A Behavioral Foundation for the Investment Wedge

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Impulse and Propagation Mechanisms
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Introduction

- Challenge: Generate comovement between real variables and financial variables
- Behavioral firms systematically underestimate competitors' investment
  - Closely related to:
    - Greenwood & Hanson (2015), GH: "competition neglect" (CN)
    - Angeletos & Lian (2023), AL: limited GE understanding
- Results:
  1. Solution method for GE models with CN
  2. Endogenous Investment Wedge in RBC
     Implies boom-bust investment dynamics
  3. Right comovement between real and financial variables
     Even in the absence of other frictions
  4. Match firm earnings survey evidence (Bordalo, Gennaioli, La Porta et al. (2024))
     and other financial moments (stock price volatility, return predictability)

Roadmap

1. Toy Model: Muth (1961) with Competition Neglect

2. Real Business Cycle Model with Competition Neglect
   - Overview of Setup
   - Overview of Solution Method
   - Result 1: Analytic Expression for Endogenous Wedge
   - Result 2: Comovement Real and Financial Variables

3. Quantitative Analysis
   - Target: Survey Data Moments
   - Result: Match Financial Cycle Moments

4. Takeaways

Example: Muth (1961) with CN

"Rational Expectations and the Theory of Price Movements"
Muth, J., Econometrica 1961

An isolated market for a commodity:

- Demand: $K_t^d = A_t - \beta P_t, \quad \beta > 0$

  Demand Shifter: $A_t = \rho A_{t-1} + \epsilon_t$, ϵ_t i.i.d. $N(0, \sigma_\epsilon^2)$

- Supply: Time-to-build investment: $I_{it} = \gamma \mathbb{E}_{it}^{\omega}[P_{t+1}], \quad \gamma > 0$

  Aggregate Investment: $I_t = \int I_{it} di$

  Supply: $K_{t+1}^s = I_t + (1 - \delta) K_t^s$

- Market Clearing: $K_t^d = K_t^s = K_t$

Competition Neglect Assumption

- Each firm i perceives aggregate investment as:

$$\mathbb{E}_{it}^{\omega}[\ I_t\ ] = \omega I_{it}, \quad 0 \leq \omega \leq 1$$

  - $\omega = 1$: rational expectations
  - $\omega < 1$: **competition neglect** (under-weights others' responses)

- ω is the CN parameter

- Under-estimate reaction of aggregate investment
  - $\Longrightarrow$ Firms under-estimate future K_{t+1}
    $\Longrightarrow$ Over-estimate future price P_{t+1}
  - Failure to understand market equilibrium

Solution

- Use market clearing + invert demand function, plug into individual investment:

$$I_{it} = \frac{\gamma}{\beta}\mathbb{E}^{\omega}_{it}\underbrace{[A_{t+1} - K_{t+1}]}_{P_{t+1}}$$

- Substituting capital dynamics:

$$I_{it} = \frac{\gamma}{\beta}\mathbb{E}^{\omega}_{it}\left[A_{t+1} - (I_t + (1-\delta)K_t)\right]$$

- Use CN assumption $\mathbb{E}^{\omega}_{it}[\ I_t\ ] = \omega I_{it}$ + compute expectation of A_{t+1}:

$$I_{it} = \frac{\gamma}{\beta}\left[\rho A_t - (\omega I_{it} + (1-\delta)K_t)\right]$$

Solution

- Capital dynamics + CN assumption:

$$I_{it} = \frac{\gamma}{\beta}\left[\rho A_t - (\omega I_{it} + (1-\delta)K_t)\right]$$

- RED: Source of boom, at t, and onward (over-investment since $\omega < 1$)
  ORANGE: Source of bust at $t+1$, and onward (stock overhang correction)

$$I_{it} = \frac{\gamma}{\beta + \gamma\omega}\left(\rho A_t - (1-\delta)K_t\right)$$

  A tug-of-war between these two effects on investment

No Storage Benchmark

- Boom, similar to Angeletos & Lian (2023)

Proposition (Boom)

Assume that $\delta = 1$. Furthermore, assume that at $t-1$ the economy is in steady state, and $\epsilon_t > 0$. Then, the IRF of investment is such that:

$$I^{CN}_{t+\tau} > I^{RE}_{t+\tau} > 0, \quad \forall \tau > 0$$

- CN generates over-investment, with decaying dynamics at rate ρ
- Intuition: $\delta = 1 \implies I_{it} = \frac{\gamma}{\beta+\gamma\omega}\rho A_t$. Only effect in RED is present.

Boom-Bust With Endogenous State

- Endogenous state with partial depreciation brings novelty

Proposition (Boom-Bust)

Assume that $\delta < 1$. Assume that at $t-1$ the economy is in steady state, and $\epsilon_t > 0$. Then, there is a ρ^* and a $t^* > t$ such that, for $\rho \in [\rho^*, 1-\delta)$:

1. *Initially, the IRF of investment features a boom:*

$$I_\tau^{CN} > I_\tau^{RE} > 0, \quad \forall \tau < t^*$$

2. *Later, the IRF of investment features a bust:*

$$I_\tau^{CN} < 0 < I_\tau^{RE}, \quad \forall \tau \geq t^*$$

- Boom at t, investment crosses zero once, converges to zero from below

  Intuition: $I_{it} = \frac{\gamma}{\beta+\gamma\omega}\left(\rho A_t - (1-\delta)K_t\right)$. Tug-of-war between RED and ORANGE.

Real Business Cycle (RBC) Model

Brief Setup Description, and Results

Towards General Equilibrium

- Embed CN into canonical Real Business Cycle model:
  - Maximizing agents (households, firms)
  - Economy buffeted by shocks to Total Factor Productivity (TFP)
- Novelty: Behavioral firms in capital-good producing sector
  - Adjustment costs $\Rightarrow$ Q theory
  - Follow GH closely for specification of CN bias
- **No other frictions!**

More on Model Details

- Standard RBC model
  - separable preferences (log-log), Cobb-Douglas technology, competitive final goods producers with flexible prices, competitive labor market
- Persistent AR(1) shocks to Total Factor Productivity (TFP)
  - Single shock: investment wedge is endogenous
- In GE, two important departures from the GH paper:
  1. interest rate is endogenous
  2. rental rate functional form is determined by the production function

  (See paper for detailed technical discussion)

Solving the Model

- Loglinearize around steady state
- Roadmap:
  1. Do business cycle accounting
     Find: CN observationally equivalent to investment wedge
  2. Calibrate model and simulate
     Find: Comovement real and financial aggregates
  3. Quantitative exercise
     Find: Match LTG earnings per share survey evidence

Investment Wedge Dynamics

Business Cycle Accounting: CN is observationally equivalent to an investment wedge:

$$\tau_{It} = \nu_k \hat{k}_t + \nu_a \hat{a}_t$$

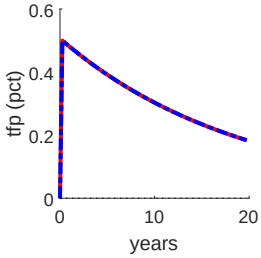
Result: Wedge has ARMA(2,1) representation:

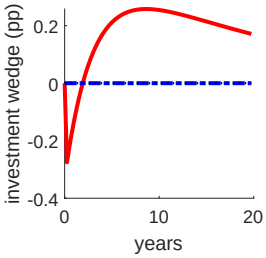
$$\tau_{It} = (1 + \psi_{Ik} + \rho_a)\tau_{It-1} - (1 + \psi_{Ik})\rho_a \tau_{It-2} + \text{MA terms}$$

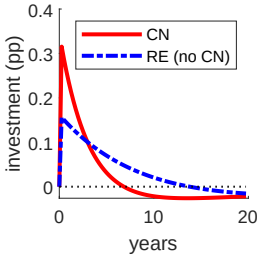
Economic Interpretation:

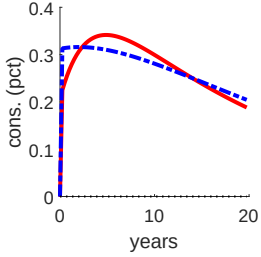
- **Boom-bust** investment
- Wedge acts like investment **subsidy** initially, **tax** subsequently (tug-of-war between initial over-investment and subsequent overhang)

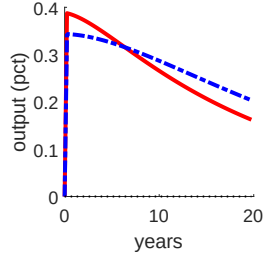
IRFs: Real Variables. Comparison: RE Versus CN

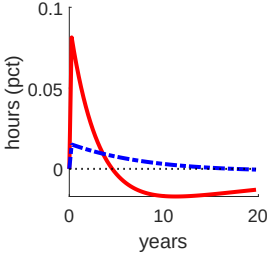












Financial Cycle Implications

Define: Stock Value and Returns:

$$V_t = D_t + \mathbb{E}_t^{\omega}[M_{t+1|t} V_{t+1}], \qquad R_{st+1} = \frac{V_{t+1}}{V_t - D_t}$$

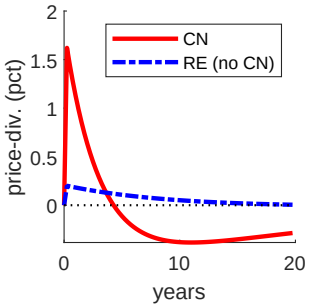
Result: Investment wedge $\Longleftrightarrow$ excess returns

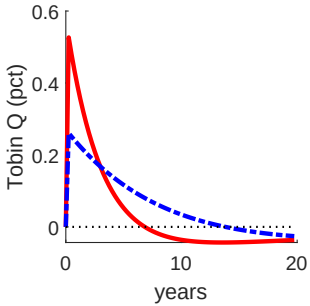
$$\mathbb{E}_t[r_{st+1} - r_t] = \tau_{It} - \beta \mathbb{E}_t[\tau_{It+1}]$$

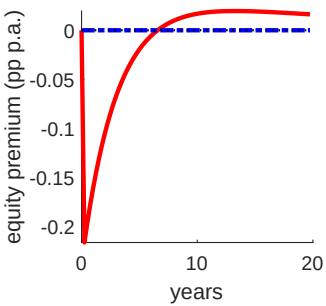
Mechanism:

- Firms do not perceive excess returns
- But perceptions are distorted $\Longrightarrow$ actual equity premia $\neq 0$ (econometrician's)
- High valuations predict *low* future excess returns!

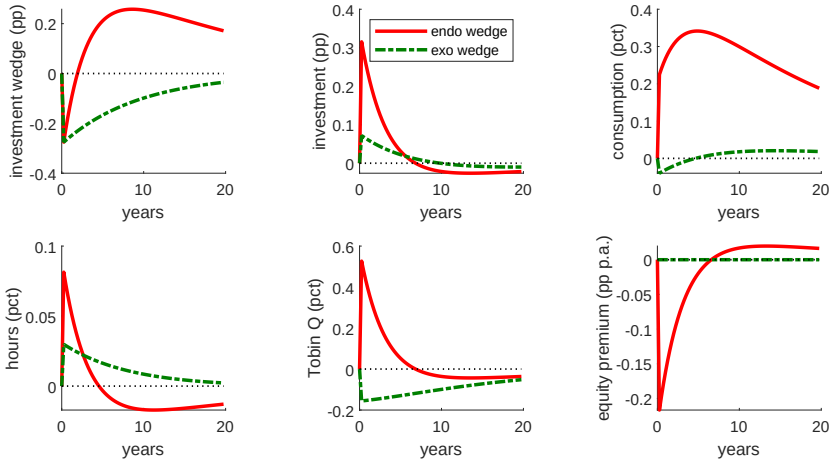
IRFs: Financial Variables







Why Not Just Use Exogenous Investment Shocks?
Comparing Dynamics: CN Versus RE with Inv. Shock



Quantitative Exercise

- Questions:
  1. How can we discipline the CN parameter ω?
  2. Can the behavioral friction account for financial cycle patterns, even in RBC?

- Answers:
  1. Bring in survey data.
     Target forecast error regression moments from Bordalo et al. (2024, Macroannual)
  2. Results: match stock price volatility and return predictability moments

Matching Bordalo et al. (2024, Macroannual) Forecast-Error Regression

- Our goal: match coefficients from forecast-error regression (Bordalo, Gennaioli, La Porta, O'Brien & Shleifer, 2024, Macroannual)
- Firm analysts forecasts from IBES survey
- Long-term growth, over next 5-y, earning-per-share expectations (LTG)

Matching Bordalo et al. (2024, Macroannual) Forecast-Error Regression

Define: $\text{FE}_{t+h} = \text{LTG}_{t+h} - \text{RealizedG}_{t+h,t+h+20}$

Empirical exercise:

$$\text{FE}_{t,t+h} = B_h \times \text{LTG}_t + \varepsilon_{t,t+h}$$

h (Q)	0	1	2	3	4	5	6	**AVE.**
LTG	3.69	3.49	3.04	2.38	1.53	0.58	-0.33	**2.05**

Economic interpretation: $B_h > 0 \Longrightarrow$ **over-optimism**

Over-optimism is highly persistent and slow moving

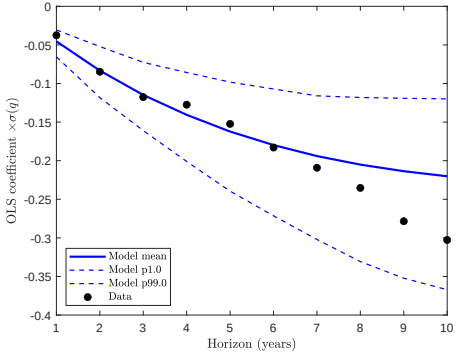
$\Longrightarrow$ Added ingredient: Use AR(1) in growth rates for TFP process

Targeted and Untargeted Moments

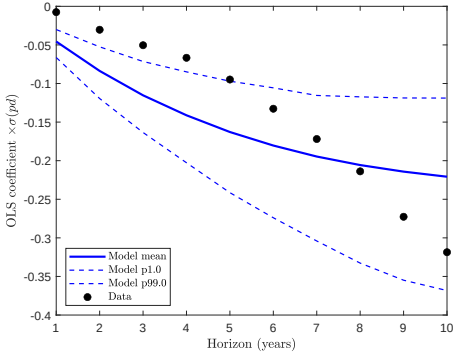
Parameter	*Targeted Moments*	Data	Model
$\omega = 0.04$	**Persistent overconfidence (from Bordalo et al. 2024)**	**2.05**	**1.98**
$\mu_a = 1.80$	Mean output growth (% p.a.)	1.80	1.80
$\sigma_a = 1.01$	s.d. output growth (% p.a.)	1.87	1.84
$\rho_a = 0.35$	Autocorrelation output growth	0.35	0.34
$\phi = 93.0$	s.d. investment growth (% p.a.)	4.64	4.59

	Untargeted Moments	Data	Model
	s.d. log Tobin's Q (%)	0.22	0.22
	s.d. log price-dividend ratios (%)	0.57	0.40
	s.d. excess returns (% p.a.)	16.3	12.8

Untargeted Moments: Return Predictability



(a) Tobin's Q as Regressor



(b) Price-Dividend Ratio as Regressor

Takeaways

- Another tool for the macroeconomist's toolbox
- Key: Real and financial cycles are interconnected
- Investment wedge emerges endogenously
  Financial variables comove with this wedge