Diagnostic Expectations and Credit Cycles

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Introduction

- Renewal of academic interest on the link between credit expansion and subsequent bust
  - Schularick, Taylor (2012): credit growth and financial crisis
  - Mian, Sufi, Verner (2015): household debt and low growth
  - Baron, Xiong (2014): bank credit and crash risk in stocks
  - Fahlenbrach et al. (2016): loan growth and bank performance
- Complementary findings for corporate debt:
  - Greenwood, Hanson (2013): in credit booms, quality of debt issuers falls. Larger high yield share in bond issuance predicts low (negative) excess returns
  - Gilchrist, Zakrajsek (2012), Krishnamurthy, Muir (2015): credit tightening anticipates the coming recession
  - Lopez-Salido, Stein, Zakrajsek (LSZ 2015): low spreads today predicts rise in credit spreads and low growth afterwards

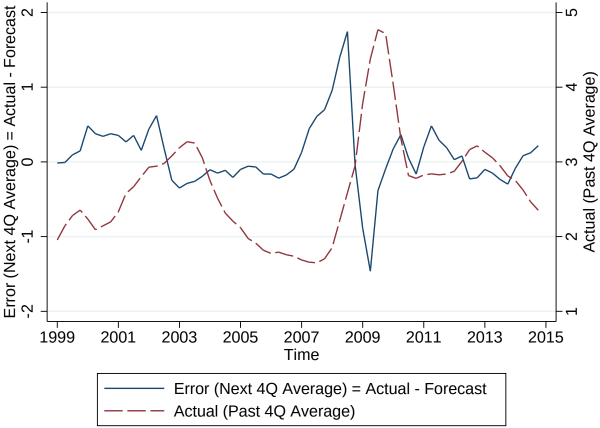
Our Approach

- Build a behavioral model of credit cycles
- Micro-found expectation formation based on Representativeness Heuristic
- Consistent with available evidence but also with predictable expectations errors
- Forward looking; immune to the Lucas critique

Related Literature

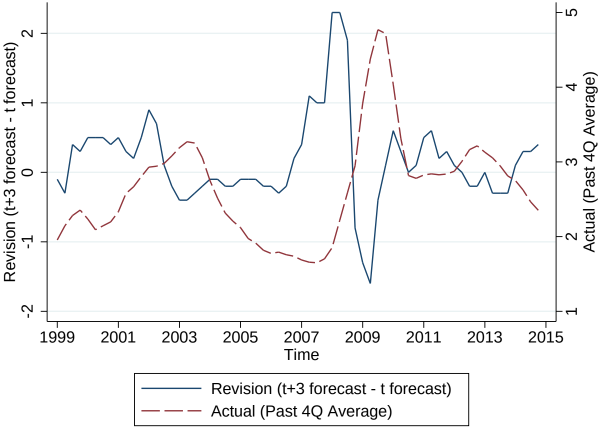
- Financial frictions
  - Those models fail to account for predictable returns and errors
  - Also do not explain where shocks come from
- Extrapolation
  - Greenwood and Shleifer 2014, Barberis et al 2015a,b
  - Our theory micro-founds extrapolation and neglect of risk
- Limited attention
  - Sims 2003, Coibion and Gorodnichenko 2012, 2015, Gabaix 2015
  - These are models of under-reaction, not over-reaction
- Behavioral models of credit cycles
  - Gennaioli, Shleifer, and Vishny 2012, 2015, Greenwood, Hanson, and Jin 2016
  - Our model provides a portable foundation of belief formation

Predictable Expectation Errors of Credit Spreads



Data Source: *Blue Chip Financial Forecasts*

Predictable Reversals in Expectations of Credit Spreads



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This Paper

- Model of expectation formation based on Gennaioli and Shleifer's (2010) formalization of Kahneman and Tversky's "representativeness" heuristic
- Inserted into a simple macroeconomic model (no financial frictions), yields many of the previous facts
- What is representativeness?
  - How to model it
  - Implications for Macro-Finance

What is Representativeness?

- KT (1974): we judge the frequency of an attribute by its similarity to, or representativeness for, the parent population
- KT (1983): "an attribute is representative of a class if it is very diagnostic; that is, the relative frequency of this attribute is much higher in that class than in a relevant reference class."
- KT argue that representativeness lies behind systematic, extensively documented biases in probability judgments:
  - Base rate neglect, Conjunction Fallacy, Disjunction Fallacy
  - Example (Linda): an intelligent, single woman in her 30's who was an activist in college is deemed more likely to be a feminist bank teller than a bank teller

How to Model Representativeness?

- Assess distribution of attribute T in class G

$$h(T = t|G)$$

- Following KT, define representativeness of $T = t$ for G as:

$$\frac{h(T = t|G)}{h(T = t|-G)}$$

- Distort $h(T = t|G)$ by inflating the probability of values t that score high, neglect / under-weight values that score low

- This model yields the KT biases (GS 2010) and accounts for "kernel of truth" in social stereotypes (Bordalo Coffman Gennaioli Shleifer 2015)

Example: Stereotypes

- Hair color distribution among the Irish

$$h\,(hair\ \ colour|Irish)$$

- $T \equiv \{red,\ light,\ dark\}$, $G = Irish$, $-G = World$

hair colour	*red*	*light*	*dark*
Irish	10%	40%	50%
World	1%	14%	85%

- The stereotype of Irish overweights red hair:

$$\frac{h\,(\text{red hair}|\text{Irish})}{h\,(\text{red hair}|\text{World})} = 10$$

- Kernel of Truth (Judd and Park 1993, BCGS 2015)
  Confirmed in data on political, gender, ethnic groups.

Implications for Macro-Finance?

- Given data (Irish), inflate prevalence of hair color (red) whose objective probability goes up the most relative to others
- In a dynamic environment:
  - given news, agents inflate future states of the world whose *objective* probability goes up the most
  - the context is lagged information
- This yields:
  - extrapolation + neglect of tail risk in a single setup
  - reversals in the absence of news
  - excess volatility
  - immunity to Lucas critique, RE as a special case
  - no learning, rather beliefs distort true process
  - model is portable: unify explanation of lab experiments, social stereotypes, macroeconomic predictions

Model Ingredients

- State of the economy Ω_t at t follows $AR(1)$

$$\omega_t = b \cdot \omega_{t-1} + \epsilon_t$$

- Diagnostic Expectations about Ω_{t+s}
- Measure 1 of firms of varying risk (different exposure to Ω_t)
- Long lived, risk neutral, representative household that supplies capital to these firms (buys risky debt from them)

Diagnostic Expectations

- After seeing the state ω_t, the agent must represent:

$$h\left(\Omega_{t+1} = \omega_{t+1} | \Omega_t = \omega_t\right)$$

  - Here $G \equiv \{\Omega_t = \omega_t\}$

- News assessed relative to $-G$ containing past information

- Main case: reference is information available at $t-1$

$$-G \equiv \{\Omega_t = b \cdot \omega_{t-1}\}$$

Then representativeness is: $\dfrac{h\left(\Omega_{t+1} = \omega_{t+1} | \Omega_t = \omega_t\right)}{h\left(\Omega_{t+1} = \omega_{t+1} | \Omega_t = b \cdot \omega_{t-1}\right)}$

Overweighing

- We assume the distorted distribution $h_t^\theta(\omega_{t+1})$ to be:

$$h\left(\Omega_{t+1}=\omega_{t+1}|\Omega_t=\omega_t\right)\cdot\left[\frac{h\left(\Omega_{t+1}=\omega_{t+1}|\Omega_t=\omega_t\right)}{h\left(\Omega_{t+1}=\omega_{t+1}|\Omega_t=b\cdot\omega_{t-1}\right)}\right]^\theta\frac{1}{Z_t}$$

- $\theta\geq 0$ measures the importance of representativeness
- Rational expectations: special case for $\theta=0$ or no news $\epsilon_t=0$
- Inflate density of future states that have become more likely
- Denote Diagnostic Expectations by

$$\mathbb{E}_t^\theta\left(\omega_{t+1}\right)=\int_{\mathbb{R}}\omega\cdot h_t^\theta\left(\omega\right)d\omega$$

Specifying $-G$

- Alternative: reference is recent diagnostic expectation

$$\frac{h\left(\Omega_{t+1} = \omega_{t+1} | \Omega_t = \omega_t\right)}{h\left(\Omega_{t+1} = \omega_{t+1} | \Omega_t = \mathbb{E}^{\theta}_{t-1}(\omega_t)\right)}$$

- $-G$ influences reaction to news
  - different specifications imply different lag structures of expectations

- We proceed with our main case:

$$-G = \{\Omega_t = b \cdot \omega_{t-1}\}$$

and then consider the other cases

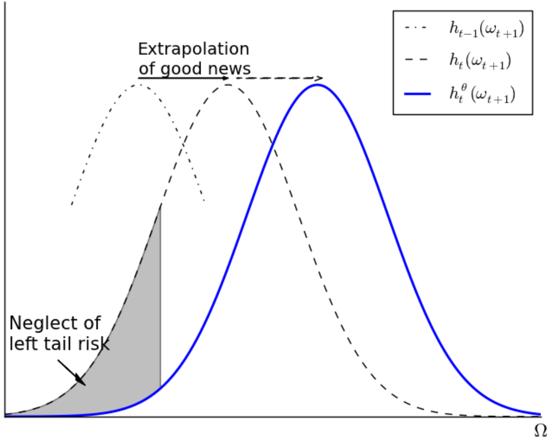
Representation

Proposition 1. When the process for ω_t is AR(1) with normal $(0, \sigma^2)$ shocks, the distribution $h^\theta(\omega_{t+1})$ is also normal, with variance σ^2 and mean:

$$\mathbb{E}_t^\theta(\omega_{t+1}) = \mathbb{E}_t(\omega_{t+1}) + \theta\left[\mathbb{E}_t(\omega_{t+1}) - \mathbb{E}_{t-1}(\omega_{t+1})\right]$$

- $\mathbb{E}_t^\theta$ is function of (lagged) rational expectations
- Kernel of truth: overweight incoming news
- Context dependence: the path is important

Neglect of Tail Risk (GSV 2012)



Extrapolation

- Plugging AR(1) in $\mathbb{E}_t^{\theta}(\omega_{t+1})$ we obtain

$$\mathbb{E}_t^{\theta}\left(\omega_{t+1}\right) - \omega_t = \left[\mathbb{E}_t\left(\omega_{t+1}\right) - \omega_t\right] + b\theta\left[\omega_t - \mathbb{E}_{t-1}(\omega_t)\right]$$

- Slant toward current objective news $\omega_t - \mathbb{E}_{t-1}(\omega_t)$
- Neglect of risk and extrapolation follow from the same psychology of context effects

Diagnostic vs. Adaptive Expectations

- Adaptive Expectations

$$\mathbb{E}_t^a(\omega_{t+1}) = \lambda\omega_t + (1-\lambda)\mathbb{E}_{t-1}^a(\omega_t), \qquad 0 < \lambda < 1$$

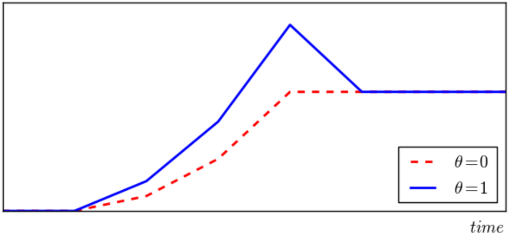
- Diagnostic Expectations

$$\mathbb{E}_t^\theta(\omega_{t+1}) = b(1+\theta)\omega_t - b\theta\mathbb{E}_{t-1}(\omega_t)$$

  - Overreaction + reversal (rather than momentum)
  - Forward looking:
    - Extrapolate only if process is stochastic and persistent, $b > 0$
    - No mistakes for i.i.d. case, $b = 0$
    - Immune to Lucas Critique

Sequences of News

- Random walk, $\omega_t = \omega_{t-1} + \epsilon_t$



  - accelerating good news cause sustained optimism
  - when good news stop, boom is followed by bust

Non-Fundamental Reversals

- Suppose fundamentals follow a random walk $(b = 1)$. Then:

$$\mathbb{E}_t^{\theta}(\omega_{t+1}) = \omega_t + \theta\left(\omega_t - \omega_{t-1}\right)$$

- As a consequence:

$$\begin{aligned}\mathbb{E}_t[\mathbb{E}_{t+1}^{\theta}(\omega_{t+2}) - \mathbb{E}_t^{\theta}(\omega_{t+1})] \\ &= \mathbb{E}_t\left[\left(\omega_{t+1} - \omega_t\right)(1+\theta) - \theta\left(\omega_t - \omega_{t-1}\right)\right] \\ &= -\theta\left(\omega_t - \omega_{t-1}\right)\end{aligned}$$

- Excess optimism at t systematically wanes at $t+1$ even in the absence of news. A boom is followed by a bust.

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Firms

- Each firm is identified by its risk $\rho \in \mathbb{R}$ (which is common knowledge), and produces output:

$$y\left(k|\omega_t, \rho\right) = \begin{cases} k^{\alpha} & \text{if} \quad \omega_t \geq \rho \\ 0 & \text{if} \quad \omega_t < \rho \end{cases}$$

- At t,firm ρ borrows at the interest rate $r_{t+1}(\rho)$ to install capital $k_{t+1}(\rho)$. Maximize expected profit:

$$\max_{k_{t+1}(\rho)} \left[k_{t+1}(\rho)^{\alpha} - k_{t+1}(\rho) \cdot r_{t+1}(\rho)\right] \cdot \mu_t^{\theta}(\rho)$$

where "perceived creditworthiness" is:

$$\mu_t^{\theta}(\rho) = \int_{\rho}^{+\infty} h_t^{\theta}\left(\omega\right) d\omega$$

Households

- The representative household solves:

$$\max_{D_{s+1}(\rho)} \; \mathbb{E}_t^{\theta}\left[\sum_{s=t}^{+\infty} \beta^{s-t} c_s\right]$$

with budget constraint

$$c_s + \int_{\mathbb{R}} D_{s+1}(\rho) f(\rho) d\rho = w + \int_{\mathbb{R}} I(\rho, \omega_s) \cdot [r_s(\rho) D_s(\rho) + \pi_s(\rho)] \, f(\rho) d\rho$$

- We assume the endowment is large enough to obtain interior solutions despite risk neutrality, $w \geq (\alpha\beta)^{\frac{1}{1-\alpha}}$

Equilibrium

- Firms invest until MPK in case of success equals contract interest rate

$$k_{t+1}(\rho) = \left[\frac{\alpha}{r_{t+1}(\rho)}\right]^{\frac{1}{1-\alpha}}$$

- Households buy debt until expected return equals inverse discount factor

$$r_{t+1}(\rho) \cdot \mu_t^{\theta}(\rho) = \frac{1}{\beta} \quad \leftrightarrow \quad r_{t+1}(\rho) = \frac{1}{\beta \mu_t^{\theta}(\rho)}$$

- Equilibrium spread between risky firm ρ and safe firm $\rho \to -\infty$

$$S\left(\rho, \mathbb{E}_t^{\theta}(\omega_{t+1})\right) \equiv r_{t+1}(\rho) - \frac{1}{\beta} = \frac{1}{\beta}\left(\frac{1}{\mu_t^{\theta}(\rho)} - 1\right)$$

Equilibrium

- Debt issuance/installed capital of firm ρ:

$$k_{t+1}(\rho) = \left[\alpha\beta\mu_t^\theta(\rho)\right]^{\frac{1}{1-\alpha}} = \left[\frac{\alpha}{1/\beta + S\left(\rho, \mathbb{E}_t^\theta(\omega_{t+1})\right)}\right]^{\frac{1}{1-\alpha}}$$

- Total debt issued and investment (full depreciation):

$$K_{t+1} = \int_{\mathbb{R}} \left[\alpha\beta\mu_t^\theta(\rho)\right]^{\frac{1}{1-\alpha}} f(\rho)d\rho$$

- Future output in state ω_{t+1}:

$$Y_{t+1}(\omega_{t+1}) = \int_{-\infty}^{\omega_{t+1}} \left[\alpha\beta\mu_t^\theta(\rho)\right]^{\frac{1}{1-\alpha}} f(\rho)d\rho$$

Spreads and Issuance

- Define average spread at t (inverse measure of optimism)

$$S_t = \int_{\mathbb{R}} S\left(\rho, \mathbb{E}_t^{\theta}(\omega_{t+1})\right) f(\rho)\, d\rho$$

- **Proposition.** Higher S_t (lower optimism at t) causes:
  - disproportionate rise in spread of riskier firms: $\frac{\partial^2 S}{\partial S_t \partial \rho} > 0$
  - disproportionate decline in debt issuance and investment by riskier firms: $\frac{\partial}{\partial S_t} \frac{k_{t+1}(\rho_1)}{k_{t+1}(\rho_2)} < 0$ for $\rho_1 > \rho_2$
  - holds for $\theta \geq 0$

- Accordingly, GH (2013) show junk share rises as spreads fall

Dynamics of Credit Spreads

- Linearise model for $\mathbb{E}_t^{\theta}(\omega_{t+1})$ near long-term mean $\overline{\omega} = 0$

$$S_t = \sigma_0 - \sigma_1 \mathbb{E}_t^{\theta}(\omega_{t+1})$$

- **Proposition.** Average spread S_t follows process:

$$S_t = (1-b)\sigma_0 + b \cdot S_{t-1} - (1+\theta) b \sigma_1 \epsilon_t + \theta b^2 \sigma_1 \epsilon_{t-1}$$

  - for $\theta = 0$ (rational expectations), spreads follow AR(1), just like fundamentals
  - for $\theta > 0$, spreads instead follow ARMA(1,1)

Dynamics of Credit Spreads

- Spreads follow ARMA(1,1):

$$S_t = (1-b)\sigma_0 + b \cdot S_{t-1} - (1+\theta)b\sigma_1\epsilon_t + \theta b^2\sigma_1\epsilon_{t-1}$$

- As S_t is function of expectations at t:
  - has autoregressive component, $S_t \sim b \cdot S_{t-1}$
  - but S_{t-1} overreact to news at $t-1$
  - $t-1$ overreaction subsides at t, does not contaminate S_t
  - add correction term $\theta b^2\sigma_1\epsilon_{t-1}$ (moving average component)

Credit Spreads Forecasts

- To compute forecasts of spreads, note:

$$\mathbb{E}_t^\theta\left(\mathbb{E}_{t+s}^\theta\left(\omega_{t+T}\right)\right)=\mathbb{E}_t^\theta\left(\omega_{t+T}\right)$$

  - diagnostic expectations satisfy law of iterated expectations

- Revisions of expectations are unpredictable to investors. Forecasts of credit spreads then follow:

$$\mathbb{E}_t^\theta\left(S_{t+T}\right)=\sigma_0\left(1-b^T\right)+b^T S_t$$

- Actual spreads follow ARMA(1,1) but forecasts follow AR(1)
  - introduces systematic errors, that can account for our motivating evidence

Credit Spreads Forecasts

- **Proposition.** Conditional on information at t:
  - forecast error at $t+1$ is predictable:

$$\mathbb{E}_t\left[S_{t+1} - \mathbb{E}_t^\theta\left(S_{t+1}\right)\right] = \theta b^2 \sigma_1 \epsilon_t$$

  - revision of forecasts are predictable:

$$\mathbb{E}_t\left[\mathbb{E}_{t+s}^\theta\left(S_{t+T}\right) - \mathbb{E}_t^\theta\left(S_{t+T}\right)\right] = \theta b^{T+1} \sigma_1 \epsilon_t$$

- Good news predict that S_t and $\mathbb{E}_t^\theta(S_{t+1})$ are too low, and that future spreads are revised upwards
- Consistent with our evidence:
  - negative correlation between S_t and error $S_{t+1} - \mathbb{E}_t^\theta\left(S_{t+1}\right)$
  - also between S_t and revision $\mathbb{E}_{t+s}^\theta\left(S_{t+T}\right) - \mathbb{E}_t^\theta\left(S_{t+T}\right)$

Predictable Returns and Excess Volatility

- **Corollary.** Let $S_t^r \equiv S_t|_{\theta=0}$ be rational spread. For $\theta > 0$:
  - avg returns are predictably low (high) on good (bad) news
  $$S_t - S_t^r = -\theta b \sigma_1 \epsilon_t$$
  - spreads exhibit excess volatility
  $$Var_{t-1}[S_t] = (1+\theta)^2 Var_{t-1}[S_t^r]$$
- Consistent with evidence
  - high junk shares predict low (even negative) returns (GH 2013)
  - fundamentals account for small share of volatility (Collin-Dufresne et al 2001)

Non-fundamental boom-bust cycles

Corollary. Let $\theta > 0$ and S_{t-1} be low due to good news $\epsilon_{t-1} > 0$. Then, controlling for fundamentals at $t-1$:

- spreads predictably rise at t
- aggregate investment at t, and aggregate production at $t+1$, predictably drop
- consistent with Lopez-Salido, Stein, Zakrajsek (2015)

Summary

- We present a psychologically founded, forward looking model of expectation formation.
  - in a simple macro model, it reproduces several features of credit cycles.
  - also reproduces facts about spreads forecasts
- Features in common with RE model:
  - spread compression in good times
  - relatively high issuance by high yield firms
- Features arising from diagnostic expectations ($\theta > 0$)
  - extrapolative expectations of fundamentals
  - excess volatility of credit spreads
  - predictably low returns in good times
  - systematic non-fundamental reversals (bad credit shocks)

Future Avenues

- Expectations
  - consider a variety of time series and their expectations
  - understand sources of under- and over-reaction
- Financial Frictions
  - Special role of debt / risk misallocation (GSV 2012, 2013)
  - Asymmetric effect of busts