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**
  - 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

Data Source: *Blue Chip Financial Forecasts*
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

\[ h(\text{hair colour}|\text{Irish}) \]

- \( T \equiv \{\text{red, light, dark}\}, \ G = \text{Irish}, \ -G = \text{World} \)

<table>
<thead>
<tr>
<th>hair colour</th>
<th>red</th>
<th>light</th>
<th>dark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irish</td>
<td>10%</td>
<td>40%</td>
<td>50%</td>
</tr>
<tr>
<td>World</td>
<td>1%</td>
<td>14%</td>
<td>85%</td>
</tr>
</tbody>
</table>

- 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 $\Omega_t$ at $t$ follows $AR(1)$

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

- Diagnostic Expectations about $\Omega_{t+s}$

- Measure 1 of firms of varying risk (different exposure to $\Omega_t$)

- Long lived, risk neutral, representative household that supplies capital to these firms (buys risky debt from them)
Diagnostic Expectations

- After seeing the state $\omega_t$, the agent must represent:

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

- 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:

$$\frac{h(\Omega_{t+1} = \omega_{t+1}|\Omega_t = \omega_t)}{h(\Omega_{t+1} = \omega_{t+1}|\Omega_t = b \cdot \omega_{t-1})}$$
Overweighing

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

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

- $\theta \geq 0$ 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

$$E^\theta_t (\omega_{t+1}) = \int_{\mathbb{R}} \omega \cdot h^\theta_t (\omega) d\omega$$
Specifying $-G$

- Alternative: reference is recent diagnostic expectation

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

$$h(\Omega_{t+1} = \omega_{t+1} | \Omega_t = \mathbb{E}_t^{\theta_t} (\omega_t))$$

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

$$E_t^\theta (\omega_{t+1}) = E_t (\omega_{t+1}) + \theta [E_t (\omega_{t+1}) - E_{t-1}(\omega_{t+1})]$$

- $E_t^\theta$ 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 of good news

Neglect of left tail risk
Extrapolation

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

$$E^\theta_t (\omega_{t+1}) - \omega_t = [E_t (\omega_{t+1}) - \omega_t] + b\theta [\omega_t - E_{t-1}(\omega_t)]$$

- Slant toward current objective news $\omega_t - E_{t-1}(\omega_t)$

- Neglect of risk and extrapolation follow from the same psychology of context effects
Diagnostic vs. Adaptive Expectations

- **Adaptive Expectations**

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

- **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:

\[
E_t^{\theta}(\omega_{t+1}) = \omega_t + \theta (\omega_t - \omega_{t-1})
\]

- As a consequence:

\[
E_t [E_{t+1}^{\theta}(\omega_{t+2}) - E_t^{\theta}(\omega_{t+1})] = E_t [(\omega_{t+1} - \omega_t) (1 + \theta) - \theta (\omega_t - \omega_{t-1})] = -\theta (\omega_t - \omega_{t-1})
\]

- Excess optimism at \(t\) systematically wanes at \(t + 1\) even in the absence of news. A boom is followed by a bust.
Model Ingredients

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

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

- Diagnostic Expectations about $\Omega_{t+s}$

- Measure 1 of firms of varying risk (different exposure to $\Omega_t$)

- Long lived, risk neutral, representative household that supplies capital to these firms (buys risky debt from them)
Each firm is identified by its risk $\rho \in \mathbb{R}$ (which is common knowledge), and produces output:

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

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

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

where “perceived creditworthiness” is:

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

The representative household solves:

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

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

\[ r_{t+1}(\rho) \cdot \mu_t(\rho) = \frac{1}{\beta} \iff r_{t+1}(\rho) = \frac{1}{\beta \mu_t(\rho)} \]

- Equilibrium spread between risky firm \( \rho \) and safe firm \( \rho \to -\infty \)

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

- Debt issuance/installed capital of firm $\rho$:

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

- 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 $\omega_{t+1}$:

$$Y_{t+1}(\omega_{t+1}) = \int_{-\infty}^{\omega_{t+1}} \left[ \alpha \beta \mu_t^\theta(\rho) \right]^{\frac{1}{1-\alpha}} f(\rho) d\rho$$
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 $E_t^\theta (\omega_{t+1})$ near long-term mean $\bar{\omega} = 0$

  \[ S_t = \sigma_0 - \sigma_1 E_t^\theta (\omega_{t+1}) \]

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

  \[ S_t = (1 - b)\sigma_0 + b \cdot S_{t-1} - (1 + \theta) b \sigma_1 \varepsilon_t + \theta b^2 \sigma_1 \varepsilon_{t-1} \]

  - 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:

\[ \mathbb{E}_t^\theta \left( \mathbb{E}_t^\theta (\omega_{t+T}) \right) = \mathbb{E}_t^\theta (\omega_{t+T}) \]

- diagnostic expectations satisfy law of iterated expectations

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

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

- 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:
    $$
    E_t \left[ S_{t+1} - E_t^\theta (S_{t+1}) \right] = \theta b^2 \sigma_1 \epsilon_t
    $$
  - revision of forecasts are predictable:
    $$
    E_t \left[ E_{t+s}^\theta (S_{t+T}) - E_t^\theta (S_{t+T}) \right] = \theta b^{T+1} \sigma_1 \epsilon_t
    $$

- Good news predict that $S_t$ and $E_t^\theta (S_{t+1})$ are too low, and that future spreads are revised upwards

- Consistent with our evidence:
  - negative correlation between $S_t$ and error $S_{t+1} - E_t^\theta (S_{t+1})$
  - also between $S_t$ and revision $E_{t+s}^\theta (S_{t+T}) - E_t^\theta (S_{t+T})$
Predictable Returns and Excess Volatility

- **Corollary.** Let $S'_t \equiv S_t|_{\theta=0}$ be rational spread. For $\theta > 0$:
  - avg returns are predictably low (high) on good (bad) news
    \[ S_t - S'_t = -\theta b_1 \epsilon_t \]
  - spreads exhibit excess volatility
    \[ \text{Var}_{t-1}[S_t] = (1 + \theta)^2 \text{Var}_{t-1}[S'_t] \]
- **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)
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