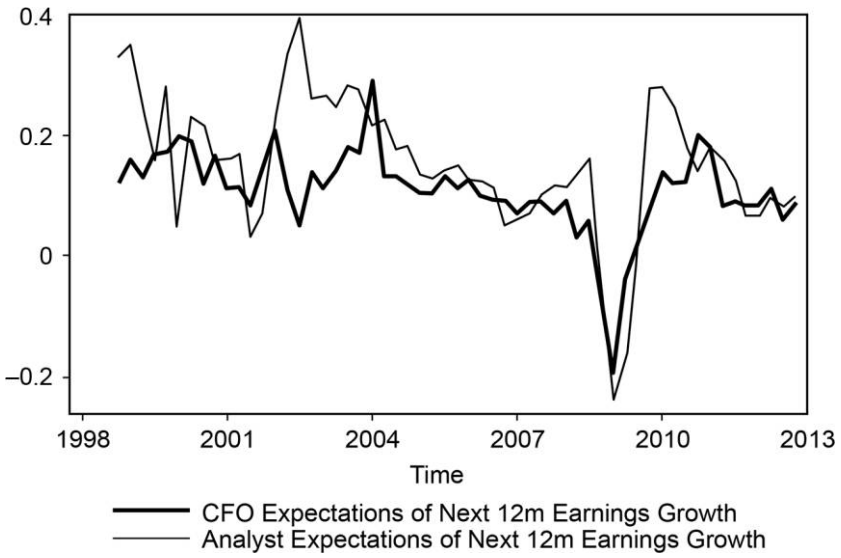
  4. Investment (plans) should predict forecast errors:

$$\Pi - \tilde{\mathbb{E}}_{inv} = -(1 + \alpha I_0)\tilde{Y}_{inv} + E[\Pi] + \varepsilon$$

Example: Aggregate investment and expectations

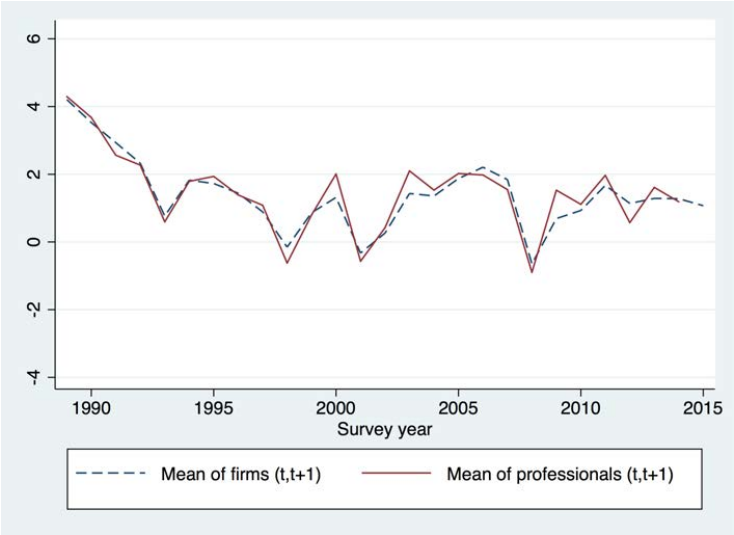
- Unlike investment "CAPM" relations, these predictions do not apply to RE model
- I will now show some suggestive pieces of evidence on a few of these assumptions and predictions
  1. Homogeneity of beliefs of firms and investors (proxied by analysts, professional forecasters)
  2. Stability of cost of capital used in firm investment decisions
  3. Investment driven by beliefs
  4. Investment plans predict forecast errors
- Room for a lot more research on these questions, also in cross-section, not just aggregate

CFO and analyst expectations of near-term earnings growth



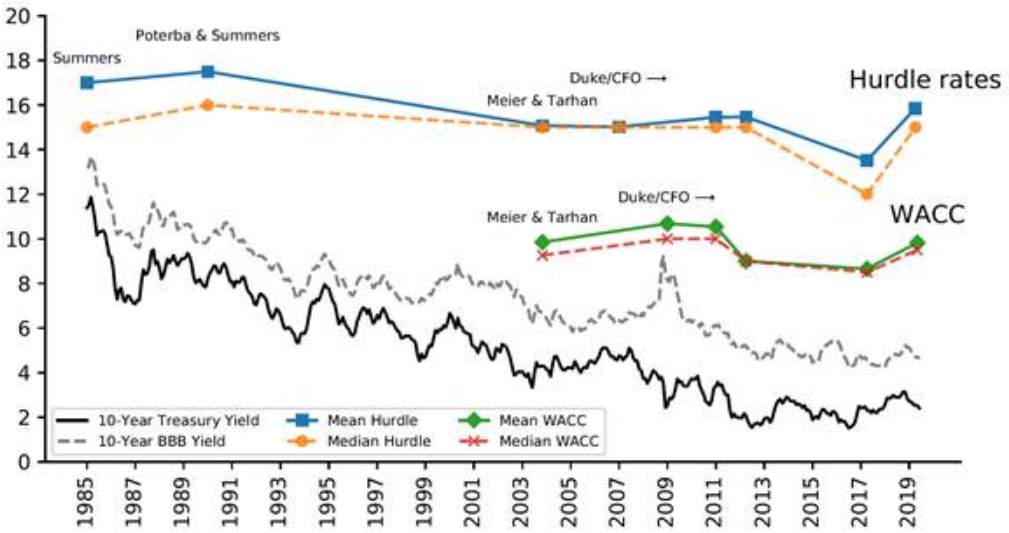
Source: Gennaioli, Ma, Shleifer (2016)

Professional Forecasters and firm expectations of GDP growth (Japan)



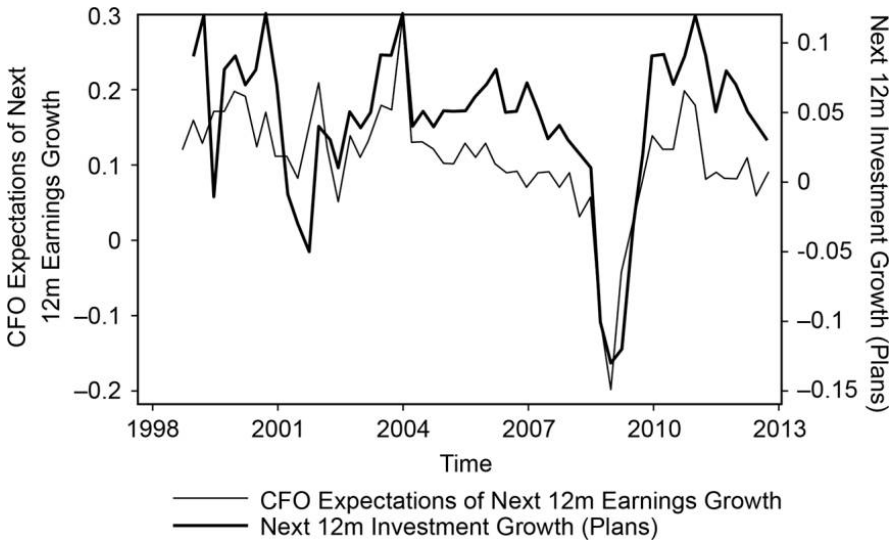
Source: Tanaka, Bloom, David, and Koga (2019)

Stability of firms' cost of capital estimates in investment decisions



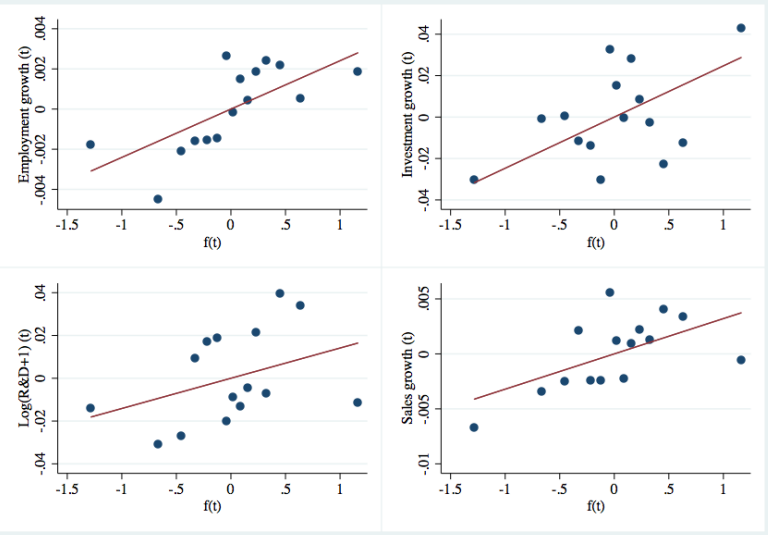
Source: John Graham

CFO earnings growth expectations and investment plans



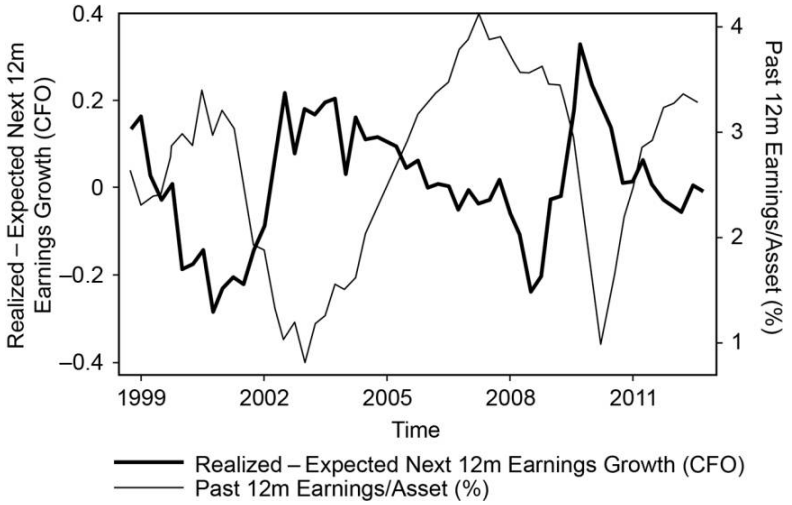
Source: Gennaioli, Ma, Shleifer (2016)

Firm GDP expectations, investment, and future growth (Japan)



$f(t)$ = Individual firm GDP forecasts, binned
Source: Tanaka, Bloom, David, and Koga (2019)

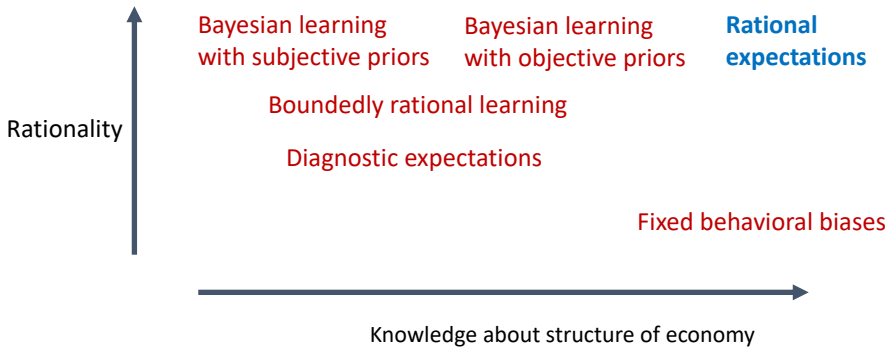
CFO earnings growth forecast errors



Source: Gennaioli, Ma, Shleifer (2016)

Interpretation of subjective beliefs evidence

- In-sample forecast error predictability $\Rightarrow$ non-RE beliefs
- But: non-RE subjective beliefs $\neq$ irrational



4. Subjective beliefs in learning models

Bayesian learning example

- Suppose managers know that productivity of firm i follows

$$z_{i,t+1} = \mu_i + \xi_{i,t+1}, \qquad \xi_{i,t+1} \sim IID$$

- Bayesian learning, with diffuse prior:

$$\tilde{\mathbb{E}}_t[z_{i,t+1}] = \frac{1}{t}\sum_{s=1}^{t} z_{i,s}$$

  - For comparison: RE would imply $\tilde{\mathbb{E}}_t[z_{i,t+1}] = \mathbb{E}_t[z_{i,t+1}] = \mu_i$

- Econometrician studying forecasts ex post will find
  - Beliefs more volatile than under RE
  - Forecast errors are predictable in-sample, but not out-of-sample

Is the learning problem empirically relevant?

- Perhaps investors or managers have already learned enough from data for RE to be a good approximation?

- But: in reality, investors and managers face a large number of potential predictor variables, e.g., suppose

$$z_{i,t+1} = a + b_1 x_{i,1} + b_2 x_{i,2} + ... + b_J x_{i,J} + \xi_{i,t+1}, \qquad \xi_{i,t+1} \sim IID$$

- Coefficients $a, b_1, b_2, ..., b_J$ must be learned from a cross-section of N available observations.

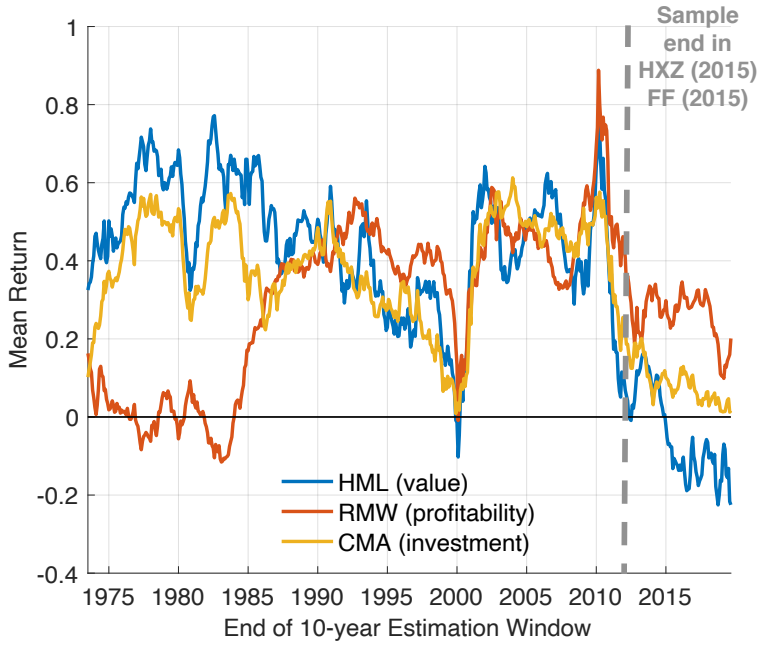
- If $N >> J \Rightarrow$ coefficients effectively known: RE is a good approximation

- But in real world, learning problem is high-dimensional: $J \approx N$, or even $J > N$. This is a hard learning problem!

Learning in high-dimensional settings

- Martin and Nagel (2019): RE is a bad approximation when the learning problem is high-dimensional
- To an econometrician studying a sample of data ex-post, forecast errors look in-sample predictable
- Similarly, returns appear cross-sectionally predictable in-sample, even if no risk premia, and even though investors are rational Bayesians in forecasting cash flows
- But in-sample predictability not informative about ex-ante expected returns: returns are not predictable out-of-sample

Out-of-sample decay of factor mean returns? 10-year MA of factor returns



Conclusion

- Asset prices and real investment data depend on beliefs of investors and firm managers
- But investment "CAPM" relationships between asset prices, investment, profits do not reveal properties of beliefs
- Asset price and investment data can be informative if combined with
  - data on expectations of investors and firm managers
  - structural models of beliefs and preferences
- Non-RE beliefs $\neq$ irrational: Includes models of rational learning
  - learning models can also produce in-sample predictable forecast errors, especially in high-dimensional settings
  - out-of-sample tests important

References

- Gennaioli, N., Y. Ma, and A. Shleifer. 2016. Expectations and investment. NBER Macroeconomics Annual, 30, 379–431.
- Martin, I., and S. Nagel, 2019. Market Efficiency in the Age of Big Data, working paper, University of Chicago.
- Stein, J. C., 1996. Rational Capital Budgeting In An Irrational World. Journal of Business, 429–455.
- Tanaka, M., N. Bloom, J.M. David, and M. Koga, 2019. Firm Performance and Macro Forecast Accuracy. Journal of Monetary Economics, forthcoming.
- Van Binsbergen, J.H., and C.C. Opp, 2019. Real Anomalies. Journal of Finance 74, 1659–1706.