# Investor Psychology and Credit Cycles

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## Abstract

We present a model of credit cycles based on a new psychological formulation of the expectations mechanism. Agents form "stereotypical" expectations whereby they over-weight, in their belief revisions, the future outcomes that have become more likely in light of incoming data. This model of context dependent beliefs is based on a formalization of Kahneman and Tversky's representativeness heuristic that has been previously used to explain a substantial amount of experimental evidence in psychology as well as the social phenomenon of stereotyping. Beliefs in this formulation are forward looking, immune to the Lucas critique, and contain rational expectations as a special case. Beliefs exhibit excess volatility, over-reaction to news, and systematic reversals. These dynamics account for many recently documented features of credit cycles and macroeconomic volatility without resort to financial frictions. In particular, they generate systematic reversion of a financial boom into a bust in the absence of deteriorating fundamentals.

## 1. Introduction

The financial crisis of 2008-2009 revived economists' and policymakers' interest in the relationship between credit expansion and subsequent financial and economic busts. According to an old argument (e.g., Minsky 1977), investor optimism brings about the expansion of credit and investment, and leads to a crisis when disappointing news arrive. Stein (2014) echoes this view by arguing that policy-makers should be mindful of credit market frothiness and consider countering it through policy.

Recent empirical research provides considerable support for this perspective. Schularick and Taylor (2012) demonstrate, using a sample of 14 developed countries between 1870 and 2008, that rapid credit expansions forecast declines in real activity. Jorda, Schularick, and Taylor (2013) further find that more credit-intensive expansions are followed by deeper recessions. Mian, Sufi, and Verner (2015) show that the growth of household debt explains future economic slowdowns. And Baron and Xiong (2014) establish in a sample of 20 developed countries that bank credit expansion predicts increased crash risk in both bank stocks and equity markets more broadly.

Parallel findings emerge from the examination of credit spreads – differences in yields between safe and risky debt. The benchmark recent study by Greenwood and Hanson (2013) shows that credit quality of corporate debt issuers deteriorates during credit booms, and that low credit spreads forecast low, and even negative, excess corporate bond returns. In addition, during credit expansions the share of credit going to risky firms rises, and this risky share, rather than credit growth per se, predicts poor economic growth. Gilchrist and Zakrajsek (2012) and Krishnamurthy and Muir (2015) relatedly establish that eventual credit tightening correctly anticipates the coming recession. Lopez-Salido, Stein, and Zakrajsek (hereafter LSZ 2015) pull a lot of this evidence together, and show that low credit spreads predict both a rise in credit spreads and low economic growth afterwards. They stress predictable mean reversion in credit market conditions[1]. Both Greenwood and Hanson (2013) and LSZ (2015) interpret the evidence as inconsistent with rational expectations.

The prevailing approach to understanding the link between financial markets and the real economy is financial frictions, which focus on the transmission of an adverse shock through a leveraged economy (Bernanke and Gertler 1989, Kiyotaki and Moore 1997, Lorenzoni 2008, Brunnermeier and Sannikov 2014). In some instances, financial frictions are supplemented by Keynesian elements, such as the zero lower bound on interest rates or aggregate demand effects (Eggertson and Krugman 2012, Farhi and Werning 2015, Guerrieri and Lorenzoni 2015, Korinek and Simsek 2014, Rognlie et al. 2015). The adverse shock in these models is either a drop in fundamentals, or a "financial shock" consisting of the tightening of collateral constraints or an increase in required returns. These models typically do not explain why a financial boom is systematically followed by a bust. In particular, there is no attempt to explain what causes financial conditions to deteriorate suddenly. Relatedly, these models do not explain predictable negative or low abnormal returns (Greenwood and Hanson 2013, LSZ 2015) or predictable expectation errors (Greenwood and Shleifer 2014, Gennaioli, Ma and Shleifer 2015). It seems that to account for the evidence more completely, one needs to abandon rational expectations.

In this paper, we follow this path. We present a psychological model of investor confidence and credit cycles that accounts for much of the evidence described above, and articulates in a fully dynamic setup the phenomenon of credit market overheating.

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[1] An older literature on financial asset prices and economic activity includes Bernanke (1990), Friedman and Kuttner (1992), and Stock and Watson (2003), among others.

It implies that in a boom investors are overly optimistic and will systematically become more pessimistic in the future, leading to crises even without deteriorating fundamentals. The model allows us to discuss in a unified framework such phenomena as adaptive expectations and extrapolation (e.g., Cagan 1956, Greenwood and Shleifer 2014, Barberis et al. 2015), as well as the neglect of risk (Gennaioli, Shleifer, and Vishny 2012). Critically, households in our model are forward looking, and recognize policy shifts. As a consequence, the model is not vulnerable to the Lucas critique, which has plagued an earlier generation of behavioral models. Indeed, for any data generating process, rational expectations emerge a special case of our model.

Our principal contribution is to write down a psychologically-founded model of beliefs and their evolution in light of new data.[2] Importantly, the model is taken from a very different context and adapted to macroeconomic problems, rather than just designed to match credit cycle facts. It is portable in the sense of Rabin (2013). Our model of belief evolution is based on a formalization of Kahneman and Tversky's representativeness heuristic proposed by Gennaioli and Shleifer (2010) and applied to stereotypes in Bordalo, Coffman, Gennaioli, and Shleifer (hereafter BCGS 2015). In BCGS, the stereotype of a certain group if formed by overweighing the traits that occur more frequently in that group *relative* to a comparison group. For instance, the share of red haired people among the Irish is exaggerated because red haired people are much more common among the Irish than in the average national group. In our framework, stereotypes contain a "kernel of truth": beliefs about a group are directionally accurate, but exaggerated relative to reality. This feature of stereotypes has been supported by

[2] Many models of beliefs in finance are motivated by psychological evidence, but use specifications specialized to financial markets (e.g., Barberis, Shleifer, and Vishny 1998, Fuster, Laibson, and Mendel **2010**, Hirshleifer et al 2015, Greenwood and Hanson 2015, Barberis et al. 2015). We discuss these alternatives later in the paper. Fuster et al (2010) review evidence from a variety of lab and field settings documenting deviations from Rational Expectations, and in particular extrapolative expectations.

considerable empirical evidence (see Jussim 2015 for a survey). More generally, the GS (2010) framework can account for several well-documented judgment biases, such as the conjunction and disjunction fallacies, as well as base rate neglect.

The idea of stereotypical thinking can be naturally applied to macroeconomic problems. In these problems, agents form beliefs about the future, and update them in light of new data. Stereotypical thinking accepts this framework, but adds the idea that agents update their beliefs *in the context* of their current data. In particular, agents focus on, and thus overweight in their expectations, incoming news that are most different from what they knew until now. Just as people over-react to the information that a person is Irish when estimating the likelihood of red hair, so they over-react to drastic news pointing to a certain future outcome. As we show below, this approach has significant implications. For example, a rising path of news will lead to excess optimism, a declining path to excess pessimism, even when these paths lead to the same fundamentals. There is a kernel of truth in assessments (after a rising path the investor revises upwards, after a falling path he revises downwards) but revisions are excessive. When news stabilize, the agent no longer extrapolates change, but such a systematic cooling off of expectations itself leads to a reversal. Excessively volatile expectations drive cyclical fluctuations in both financial and economic activity.

We construct a neoclassical macroeconomic model in which the only non-standard feature is expectations. In particular, we do not include financial or any other frictions. The model accounts for many empirical findings, some of which also obtain under rational expectations, but some do not. In our model:

1) In response to good news about the economy, credit spreads decline, credit expands, the share of high risk debt rises, and investment and output grow.

2) Following this period of narrow credit spreads, these spreads predictably rise on average, credit and share of high risk debt decline, while investment and output decline as well. Larger spikes in spreads predict lower GDP growth.
3) Credit spreads are too volatile relative to fundamentals and their changes are predictable in a way that parallels the cycles described in points 1) and 2).
4) There are predictable forecast errors in investor beliefs, and thus systematic abnormal bond returns, that parallel the cycles described in points 1) and 2).

Prediction 1) can obtain under rational expectations, and the same is true about prediction 2) provided fundamentals are mean reverting. Predictions 3) and 4), in contrast, depend on our psychological model of expectations.

In the next section, we present our basic macroeconomic model. Section 3 focuses on our specification of the expectations mechanism, and introduces stereotypical thinking. It also describes how expectations evolve in our model, and relates our formulation to extrapolation and neglected risk. Section 4 examines credit markets in this model, and in particular focuses on credit spreads, total credit, and credit share accruing to risky firms. Section 5 turns to the predictions of the model for aggregate macroeconomic volatility. Section 6 concludes.

## 2. The model

### 2.1 Production

Time is discrete $t = 0,1,\ldots$ The state of the economy at $t$ is captured by a random variable $\Omega_t \in \mathbb{R}$, whose realization is denoted by $\omega_t$. This random variable follows a Markov process and we further assume that the distribution of $\Omega_t$ conditional on $\Omega_{t-1}$ is normal, as in the AR(1) case $(\omega_t - \overline{\omega}) = b(\omega_{t-1} - \overline{\omega}) + \epsilon_t$, with $\epsilon_t \sim N(0, \sigma^2)$ and $\overline{\omega} \in \mathbb{R}$, $b \in [0,1]$.

A measure 1 of atomistic firms uses capital to produce output. The productivity of firms at $t$ depends on the aggregate state $\omega_t$, but to a different extent for different firms. Each firm is identified by a risk parameter $\rho \in \mathbb{R}$. Firms with higher $\rho$ are less likely to be productive in any state $\omega_t$. Formally, if at $t$ a firm of type $\rho$ has invested capital $k$, its output is given by:

$$y(k|\omega_t,\rho) = \begin{cases} k^\alpha & if \quad \omega_t \geq \rho \\ 0 & if \quad \omega_t < \rho \end{cases}, \tag{1}$$

where $\alpha \in (0,1)$. The firm produces only if it is sufficiently safe, $\rho < \omega_t$. Very safe firms, for which $\rho = -\infty$, produce $k^\alpha$ in every state of the world. The higher is $\rho$, the better the state of the economy needs to be (in the sense of $\omega_t$ being large enough) for a risky firm's investment to pay off. Conditional on the capital stock $k$, two firms produce the same output if they are both active, namely if $\omega_t \geq \rho$ for both firms.

A firm's riskiness is common knowledge and $\rho$ is distributed across firms with density $f(\rho)$. Capital for production at $t+1$ must be installed at $t$, before $\omega_{t+1}$ is known. Capital fully depreciates after usage. Thus, at time $t$ each firm $\rho$ demands funds $D^f_{t+1}(\rho)$ from a competitive financial market to finance its capital investment, namely $D^f_{t+1}(\rho) = k_{t+1}(\rho)$. The firm issues risky debt that promises a contractual interest rate $r_{t+1}(\rho)$. Debt is repaid only if the realized state of the economy allows the firm to be productive. If at $t$ the firm borrows $D^f_{t+1}(\rho)$ at the interest rate $r_{t+1}(\rho)$, next period it produces and repays $r_{t+1}(\rho)D^f_{t+1}(\rho)$ provided $\omega_{t+1} \geq \rho$, and defaults otherwise.

Because there are no agency problems and each firm's output has a binary outcome, the model does not distinguish between debt and equity issued by the firm. Both contracts are contingent on the same outcome and promise the same rate of return. For concreteness, we refer to the totality of capital invested as debt.

## 2.2 Households

A risk neutral, infinitely lived, representative household discounts the future by a factor $\beta < 1$. At each time $t$, the household allocates its current income between consumption and investment by maximizing its expectation of the utility function:

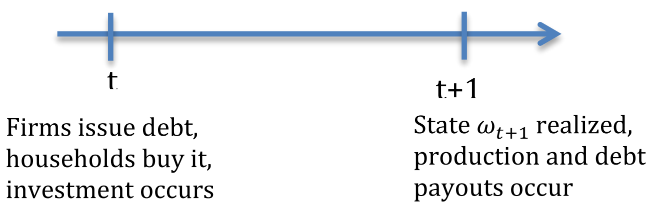
$$\sum_{s=t}^{+\infty} \beta^{s-t} c_s.$$

The household's investment consists in buying the claims issued by firms – which then pay out or default in the next period – while its income consists of the payout of debt bought in the previous period, the profits of firms (which are owned by the household), and a fixed endowment $w$. That is, for each time $s$ and state $\omega_s$ the household's budget constraint is:

$$c_s + \int_{-\infty}^{+\infty} D_{s+1}^h(\rho) f(\rho) d\rho = w + \int_{-\infty}^{+\infty} I(\rho, \omega_s)[r_s(\rho) D_s^h(\rho) + \pi_s(\rho)] f(\rho) d\rho,$$

where $c_s$ is consumption, $D_{s+1}^h(\rho)$ is capital currently supplied to firm $\rho$, $I(\rho, \omega_s)$ is an indicator function equal to one when firm $\rho$ repays, namely when $\omega_s \geq \rho$, and $\pi_s(\rho)$ is the profit of firm $\rho$ when active. The household's income depends, via debt repayments, on the state of the economy: the worse is the current state (the lower is $\omega_s$), the higher is the fraction of firms that default and thus the lower is the household's income. [3]

The timeline of an investment cycle in the model is illustrated below.




[3] As we show later, the fixed endowment $w$ ensures that the household's income is high enough that the equilibrium expected return of any investment (that is, the expected marginal product of capital) is equal to $\beta^{-1}$. We could alternatively assume that there is a riskless, fixed size, technology that guarantees the household's income to be high enough in any state $\omega_t$.

Investment decisions by households and firms depend on the *perceived* probability with which each firm type $\rho$ repays its debt in the next period. When the current state is $\omega_t$, the objective probability of repayment is given by:

$$\mu(\rho|\omega_t) = \Pr(\omega_{t+1} \geq \rho|\omega_t) = \int_{\rho}^{+\infty} h(\Omega_{t+1} = \omega|\Omega_t = \omega_t)\, d\omega, \qquad (2)$$

where $h(\Omega_{t+1} = \omega|\Omega_t = \omega_t)$ is the probability density of next period's state conditional on the current state. The firm defaults with complementary probability $1 - \mu(\rho|\omega_t)$.

Under rational expectations, the repayment probability expected by households and firms is given by $\mu(\rho|\omega_t)$. When psychological factors shape beliefs, the expected and the objective probability distributions of future states may differ. We now introduce investor psychology using the formalization of representativeness developed by GS (2010) and BCGS (2015).

## 3. Stereotypical Thinking and Investor Psychology

### 3.1 Introduction to Stereotypes

Individuals often form stereotypes about social groups or broader categories of activities: Florida residents are elderly, the Irish are red-headed, rust causes tetanus. Social psychologists view stereotypes as simplified models, intuitive generalizations that individuals routinely use in their judgments. Hilton and von Hippel (1996) describe them as "mental representations of real differences between groups […] allowing easier and more efficient processing of information. Stereotypes are selective, however, in that they are localized around group features that are the most *distinctive*, that provide the greatest differentiation between groups[…]."[4] Critically, in this

[4] An earlier approach viewed stereotypes as derogatory generalizations of group traits, reflecting prejudices (Adorno et al. 1950) or other internal motivations (Schneider 2004). This view cannot account for flattering or non-politically charged stereotypes (see BCGS 2015 for a discussion).

definition stereotypes are comparative in nature: Florida residents are elderly compared to residents of other states, the Irish are red-headed compared to other nationalities, rusty nails are slightly more likely to cause tetanus infection than the average object. Stereotypes capture distinctive features as compared to other groups.

In BCGS (2015), we argued that the representativeness heuristic, described in Kahneman and Tversky (KT, 1972), provides a psychological foundation for stereotypes. According to KT (1972), "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 the relevant reference class." Being red-headed is representative of the Irish because red hair is more common among the Irish than among other groups, even though it is not that common in absolute terms. By focusing a decision maker's attention on such distinctive group traits, representativeness creates fast and frugal models that are often reliable, but sometimes entail biases in judgment.

The representativeness heuristic yields a commonly noted aspect of stereotypes, what social psychologists call the "kernel of truth" hypothesis: stereotypes capture empirically valid differences among groups, but may exaggerate them (Judd and Park 1993). This leads to exaggeration of the incidence of the distinctive features in the target group, but also, with continuous distributions, to exaggeration of their means. The Irish are stereotyped as red-haired because red hair is indeed more common among the Irish, but not so much more common as stereotypical thinkers estimate. Floridians are stereotyped as elderly because the share of Florida population over 65 is indeed higher than in the US as a whole. But the share of Floridians over 65 and the average age of the Floridians are estimated to be substantially higher than the truth.

The formalism in BCGS (2015) is as follows. A decision maker judges the distribution of a trait $T$ (e.g. hair color) in a group $G$ (e.g., the Irish). The true distribution of the trait is $h(T = t|G)$, but – due to limited working memory – the decision maker disproportionally attends to representative traits, which are easier to recall. Following GS (2010), the representativeness of $T = t$ for group $G$ is defined as:

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

where $-G$ is a relevant comparison group. As in KT's quote, a trait is more representative if it is relatively more frequent in $G$ than in $-G$. By overweighing representative traits, stereotypes are titled towards true group differences, but downplay common features.

To see this, consider an individual assessing hair color among the Irish. The distributions of hair color in the Irish population and in the world at large are:[5]

| | $T = red$ | $T = blond/light\ brown$ | $T = dark$ |
|---|---|---|---|
| $G \equiv Irish$ | 10% | 40% | 50% |
| $-G \equiv World$ | 1% | 14% | 85% |

The most representative hair color for the Irish is red because it is associated with the highest likelihood ratio among hair colors:

$$\frac{Pr(red\ hair|Irish)}{Pr(red\ hair|World)} = \frac{10\%}{1\%} = 10,$$

When thinking about the Irish, "red haired" is representative and creates a stereotype because the proportion of red haired people among the Irish is ten times higher than in the rest of the world. This stereotype contains a "kernel of truth", since red hair is indeed much more common among the Irish than the rest, but it is

[5] See http://www.eupedia.com/genetics/origins_of_red_hair.shtml and http://www.eupedia.com/europe/genetic_maps_of_europe.shtml. Shares of red hair are based on the sampled distribution of the small number of genetic variants that cause this phenotype. As such, these shares are relatively accurate. The definitions, and shares, of brown and dark hair are approximate.

inaccurate: as in the rest of the world, red hair is uncommon, and dark hair is most common even among the Irish. Likewise, although men are stereotyped as better at math than women, the average differences are trivial relative to the perceived ones: there are more men at the far right tail, but no differences in nearly the whole distribution (BCGS, 2015).

The stereotypical thinker therefore knows the true distribution $h(T = t|G)$, but he disproportionally attends to portions of that distribution that are most different from the distribution of the comparison group $h(T = t| - G)$. In GS (2010) and BCGS (2015) we show that this approach to the representativeness heuristic provides a unified account of several widely documented judgment biases, including base rate neglect, conjunction and disjunction fallacy, over- and under-reaction to data, as well as confirmation bias. It also explains empirical evidence on beliefs about different genders, races, and ethnic groups on a whole variety of dimensions. We next show that the same logic of representativeness that accounts for stereotype formation can be applied to analyzing the evolution of beliefs in a macroeconomic context.

### 3.2 Expectations as Stereotypes

Our model of stereotypes is portable to dynamic environments such as the Markov process, and in particular the AR(1) process, described in Section 2. Here, the agent seeks to represent the distribution of a future state, say $\Omega_{t+1}$, entailed by current conditions $\Omega_t = \omega_t$. The model is easily generalized to longer term predictions $\Omega_{t+T}$ and to richer AR(N) processes. To use the notation of the previous example, where the agent assesses the distribution of hair color conditional on $G = Irish$, here he assesses the distribution of $\Omega_{t+1}$ conditional on $\Omega_t = \omega_t$. To pursue the analogy, we refer to

$G \equiv \{\Omega_t = \omega_t\}$ as the "group" of all realizations of future states in period $t+1$ conditional on $\Omega_t = \omega_t$.

A rational agent assesses $\Omega_{t+1}$ using the true conditional distribution $h(\Omega_{t+1} = \omega_{t+1} | \Omega_t = \omega_t)$. The stereotypical thinker also knows the true distribution, but he overweighs the probability of future states $\omega_{t+1}$ that are representative of $G \equiv \{\Omega_t = \omega_t\}$ relative to a comparison group $-G$.

In the hair color example, $-G$ was taken to be the world population, namely the population not conditioned on the information $G = Irish$. In the current dynamic setting, then, the comparison group for $G \equiv \{\Omega_t = \omega_t\}$ should be the population not conditioned to the current information $\omega_t$. This is represented by *all* past information that bears on forecasts for $\Omega_{t+1}$ up to, but excluding, the realization $\omega_t$ that identifies $G$. By the Markov property, this information is summarized by the past state $\omega_{t-1}$. Thus, the comparison group $-G$ is captured by the distribution of states at $t+1$ that is expected in light of the information set at $t-1$, before $\omega_t$ is realized. Formally, $-G \equiv \{\Omega_t = \mathbb{E}(\omega_t | \omega_{t-1})\}$, where $\mathbb{E}(\omega_t | \omega_{t-1})$ is the state that would prevail at $t$ if new information $\omega_t - \mathbb{E}(\omega_t | \omega_{t-1})$ had not arrived.[6] In the remainder of the paper, we use the standard notation $\mathbb{E}_{t-1}(\omega_t) = \mathbb{E}(\omega_t | \omega_{t-1})$.

When implementing the definition of representativeness, then, the comparison distribution is given by $h(\Omega_{t+1} = \omega_{t+1} | \Omega_t = \mathbb{E}_{t-1}(\omega_t))$, and the representativeness of state $\omega_{t+1}$ is measured by the likelihood ratio:

[6] It is also possible to define $-G \equiv \{\Omega_{t-1} = \omega_{t-1}\}$, which uses the same information set as the above, so that the comparison distribution is $h(\Omega_{t+1} = \omega_{t+1} | \Omega_{t-1} = \omega_{t-1})$. In this case the analysis is slightly more cumbersome (because the target and the comparison distributions have different variances), but the results are qualitatively the same. In particular, the stereotypical thinker's expectations are still represented by Equation (4) below but where the coefficient $\theta$ of the term that departs from rational expectations is replaced by $\frac{\theta r_\sigma^2}{1+\theta(1-r_\sigma^2)}$. In this expression, $r_\sigma^2 = \sigma^2 / \hat{\sigma}^2 < 1$, where $\sigma^2$ is the variance of $h(\Omega_{t+1} = \omega_{t+1} | \Omega_t = \mathbb{E}_{t-1}(\omega_t))$ and $\hat{\sigma}^2$ is the variance of $h(\Omega_{t+1} = \omega_{t+1} | \Omega_{t-1} = \omega_{t-1})$.

$$\frac{h(\Omega_{t+1} = \omega_{t+1} | \Omega_t = \omega_t)}{h(\Omega_{t+1} = \omega_{t+1} | \Omega_t = \mathbb{E}_{t-1}(\omega_t))}. \tag{3}$$

The most representative state is the one whose likelihood increases the most in light of recent information $\omega_t - \mathbb{E}_{t-1}(\omega_t)$.

In general, one could specify the comparison group to be anchored to a different conditioning state $\omega^c$, so that $-G \equiv \{\Omega_t = \omega^c\}$. For instance, in our AR(1) example the reference could be the long run distribution centered around the state to which the process reverts in the long run (i.e., $\omega^c = \overline{\omega}$). At the end of this section, we discuss alternative ways of specifying $\omega^c$ and their implications for expectation formation.

We formalize overweighting of representative states by assuming that the stereotypical thinker attaches to future state $\omega_{t+1}$ the distorted probability density:

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

where $Z$ is a normalizing constant ensuring that $h_t^\theta(\omega_{t+1})$ integrates to one, and $\theta \in (0, +\infty)$ measures the severity of stereotyping.

Compared to the formalism in BCGS (2015), this formula allows for a smooth distortion of the true distribution. When $\theta = 0$, the stereotypical thinker uses the available data to form correct expectations of future performance: he holds rational expectations. Our formalism thus allows us to examine rational expectations as a special case. When $\theta > 0$, the stereotypical distribution $h_t^\theta(\omega_{t+1})$ inflates the likelihood of representative states and deflates the likelihood of non-representative ones.

In this formulation, news do not just alter the objective likelihood of certain states. They also change, through representativeness, the extent to which the agent focuses on particular states. An event that increases the likelihood of future state $\omega_{t+1}$

also makes it more representative, so $h_t^\theta(\omega_{t+1})$ overshoots. The reverse occurs when the likelihood of $\omega_{t+1}$ decreases.

If the likelihood ratio in (2') is monotonically increasing in $\omega_{t+1}$, then "rationally" good news $\omega_t > \mathbb{E}_{t-1}(\omega_t)$ cause the household to overweight good future states, and to underweight future bad states (and conversely if news are bad). In this sense, stereotypes cause good news to induce neglect of downside risk. This is illustrated in the result below.

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

$$\mathbb{E}_t^\theta(\omega_{t+1}) = \mathbb{E}_t(\omega_{t+1}) + \theta[\mathbb{E}_t(\omega_{t+1}) - \mathbb{E}_{t-1}(\omega_{t+1})]. \quad (4)$$

Stereotypical beliefs can be represented as a linear combination of the rational expectation of the same variable $\omega_{t+1}$ held at dates $t$ and $t-1$. The interpretation is not that the decision-maker computes rational expectations and combines them according to Proposition 1. Rather, overweighting the likelihood of representative future states yields expectations equivalent to the linear combination (4). This feature obtains because representativeness is itself a function of true probability densities, as in the ratio (3). Thus, deviations from rationality are closely connected to the rational process: when adjusting beliefs about future states that have become more likely, agents focus on the news that drive the updating of beliefs, and overreact to them.[7]

The property that $\mathbb{E}_t^\theta(\omega_{t+1})$ is a function of rational expectations is a reflection of the "kernel of truth" logic: stereotypical expectations differ from rational expectations by a shift in the direction of the information received at $t$, given by $[\mathbb{E}_t(\omega_{t+1}) -$

[7] This logic also implies that overreaction to *given* information is temporary: while on impact the decision maker overreacts to new information, in the future he correctly uses past information to make his forecast. This feature plays a key role in our analysis of economic cycles in Section 5.

$\mathbb{E}_{t-1}(\omega_{t+1})]$.[8] Figure 1 illustrates the entailed neglect of risk. After receiving good news, the stereotypical distribution of $\omega_{t+1}$ is a right shift of the objective distribution. Due to the monotone increasing and unbounded likelihood ratio of normal densities, good news cause under-estimation of probabilities in the left tail (the shaded area).

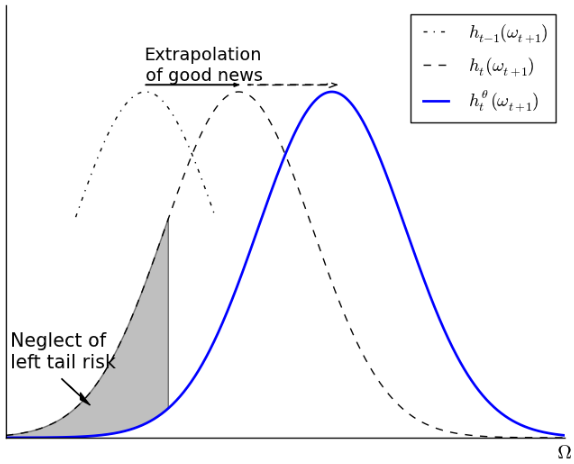



Figure 1.

This logic also provides a psychological foundation for extrapolative expectations. Writing the AR(1) process as $(\omega_t - \overline{\omega}) = b(\omega_{t-1} - \overline{\omega}) + \epsilon_t$, with persistence parameter $b$, Equation (4) becomes:

$$\mathbb{E}_t^\theta(\omega_{t+1}) - \omega_t = [\mathbb{E}_t(\omega_{t+1}) - \omega_t] + b\theta[\omega_t - \mathbb{E}_{t-1}(\omega_t)], \tag{5}$$

The stereotypical thinker ($\theta > 0$) extrapolates the current shock $\omega_t - \mathbb{E}_{t-1}(\omega_t)$ into the future. Extrapolation arises because he overreacts to the information contained in $\omega_t - \mathbb{E}_{t-1}(\omega_t)$ (and only if the data are serially correlated, $b > 0$). The stereotypical thinker's forecasts exaggerate the role of surprising new information, corresponding to Kahneman's (2011) view that "our mind has a useful capability to focus spontaneously

[8] According to Equation (4), the effect of surprises is summarized by a shift in the point expectation. This feature – and the tractability it entails – extends to the exponential class of distributions, including many of the most commonly used distributions (including lognormal, exponential, and others).

on whatever is odd, different, or unusual." This property differentiates our model from backward looking models such as adaptive expectations. We return to this point below.

As Figure 1 illustrates, in our model neglect of risk and extrapolation are connected by the same psychological mechanism. Good news render good future states representative. The agent thus overweighs good future states, effectively extrapolating the news into the future and downplaying the probability of future bad events.

The model can account for both over- and under-reaction to information. In particular, Equation (4) generates over-reaction to repeated news in the same direction provided these news accelerate, such as when a small piece of positive news is reinforced by bigger positive news. When alternatively the news fail to maintain momentum, as when a large positive shock is followed by a small positive shock, Equation (4) entails under-reaction.[9]

This is illustrated in Figure 2, which shows two alternative paths of a random walk ($b = 1$) between the same end-points. Rational Expectations always coincide with the current state of the world (dotted line, $\theta = 0$), but stereotypical expectations do not (solid line, $\theta = 1$). The top panel shows that accelerating news cause stereotypical expectations to be too optimistic; conversely, a strong deceleration at the end of this streak causes a major reversal in expectations (back to rationality). The bottom panel shows that decelerating good news can, through cooling off of previous overreaction, cause expectations to underreact, and even move in the opposite direction of news. However, in this case major reversals reversals are avoided.

[9] Formally, we have that $\left|\mathbb{E}_t^\theta(\omega_{t+1}) - \mathbb{E}_{t-1}^\theta(\omega_{t+1})\right| > |\mathbb{E}(\omega_{t+1}|\omega_t) - \mathbb{E}(\omega_{t+1}|\omega_{t-1})|$ if and only if the following condition holds: $|\mathbb{E}(\omega_{t+1}|\omega_t) - \mathbb{E}(\omega_{t+1}|\omega_{t-1})| > |\mathbb{E}(\omega_{t+1}|\omega_{t-1}) - \mathbb{E}(\omega_{t+1}|\omega_{t-2})|$.

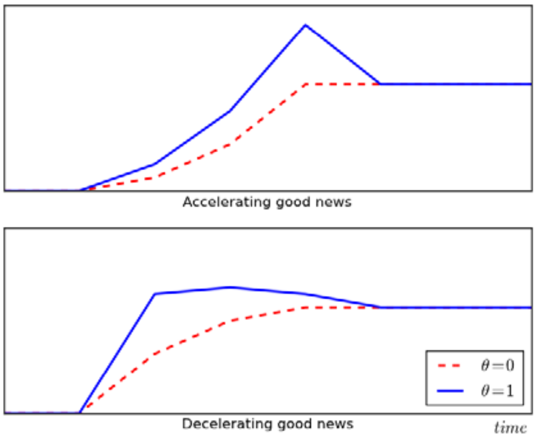



Figure 2.

The specific predictions of the model concerning agent's reaction to certain paths of news depend on the specification of the comparison group $-G$. Here we have assumed that $-G$ is the immediate past. This formulation imposes a lot of volatility in the frames used to interpret news, because $-G$ is updated each period. More rigid frames can also be considered. For example, Gennaioli, Shleifer and Vishny (2015) present a model of stereotypes in which the reference group is updated only every $T > 1$ periods. This implies that Equation (4) takes the form:

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

In this case, the agent over-reacts in the direction of the total update $\mathbb{E}_t(\omega_{t+1}) - \mathbb{E}_{t-T}(\omega_{t+1})$, but under-reacts to individual news going in the opposite direction.[10]

More broadly, the stereotypical thinker exhibits context-dependence in his reaction to information. The interpretation of a given piece of news can be more or less

[10] GSV (2015) use this form of under-reaction to contrary news to explain why, during periods of market euphoria, early warnings are neglected until a large shock strikes. In general, one could specify $-G$ to be a linear combination of past news (e.g. $\omega^c = \sum \theta_r \mathbb{E}(\omega_{t+1}|\omega_{t-r})$). Under the assumed normal process, this specification is appropriate when representativeness is shaped also by past changes, not only by the change experience between $t-1$ and $t$. It reflects the fact that the more remote past also provides references to interpret recent information and may allow us to analyze recency effects.

favorable depending on the agent's reference comparison – $G$.[11] The structure of – $G$ can be analysed empirically by comparing model predictions with data on expectations elicited in the field or under experimental conditions. Here we choose $-G \equiv \{\Omega_t = \mathbb{E}_{t-1}(\omega_t)\}$ because it is in a sense the simplest specification and yields several phenomena we are interested in, including credit cycles.

### 3.3 Relationship to the Literature

We conclude this section by comparing our model with several others in the literature. We note to begin that the forward-looking nature of expectations in our model avoids well-known pitfalls of adaptive expectations. For instance, $\mathbb{E}_t^{\theta}(\omega_{t+1})$ is fully rational when the state follows an i.i.d. process ($b = 0$ in Equation (5)) or a deterministic path ($h(\omega_t|\omega_s)$ is degenerate), or when no shock occurred, $h(\omega_{t+1}|\omega_t) = h(\omega_{t+1}|\omega_{t-1})$ or equivalently $\omega_t = \mathbb{E}_{t-1}(\omega_t)$. Stereotyping distorts reaction to information, but does not cause reaction to uninformative data.

There have been other attempts to model extrapolative beliefs.[12] Barberis, Shleifer and Vishny (1998) consider a decision maker who, in light of incoming news, updates his beliefs on whether the economy is in a mean reverting or a trending regime. Both regimes he believes are possible are wrong (the data generating process is a random walk) and the decision maker erroneously extrapolates from sequences of positive shocks because the latter support the trending model. Hirshleifer and Yu (2015) and Greenwood and Hanson (2015) assume that investors believe that shocks to

[11] As stressed by Kahneman (2003), this is a key feature of human perception "Perception is reference-dependent: the perceived attributes of a focal stimulus reflect the contrast between that stimulus and a context of prior and concurrent stimuli."

[12] Some of the early attempts include DeLong et al. (1990) and Cutler et al. (1990).

fundamentals are more persistent than in the data generating process. In these models, positive shocks are believed to impact the economy farther into the future.

Our model shows that the intuitions about belief updating captured by these models follow naturally from a single underlying psychological principle, namely representativeness. Individuals focus on scenarios that become representative in light of news, while neglecting unrepresentative scenarios. Good news leads investors to stereotype the future as trending, neglecting a significant probability of a correction. This also implies that the current shock is believed to be more persistent than it is in reality.[13] Importantly, our formalization of representativeness is capable of accounting for a variety of other pieces of evidence on human judgment, ranging from systematic errors in probabilistic judgments (Gennaioli and Shleifer 2010) to social psychologists' accounts of stereotypes (Bordalo, Coffman, Gennaioli and Shleifer, 2015). Our model is portable in Rabin's (2013) sense: it can be applied across different domains, from beliefs in social contexts to expectations in financial markets, in a consistent way.

The second important concern our model explicitly addresses is the Lucas critique. This critique holds that mechanical models of expectations can be used for policy evaluation only under the very restrictive assumption that the expectations formation process is invariant to changes in policy. The validity of this assumption was

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[13] Stereotypes can be mapped more precisely to these models. In a setting in which the agent learns the persistence of fundamentals, we conjecture that the stereotypical thinker switches too much between the extremes of a trending and an i.i.d. model, neglecting the more likely middle ground. This provides a foundation for the assumption in BSV (1998) that the middle ground is not in the support of the models considered by the agent.

Stereotypes also offer a psychological foundation for the assumption that decision makers exaggerate the persistence parameter of an underlying AR(1) process. In our model, this case arises when fundamentals indeed follow an AR(1) *and* when individuals compare observed outcomes to the long run distribution. Formally, assuming that $-G \equiv \{\Omega_t = \overline{\omega}\}$ yields $\mathbb{E}_t^{\theta}(\omega_{t+1} - \overline{\omega}) = b(1+\theta)(\omega_t - \overline{\omega})$, as in Greenwood and Hanson (2015).

Daniel, Hirshleifer and Subrahmanyam (1998) consider overconfident investors, who exaggerate the precision of privately observed signal, extrapolating private information. Stereotypical thinking is portable to such models of Bayesian learning. In these settings, representativeness indeed induces agents to compress the true variance of private signals, and also to exaggerate the direction of the signal.

challenged after empirical estimates of adaptive expectations processes revealed substantial parameter instability to policy change. This instability led researchers to prefer the polar alternative of rational expectations, precisely to account for changes in expectations due to regime shifts. But, importantly, responding to the Lucas critique does not necessitate rational expectations; it merely requires that expectations be sensitive to future changes in the environment.

Our model of stereotypical thinking shares this important feature with rational expectations. It is immune to the Lucas critique in the precise sense that the process of expectation formation is forward looking and depends on the prevailing data generating process. Because stereotypical expectations distort the true distribution $h_t(\omega_{t+1})$, these expectations respond to policy changes that affect $h_t(\omega_{t+1})$. The stereotypical distribution $h_t^\theta(\omega_{t+1})$ incorporates changes in the objective frequency (as under rational expectations) but also changes in representativeness. Thus, if the government commits to inflating the economy, inflation expectations will also react upwards.

In his path-breaking paper introducing Rational Expectations, Muth (1961) discusses the possibility that expectations over or under-react to news. To capture these phenomena while keeping model consistency, he proposes a generalization of rational expectations that allows for systematic expectational errors. Muth's formula is precisely of the linear form of Equation (4): relative to rationality, expectations can distort the effect of recent news. Our model shows that Muth's formulation is not ad-hoc: it follows from a natural formalization of the psychology of representativeness.

We now return to the model and show that the psychology of representativeness can generate excess volatility in beliefs, over-heating and over-cooling of credit markets, as well as predictable shifts in market sentiment, credit spreads, and economic activity that account for many features of observed credit cycles.

## 4. Equilibrium under Stereotypical Thinking

### 4.1 Capital Market Equilibrium and Credit Spreads

At time $t$ firm $\rho$ demands capital $k_{t+1}(\rho)$ at the market contractual interest rate $r_{t+1}(\rho)$ so as to maximize its expected profit at $t+1$:

$$\max_{k_{t+1}(\rho)} (k_{t+1}(\rho)^{\alpha} - k_{t+1}(\rho) \cdot r_{t+1}(\rho)) \cdot \mu_t^{\theta}(\rho), \tag{6}$$

where investment is financed with debt issuance $k_{t+1}(\rho) = D_{t+1}^{f}(\rho)$. The function $\mu_t^{\theta}(\rho)$ denotes the firm's believed probability at time $t$ that it is productive at $t+1$. It is obtained by computing Equation (2) under the stereotypical distribution:

$$\mu_t^{\theta}(\rho) = \int_{\rho}^{+\infty} h_t^{\theta}(\omega_{t+1})\, d\omega_{t+1}. \tag{7}$$

The first order condition for the profit maximization problem is given by:

$$k_{t+1}(\rho) = \left[\frac{\alpha}{r_{t+1}(\rho)}\right]^{\frac{1}{1-\alpha}}, \tag{8}$$

which is the usual downward sloping demand for capital.

Households are willing to supply any amount of capital to firm $\rho$ at the interest rate $r_{t+1}(\rho)$ at which the expected repayment of the firm is just sufficient for the household to be willing to postpone its consumption:

$$r_{t+1}(\rho)\mu_{t+1}^{\theta}(\rho) = \beta^{-1} \quad \Leftrightarrow \quad r_{t+1}(\rho) = \frac{1}{\beta\mu_{t+1}^{\theta}(\rho)}. \tag{9}$$

In equilibrium, this condition must hold for all firms $\rho$. First, debt of all firms must yield the same expected return, which cannot be below $\beta^{-1}$. Otherwise, the household would not supply capital to some or all firms. There would thus exist investment opportunities yielding an infinite expected return, which cannot occur in equilibrium. Second, if the expected return from investment rose above $\beta^{-1}$, the household would save the totality of its income. As previously noted, the endowment $w$

is large enough that the marginal product of capital would fall below $\beta^{-1}$, which – as argued above – cannot occur in equilibrium. Formally, we assume:

**A.1** $w \geq (\alpha\beta)^{\frac{1}{1-\alpha}}$.

This condition implies that even if all firms are believed to repay for sure ($\mu_{t+1}^{\theta}(\rho) = 1$ for all $\rho$), the endowment is large enough that, if invested entirely, would drive the marginal return on capital below $\beta^{-1}$. We assume A.1 throughout.

By combining Equations (8) and (9) we obtain the volume of debt that firm $\rho$ issues at $t$ and households purchase, as well as the firm's installed capital stock at $t+1$:

$$k_{t+1}(\rho) = \left[\alpha\beta\mu_t^{\theta}(\rho)\right]^{\frac{1}{1-\alpha}}. \tag{10}$$

Using firm level investment, we can compute other key real variables. Aggregate investment at $t$, and thus capital installed at $t+1$, is given by:

$$K_{t+1} = \int_{-\infty}^{+\infty} \left[\alpha\beta\mu_t^{\theta}(\rho)\right]^{\frac{1}{1-\alpha}} f(\rho)d\rho. \tag{11}$$

Aggregate output at $t+1$ conditional on state $\omega_{t+1}$:

$$Y_{t+1}(\omega_{t+1}) = \int_{-\infty}^{\omega_{t+1}} \left[\alpha\beta\mu_t^{\theta}(\rho)\right]^{\frac{\alpha}{1-\alpha}} f(\rho)d\rho. \tag{12}$$

Financial markets and production are shaped by the perceived creditworthiness of firms, $\mu_t^{\theta}(\rho)$. When times are good, households are optimistic about the future state of the economy. The perceived creditworthiness of firms is high, households supply more capital, the interest rate falls, firms issue more debt and invest more, and future output rises. When times turn sour, households cut lending, firms issue less debt and cut investment, and the economy contracts.

### 4.2 Credit Spreads and the short run response to shocks

We now analyze the role of stereotypical thinking in determining perceived creditworthiness of firms and, through that, the behavior of the economy. We focus on the short term link between credit spreads, debt issuance, and investment. We analyze the economic cycle in Section 5.

Under the assumed AR(1) process, the perceived creditworthiness of firm $\rho$ at time $t$ (i.e. its assessed probability of repayment at $t+1$) is given by:

$$\mu_t^\theta(\rho) = \frac{1}{\sigma\sqrt{2\pi}} \int_\rho^{+\infty} e^{-\frac{\left(\omega_{t+1} - \mathbb{E}_t^\theta(\omega_{t+1})\right)^2}{2\sigma^2}} d\omega_{t+1}. \qquad (13)$$

A perfectly safe firm $\rho \to -\infty$ never defaults, since $\lim_{\rho\to-\infty} \mu_{t+1}^\theta(\rho) = 1$. By Equation (8), then, it promises the safe interest rate $\lim_{\rho\to-\infty} r_{t+1}(\rho) = \beta^{-1}$.

Riskier firms have to compensate debt holders for bearing their default risk by promising contractual interest rates above $\beta^{-1}$. The spread obtained on their debt relative to the debt of safe firms is given by:

$$S_t^\theta(\rho) \equiv r_{t+1}(\rho) - \beta^{-1} = \left(\frac{1}{\mu_t^\theta(\rho)} - 1\right)\beta^{-1}. \qquad (14)$$

The credit spread increases for riskier firms, namely those with lower $\mu_t^\theta(\rho)$, so riskier firms borrow and invest less in equilibrium:

$$k_{t+1}(\rho) = \left(\frac{\alpha\beta}{1 + \beta S_t^\theta(\rho)}\right)^{\frac{1}{1-\alpha}}.$$

To proceed, consider how a firm's perceived creditworthiness depends on the current state $\omega_t$. After some algebra, we can show:

$$\frac{\partial \ln \mu_t^\theta(\rho)}{\partial \omega_t} = \left[\mathbb{E}_t^\theta(\omega_{t+1}|\omega_{t+1} \geq \rho) - \mathbb{E}_t^\theta(\omega_{t+1})\right]\frac{b(1+\theta)}{\sigma^2} > 0. \qquad (15)$$

Better news boost households' perception of creditworthiness. The effect is proportionally stronger for riskier firms, because $\partial^2 \ln \mu_t^\theta(\rho)/\partial\omega_t\partial\rho > 0$. Riskier firms are more exposed to the aggregate state, so they benefit relatively more when economic conditions improve. Improvements in perceived creditworthiness are also stronger when $\theta$ is higher: stereotypical thinking causes a stronger reaction of perceived creditworthiness to better news.

We then have:

**Proposition 2** *As current aggregate conditions $\omega_t$ improve:*

*i) spreads drop and become compressed:*

$$\frac{\partial S_t^{\theta}(\rho)}{\partial \omega_t} = -\frac{1}{\beta\sigma^2\mu_t^{\theta}(\rho)}\frac{\partial \ln \mu_t^{\theta}(\rho)}{\partial \omega_t} < 0, \qquad \frac{\partial^2 S_t^{\theta}(\rho)}{\partial \omega_t \partial \rho} < 0.$$

*ii) debt issuance and investment increase, disproportionately so for riskier firms:*

$$\frac{\partial K_{t+1}}{\partial \omega_t} = \left(\frac{1}{1-\alpha}\right)\int_{-\infty}^{+\infty} \frac{\partial \ln \mu_t^{\theta}(\rho)}{\partial \omega_t} k_{t+1}(\rho) f(\rho) d\rho > 0,$$

$$\frac{\partial}{\partial \omega_t}\frac{k_{t+1}(\rho_1)}{k_{t+1}(\rho_2)} \propto \frac{\partial \ln \mu_t^{\theta}(\rho_1)}{\partial \omega_t} - \frac{\partial \ln \mu_t^{\theta}(\rho_2)}{\partial \omega_t} > 0 \;\; for\ all\ \rho_1 > \rho_2.$$

As current and thus expected conditions improve, firms' perceived creditworthiness improves as well. As a consequence, interest rate spreads charged to risky firms fall. This decline in the cost of borrowing is greater for riskier firms, so that credit spreads become compressed. The decline in the borrowing costs in turn stimulates debt issuance and aggregate investment. Once again, because spreads fall more for riskier firms, the increase in debt issuance is greater for those firms.

These predictions of the model are consistent with the evidence of Greenwood and Hanson (2013). They document that when the BBB-credit spread falls, bond issuance increases and the effect is particularly strong for firms characterized by higher expected default rates. As a consequence, the share of non-investment grade debt over total debt (the "junk share") increases, as has also been documented by LSZ (2015).

Our model also accounts for the behavior of the junk share. Consider the share of debt issued by firms riskier than an arbitrary threshold $\hat{\rho}$:

$$\frac{\int_{\hat{\rho}}^{+\infty} k_{t+1}(\rho) f(\rho) d\rho}{K_{t+1}}.$$

This quantity increases as spreads become compressed (for any $\hat{\rho}$). The opposite effects arise when economic conditions deteriorate. Credit spreads increase, investment falls and there is a flight to safety, so that the junk share falls as well.

In our model, this relation between spreads and debt issuance is triggered by the asymmetric exposure of different firms to changes in fundamentals assumed in (1). More generally, the qualitative effects described in Proposition 2 do not rely on stereotypical thinking and obtain even if households are fully rational, since, as illustrated in Equation (15), positive news always leads to an upward revision of firms' creditworthiness, and the more so for riskier firms.

However, stereotypical thinking complements the effect of fundamentals and allows the model to match additional pieces of evidence that the rational expectations assumption cannot accommodate. Before analyzing these predictions, it is useful to consider the way in which the expectations of our decision makers differ from the rational benchmark. Due to their extrapolative nature, stereotypical beliefs: i) exhibit too much volatility, and ii) are systematically wrong. Formally:

**Proposition 3** *Equation (4) implies that:*

*i) At $t-1$, the variance of future expectations $\mathbb{E}_t^\theta(\omega_{t+1})$ increases in $\theta$:*

$$Var\left[\mathbb{E}_t^\theta(\omega_{t+1})|\omega_{t-1}\right] = (1+\theta)^2 Var[\mathbb{E}(\omega_{t+1}|\omega_t)|\omega_{t-1}].$$

*ii) At $t$, the stereotypical thinker makes a predictable forecast error:*

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

The beliefs of stereotypical thinkers display excess volatility because they are distorted in the direction of realized news. When news is positive (negative), expectations are too optimistic (pessimistic).

Excess volatility also causes predictable forecasting errors. After good news, the error is negative, the more so the better the current state $\mathbb{E}_t(\omega_{t+1})$, and conversely after bad news. These predictions are illustrated in Figure 3. Panel A simulates a path of an AR(1) process and shows excess volatility of stereotypical expectations $\mathbb{E}_t^\theta(\omega_{t+1})$ (solid line) relative to rational expectations $\mathbb{E}_t(\omega_{t+1})$ (dashed line).[14] For the same simulation, Panel B documents the negative correlation between forecast errors $\omega_{t+1} - \mathbb{E}_t^\theta(\omega_{t+1})$ and current conditions $\omega_t$.

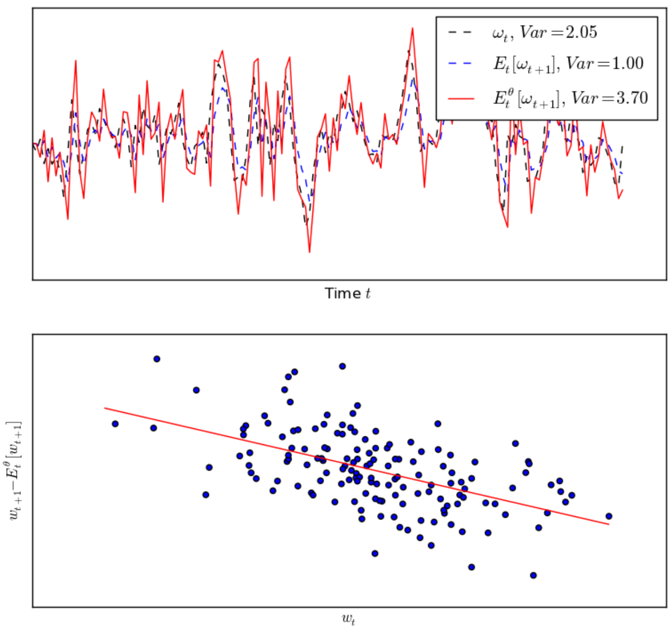


Figure 3.

We focus on current conditions – instead of recent changes in fundamentals as suggested by Corollary 1ii) – because the former have been studied more extensively in

[14] The simulated process is $\omega_t = 0.7\omega_{t-1} + \varepsilon_t$, with shocks $\varepsilon_t \sim \mathcal{N}(0,1)$ i.i.d. across time. The simulation started at $\omega_t = 0$ (the long-term mean of the process), and was run for 150 periods. The stereotypical thinking parameter was set at $\theta = 1$, and the technology scaling parameter at $\alpha = 0.8$.

the literature.[15] For example, Gennaioli, Ma, and Shleifer (2015) analyze quarterly data on the expectations of earning growth reported by CFOs of large U.S. corporations during the period 2005-2012. They find that these expectations are too volatile relative to fundamentals and that they have an extrapolative structure: the error in forecasting earnings growth is negatively related to past earnings. Our model of stereotypical thinking offers a psychologically founded way to account for these findings, as illustrated in Panel B of Figure 3.

In the current setup, excess volatility and systematic errors in expectations immediately translate into excess volatility and abnormal returns in credit markets:

**Proposition 4** *Suppose that at time t new information* $[\mathbb{E}(\omega_{t+1}|\omega_t) - \mathbb{E}(\omega_{t+1}|\omega_{t-1})]$ *arrives. Then, under stereotypical thinking* $\theta > 0$ *we have that:*

*i) Credit spreads overreact:*

$$\frac{\partial S_t^\theta(\rho)}{\partial\theta} = \frac{\partial S_t^\theta(\rho)}{\partial\omega_t}\frac{[\mathbb{E}_t(\omega_{t+1}) - \mathbb{E}_{t-1}(\omega_{t+1})]}{b(1+\theta)}.$$

*Moreover, spreads exhibit excess volatility. To a second order approximation in* $\theta$*:*

$$Var\left[S_t^\theta(\rho)|\omega_t\right] \approx (1+\theta)^2 Var[S_t^0(\rho)|\omega_t],$$

*where* $S_t^0(\rho)$ *denotes the spread in the rational expectations benchmark* $(\theta = 0)$. *As a consequence, aggregate investment also displays excess volatility.*

*ii) Positive **news** compresses credit spreads* $S_t(\rho)$ *at time t and predicts low average debt returns* $\frac{\mu_{t+1}(\rho)}{\mu_{t+1}^\theta(\rho)}\beta^{-1} < \beta^{-1}$ *at time* $t+1$. *With negative **news**, the reverse happens.*

[15] Provided the AR(1) process has some mean reversion, $b < 1$, high levels of expectations are statistically associated with recent positive news, so that the model also generates a negative correlation between forecast error and expectation levels.

As shown in Section 2, stereotypical thinking exaggerates the reaction of beliefs to new information. For a given $\omega_{t-1}$, households become too optimistic when new information at $t$ is positive and too pessimistic when it is negative. Stereotypical thinking leads to an excessive spread compression when economic times are improving, and conversely to an excessive widening in spreads when economic times are deteriorating. These effects are stronger for riskier firms.

As a consequence of overreaction, expectations exhibit excess volatility with respect to the true underlying volatility of fundamentals. As we have seen in Proposition 3, excess volatility is due to the fact that the beliefs of stereotypical thinkers do not just depend on the *level* of the current fundamentals $\omega_t$ (as would be the case under rational expectations). They also depend on the magnitude of the recently observed news, which corresponds roughly speaking to the *change* in fundamentals. Reaching a given level of fundamentals through a large positive piece of news causes more optimism than reaching the same level via a small upgrade. This path-dependence introduces excess volatility as well as predictability of expectations and spreads that helps account for a variety of empirical findings.

First, several papers document that credit spreads appear too volatile relative to what could be explained by the volatility in default rates or fundamentals (Collin-Dufresne et al. 2001, Gilchrist and Zakrasjek 2012). For instance, Collin-Dufresne et al. (2001) find that credit spreads display excess volatility relative to measures of fundamentals such as realized default rates, liquidity, or business conditions. They argue this excess volatility can be explained by a common factor that captures aggregate shocks in credit supply and demand. Our model suggests that investors' excessive reaction to changing news can offer an account of these shocks.

Excess volatility in reaction to news yields another key implication of stereotypical thinking: predictable forecast errors. In a financial market context, this implies the existence of predictable anomalous returns. As Proposition 4 shows, when perceived creditworthiness is too high, $\mu_{t+1}^{\theta}(\rho) > \mu_{t+1}(\rho)$, credit spreads are too low. Going forward, the average return on debt is anomalously low, in our model lower than the investor's required return $\beta^{-1}$. The reverse is the case when perceived creditworthiness is too low, $\mu_{t+1}^{\theta}(\rho) < \mu_{t+1}(\rho)$: credit spreads are now too high and there are positive abnormal returns going forward.

Greenwood and Hanson (2013) document precisely the pattern of return predictability in Proposition 3. They find that high levels of the junk share predict anomalously low, and even negative, excess returns (point ii), and that this occurs precisely after good news, measured by drops in expected default rates (point i). [16] They consider conventional explanations for this finding, such as time varying risk aversion and financial frictions, but conclude that the evidence (particularly negative returns) is more consistent with the hypothesis that the junk share is a proxy for investor sentiment and extrapolation. Our model of stereotypes offers a psychological foundation for this account.

Proposition 4 describes how that excess volatility in financial markets and the cost of capital translates into excess volatility in the real economy, as measured by real investment and the economic return on this investment. Gennaioli, Ma and Shleifer (2015) find that CFOs with more optimistic earnings expectations invest more. Greenwood and Hanson (2015) study empirically investment cycles in the ship

[16] One intuitive way to see this is to note (see Equation (16)) that the credit terms obtained by riskier firms are more sensitive to the biases caused by stereotypes than those obtained by safer firms. Periods of excess optimism witness an abnormal increase in the junk share and disappointing subsequent returns. Periods of excess pessimism see the reverse pattern.

industry. Consistent with our model, they find that returns to investing in dry bulk ships are predictable and tightly linked to boom-bust cycles in industry investment. High current ship earnings are associated with higher ship prices and higher industry investment, but predict low future returns on capital.

In sum, stereotypical thinking creates short-term extrapolative behavior, which is in line with a large set of recent empirical findings on both financial markets and production, including: i) excess volatility of spreads relative to measures of fundamentals, ii) excessive spread compression in good times and excessive spread widening in bad times, iii) a similar pattern in the junk share, which expands excessively in good times and contracts excessively in bad times, iv) excessively volatile investment and output, and finally, v) good times predicting abnormally low returns.

Having assessed the implication of stereotypical thinking for the immediate reaction of the economy to a shock, we now study implications for the *cyclical* properties of the economy.

## 5. Credit and Economic Cycles

We now analyze the implications of our model for the link between credit markets and economic activity. To address existing empirical work, we perform two exercises. First, we explore how a tightening in credit spreads at $t$ affects output at $t+1$. Second, we examine credit cycles by analyzing the link between credit spreads at $t-1$, credit spreads at $t$, and output at $t+1$.

Krishnamurthy and Muir (2015) present evidence that a tightening of credit spreads at $t$ induces an output contraction in period $t+1$. Our model yields this pattern. Suppose that bad news at time $t$ cause expectations of future fundamentals

$\mathbb{E}_t^\theta(\omega_{t+1})$ to drop by $\Delta\mathbb{E}_t^\theta(\omega_{t+1}) < 0$. Proposition 2 and Equation (12) together lead to the following result:

**Corollary 2** *For any $\theta \geq 0$, an adverse shock $\Delta\mathbb{E}_t^\theta(\omega_{t+1}) < 0$ to confidence at $t$ causes a predictable change in total output at $t+1$ given by:*

$$\mathbb{E}_t\left[\frac{1}{(1-\alpha)\beta}\cdot\int_{-\infty}^{\omega_{t+1}}\left[\alpha\beta\mu_t^\theta(\rho)\right]^{\frac{\alpha}{1-\alpha}}\frac{\partial \ln \mu_t^\theta(\rho)}{\partial\mathbb{E}_t^\theta(\omega_{t+1})}f(\rho)d\rho\right]\Delta\mathbb{E}_t^\theta(\omega_{t+1}) < 0$$

The expression above illustrates the link through which the household's pessimism at $t$ predictably reduces output at $t+1$. As confidence drops, perceived creditworthiness at $t$ also declines. This effect, captured by the term $\partial \ln \mu_t^\theta(\rho)/\partial\mathbb{E}_t^\theta(\omega_{t+1})$ inside the integral, increases spreads at $t$, reducing debt issuance and investment and leading to a decline in aggregate production at $t+1$. The magnitude of the output drop is tempered by the fact that the firms cutting investment the most, the riskier ones, invest less to begin with. Still, because all firms cut investment (except for the safest ones $\rho = -\infty$), output declines. This decline is larger the more pronounced is the hike in credit spreads.

This result, which obtains when bad news cause households to downgrade their perception of firms' creditworthiness, becomes stronger in the presence of stereotypical thinking. When $\theta > 0$, bad news cause greater pessimism about future conditions. As a result, for given bad news and controlling for fundamentals, the term $\Delta\mathbb{E}_t^\theta(\omega_{t+1})$ in Corollary 2 is on average more negative, the tightening of credit spreads is more pronounced, and the output decline is larger.

LSZ (2015) confirm that a tightening in credit markets at $t$ is associated with a drop in output at $t+1$, and show further that the current tightening can be predicted by credit conditions in the previous period. In particular, LSZ document that low credit spreads at $t-1$ systematically predict high credit spreads at $t$ and then a drop in output at $t+1$. This evidence bears directly on the second issue we address, namely the possibility for our model to generate full-fledged credit cycles. There is growing evidence of systematic reversion in credit conditions and of subsequent output drops. Jorda, Schularick and Taylor (2012) document that strong growth of bank loans forecasts future financial crises and output drops. Baron and Xiong (2014) show that credit booms are followed by stock market declines.

When predicting credit spreads, LSZ (2015) do not try to tease out whether the cycle in credit spreads is due to fundamentals (e.g., mean reversion in the state of the economy) or to fluctuations in investor sentiment. According to the sentiment account, which they seem to favor, a period of excessive investor optimism is followed by a period of cooling off, which they refer to as "unwinding of investor sentiment". This reversal contributes to a recession over and above the effect of changes in fundamentals. Baron and Xiong (2014) document that in good times banks expand their loans, and this expansion predicts future negative returns on bank equity. The negative returns to equity might reflect the unwinding of initial investor optimism, or might be caused by abnormally low realized performance on the bank's credit decisions (as per Proposition 3). Either way, excess optimism in good times seems needed to account for this evidence.

Stereotypical thinking yields these dynamics, and in particular can reconcile excess optimism with unwinding of investor sentiment. To see why, consider the dynamics of the investors' assessment of future economic conditions. Using Equation (4), we can compute the predictable change from $t-1$ to $t$ in investors' assessment of the future state of the economy:

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

$$= \mathbb{E}_{t-1}[\mathbb{E}_t(\omega_{t+1}) - \mathbb{E}_{t-1}(\omega_t)]$$

$$+ \theta\mathbb{E}_{t-1}[\mathbb{E}_t(\omega_{t+1}) - \mathbb{E}_{t-1}(\omega_{t+1}) - \mathbb{E}_{t-1}(\omega_t) + \mathbb{E}_{t-2}(\omega_t)].$$

Under the assumed AR(1) process, this quantity is equal to:

$$\mathbb{E}_{t-1}\left[\mathbb{E}_t^{\theta}(\omega_{t+1}) - \mathbb{E}_{t-1}^{\theta}(\omega_t)\right] = (\bar{\omega} - \omega_{t-1})(1-b) - \theta[\mathbb{E}_{t-1}(\omega_t) - \mathbb{E}_{t-2}(\omega_t)]. \quad (16)$$

There are two terms in expression (16). The first term is mean reversion: conditions at $t$ can be predicted to deteriorate if the current state is below the long run value $\bar{\omega} > \omega_{t-1}$. The second term instead captures reversals of past sentiment, which is a function of past news $[\mathbb{E}(\omega_t|\omega_{t-1}) - \mathbb{E}(\omega_t|\omega_{t-2})]$.

Mean reversion can only generate a systematic cooling off in optimism if the current fundamental $\omega_{t-1}$ is above its long run mean $\bar{\omega}$. Stereotypical thinking, in contrast, generates predictable pessimism whenever the arrival of good news at $t-1$ caused investors to be too optimistic to begin with, $[\mathbb{E}(\omega_t|\omega_{t-1}) - \mathbb{E}(\omega_t|\omega_{t-2})] > 0$. Indeed, when this is the case, investor beliefs on average revert (to rationality) next period. The intuition is simple: stereotypical thinkers become too optimistic when their attention is caught by positive trends or good news. Because there is no systematic news going forward, any current optimism cools off on average. We view this cycle of beliefs as capturing what LSZ (2015) refer to as "unwinding of sentiment".

In a market equilibrium context, Equation (16) offers a way to think about predictable spread reversals. Such reversals can be created either by mean reverting fundamentals or by stereotypical thinking. The testable implication of stereotypical thinking, however, is that mean reversions is predictable in light of the level of fundamentals whereas unwinding of sentiment is predictable using past news. The Proposition below illustrates this point.

**Proposition 5.** *Suppose that households are stereotypical thinkers* $\theta > 0$ *and at* $t-1$ *perceived creditworthiness is too high due to good news,* $\mathbb{E}_{t-1}(\omega_t) > \mathbb{E}_{t-2}(\omega_t)$*. Then:*

*i) Controlling for fundamentals at* $t-1$*, perceived creditworthiness predictably falls at* $t$*, namely* $\mathbb{E}\left[\mu_t^\theta(\rho)|\omega_{t-1}\right] < \mu_{t-1}^\theta(\rho)$*, and credit spreads predictably rise.*

*ii) Controlling for fundamentals at* $t-1$*, there is a predictable drop in aggregate investment at* $t$ *and in aggregate production at* $t+1$*.*

Because on average investor optimism at $t-1$ predictably reverts at $t$, there is, controlling for fundamentals, a predictable credit tightening at $t$ which in turn depresses investment in the same period and thus output next period. This cycle around fundamentals is entirely due to stereotypical thinking: over-reaction to good news causes credit markets and the economy to overshoot at $t-1$. The subsequent reversal of such over-reaction causes a drop in credit and economic activity that is more abrupt than what could be accounted for by mean reversion in fundamentals.

This reasoning implies that investor psychology can itself be a cause of volatility in credit and investment, and thus of business cycles, even in the absence of mean reversion in fundamentals. Even if the process for aggregate productivity $\omega_t$ is a random walk, namely when $b = 1$, and economy buffeted by shocks systematically experiences boom-bust episodes because investors react to news by becoming excessively optimistic or pessimistic, but then such excess pessimism or optimism mean reverts on average, in the absence of contrary news.

The current model does not feature an asymmetry between positive and negative news, because it abstracts from realistic ingredients such as financial frictions. Interesting effects could arise from the interaction between stereotypical thinking and collateral constraints. By making investors excessively optimistic, a period of good news fuels excess optimism and credit expansion. During such a credit expansion households would pay insufficient attention to the possibility of a bust.

As fundamentals stabilize, the initial excess optimism unwinds, bringing to investors' mind the possibility of a bust. The economy would appear to be hit by a "financial shock": a sudden, seemingly unjustified, increase in credit spreads. Economic agents would appear to have magically become more risk averse: they now take into account the crash risk they previously neglected.

In the presence of financial frictions, the economy will not go back to its normal course. When excessive leverage is revealed, debt investors try to shed the excessive risk they engaged in, depressing debt prices and market liquidity as in Gennaioli, Shleifer and Vishny (2012, 2015). The tightening of debt constraints causes fire-sales and corporate investment cuts, destroying good investment opportunities. Such a crisis does not occur because of deteriorating fundamentals, but because the initial excess optimism burst. Years of bonanza plant the seeds for a financial crisis.

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**Proofs**

**Proposition 1.** Let $\omega_t$ be an AR(1) process, $\omega_{t+1} = a + b\omega_t + \varepsilon_t$, with i.i.d. normal $(0, \sigma^2)$ shocks $\varepsilon_t$. At $t$, the true distribution of $\omega_{t+1}$ is

$$h_t(\omega_{t+1}) = h(\Omega_{t+1} = \omega_{t+1} | \Omega_t = \omega_t) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(\omega_{t+1} - \mathbb{E}_t(\omega_{t+1}))^2}{2\sigma^2}}$$

where $\mathbb{E}_t(\omega_{t+1}) = a + b\omega_t$. The comparison distribution is instead

$$h_{t-1}(\omega_{t+1}) = h(\Omega_{t+1} = \omega_{t+1} | \Omega_t = \mathbb{E}_{t-1}(\omega_t)) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(\omega_{t+1} - \mathbb{E}_{t-1}(\omega_{t+1}))^2}{2\sigma^2}}$$

where we used the law of iterated expectations, $\mathbb{E}_{t-1}\big(\mathbb{E}_t(\omega_{t+1})\big) = \mathbb{E}_{t-1}(\omega_{t+1})$. From Equation (*), the stereotypical distribution is then:

$$h_t^\theta(\omega_{t+1}) = \frac{1}{Z} e^{-\frac{1}{2\sigma^2}\left[(1+\theta)(\omega_{t+1} - \mathbb{E}_t(\omega_{t+1}))^2 - \theta(\omega_{t+1} - \mathbb{E}_{t-1}(\omega_{t+1}))^2\right]}$$

$$= \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2\sigma^2}\left[\left(\omega_{t+1} - \mathbb{E}_t^\theta(\omega_{t+1})\right)^2\right]}$$

where $Z$ is a normalizing constant, and:

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

■

**Proposition 2.** We start by proving Equation (15). We have:

$$\frac{\partial \ln \mu_t^\theta(\rho)}{\partial \omega_t} = \frac{1}{\mu_t^\theta(\rho)} \frac{\partial \mu_t^\theta(\rho)}{\partial \mathbb{E}_t^\theta(\omega_{t+1})} \cdot \frac{\partial \mathbb{E}_t^\theta(\omega_{t+1})}{\partial \omega_t}$$

The first term reads

$$\frac{1}{\mu_t^\theta(\rho)} \frac{\partial \mu_t^\theta(\rho)}{\partial \mathbb{E}_t^\theta(\omega_{t+1})\omega_t} = \frac{1}{\sigma^2} \int_\rho^{+\infty} \omega\, e^{-\frac{1}{2\sigma^2}\left[\left(\omega - \mathbb{E}_t^\theta(\omega_{t+1})\right)^2\right]} \frac{d\omega}{\mu_t^\theta(\rho)} - \frac{\mathbb{E}_t^\theta(\omega_{t+1})}{\sigma^2}$$

$$= \left[\mathbb{E}_t^\theta(\omega_{t+1} | \omega_{t+1} \geq \rho) - \mathbb{E}_t^\theta(\omega_{t+1})\right] \frac{1}{\sigma^2}$$

This term is strictly positive for $\rho > -\infty$. Moreover, given Equation (4), the second term reads $\frac{\partial \mathbb{E}_t^\theta(\omega_{t+1})}{\partial \omega_t} = b(1+\theta)$>0. In particular, we have $\frac{\partial \ln \mu_t^\theta(\rho)}{\partial \omega_t} > 0$.

Consider now the proposition's point i). From the definition (14) of credit spreads, we have

$$\frac{\partial S_t^\theta(\rho)}{\partial \omega_t} = -\frac{1}{\beta \sigma^2 \mu_t^\theta(\rho)} \frac{\partial \ln \mu_t^\theta(\rho)}{\partial \omega_t}$$

which is negative, i.e. spreads drop as conditions $\omega_t$ improve. Moreover, spreads also become compressed. Formally,

$$\frac{\partial^2 S_t^\theta(\rho)}{\partial \omega_t \partial \rho} \propto -\frac{\partial}{\partial \rho}\left[\mathbb{E}_t^\theta(\omega_{t+1}|\omega_{t+1} \geq \rho) - \mathbb{E}_t^\theta(\omega_{t+1})\right] < 0$$

Turning to the proposition's point ii), recall from Equation (11) that equilibrium debt issuance for firm is $k_{t+1}(\rho) = \left[\alpha\beta\mu_t^\theta(\rho)\right]^{\frac{1}{1-\alpha}}$, while total debt issuance is given by $K_{t+1} = \int_{-\infty}^{+\infty}\left[\alpha\beta\mu_t^\theta(\rho)\right]^{\frac{1}{1-\alpha}} f(\rho)d\rho$. Thus, firms' debt grows as:

$$\frac{\partial k_{t+1}(\rho)}{\partial \omega_t} = \left(\frac{1}{1-\alpha}\right)\frac{\partial \ln \mu_t^\theta(\rho)}{\partial \omega_t} k_{t+1}(\rho)$$

implying that total investment grows:

$$\frac{\partial K_{t+1}}{\partial \omega_t} = \left(\frac{1}{1-\alpha}\right)\int_{-\infty}^{+\infty}\frac{\partial \ln \mu_t^\theta(\rho)}{\partial \omega_t} k_{t+1}(\rho) f(\rho) d\rho > 0.$$

and that it grows disproportionately for riskier firms:

$$\frac{\partial}{\partial \omega_t}\frac{k_{t+1}(\rho_1)}{k_{t+1}(\rho_2)} = \left(\frac{1}{1-\alpha}\right)\left[\frac{\partial \ln \mu_t^\theta(\rho_1)}{\partial \omega_t} - \frac{\partial \ln \mu_t^\theta(\rho_2)}{\partial \omega_t}\right] > 0 \;\; for\ all\ \rho_1 > \rho_2.$$

■

**Proposition 3.** The variance of future expectations $\mathbb{E}_t^\theta(\omega_{t+1})$, computed in period $t-1$, are given by

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

where the variance is computed over all possible realizations of $\omega_{\mathrm{t}}$. From this perspective, the second term is constant and its variance is zero. The expression thus becomes:

$$\mathrm{Var}_{t-1}\left[\mathbb{E}_{\mathrm{t}}^{\theta}(\omega_{\mathrm{t+1}})\right] = (1+\theta)^2\mathrm{Var}_{t-1}[\mathbb{E}_{t}(\omega_{\mathrm{t+1}})].$$

The expected forecast error at $t$ is given by $\mathbb{E}_{t}\left[\omega_{\mathrm{t+1}} - \mathbb{E}_{\mathrm{t}}^{\theta}(\omega_{\mathrm{t+1}})\right]$. Replacing $\mathbb{E}_{\mathrm{t}}^{\theta}(\omega_{\mathrm{t+1}})$ with Equation (4), we find

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

■

**Proposition 4.** Suppose that no information arrived at time $t-1$, $\mathbb{E}_{\mathrm{t-1}}(\omega_{\mathrm{t}}) = \mathbb{E}_{\mathrm{t-2}}(\omega_{\mathrm{t}})$, and that new information $\mathbb{E}_{\mathrm{t}}(\omega_{\mathrm{t+1}}) - \mathbb{E}_{\mathrm{t-1}}(\omega_{\mathrm{t+1}}) \neq 0$ arrives at time $t$. The impact on credit spreads depends on the degree $\theta$ of stereotypical thinking, which modulates how investors' expectations respond to information. We have:

$$\frac{\partial \mathrm{S}_{\mathrm{t}}^{\theta}(\rho)}{\partial\theta} = \frac{\partial \mathrm{S}_{\mathrm{t}}^{\theta}(\rho)}{\partial \mathbb{E}_{t}^{\theta}(\omega_{t+1})}\cdot\frac{\partial \mathbb{E}_{t}^{\theta}(\omega_{t+1})}{\partial\theta} = \frac{\partial \mathrm{S}_{\mathrm{t}}^{\theta}(\rho)}{\partial \mathbb{E}_{t}^{\theta}(\omega_{t+1})}\cdot[\mathbb{E}_{\mathrm{t}}(\omega_{\mathrm{t+1}}) - \mathbb{E}_{\mathrm{t-1}}(\omega_{\mathrm{t+1}})]$$

Using $\frac{\partial \mathrm{S}_{\mathrm{t}}^{\theta}(\rho)}{\partial\omega_{\mathrm{t}}} = \frac{\partial \mathrm{S}_{\mathrm{t}}^{\theta}(\rho)}{\partial \mathbb{E}_{t}^{\theta}(\omega_{t+1})}\frac{\partial \mathbb{E}_{t}^{\theta}(\omega_{t+1})}{\partial\omega_{\mathrm{t}}} = \frac{\partial \mathrm{S}_{\mathrm{t}}^{\theta}(\rho)}{\partial \mathbb{E}_{t}^{\theta}(\omega_{t+1})}\cdot \mathrm{b}(1+\theta)$, we obtain the result. Therefore, $\frac{\partial \mathrm{S}_{\mathrm{t}}^{\theta}(\rho)}{\partial\theta}$ has the same sign as $\frac{\partial \mathrm{S}_{\mathrm{t}}^{\theta}(\rho)}{\partial\omega_{\mathrm{t}}}$ (and opposite sign as the information), so credit spreads overreact to information.

Turning to volatility, recall that $\mathrm{Var}[f(\mathrm{X})] \approx \left(f'\left(\mathbb{E}(\mathrm{X})\right)\right)^2\mathrm{Var}[\mathrm{X}]$, provided $f$ is twice differentiable and $\mathbb{E}(\mathrm{X})$, $\mathrm{Var}[\mathrm{X}]$ are finite. Therefore,

$$\mathrm{Var}_{t-1}\left[\mathrm{S}_{\mathrm{t}}^{\theta}(\rho)\right] \approx \left(\frac{\partial \mathrm{S}_{\mathrm{t}}^{\theta}(\rho)}{\partial\omega_{\mathrm{t}}}\left(\mathbb{E}_{\mathrm{t-1}}\left(\mathbb{E}_{t}^{\theta}(\omega_{t+1})\right)\right)\right)^2\mathrm{Var}_{t-1}\left[\mathbb{E}_{t}^{\theta}(\omega_{t+1})\right]$$

and similarly $\mathrm{Var}_{t-1}[\mathrm{S}_t^0(\rho)] \approx \left(\frac{\partial \mathrm{S}_t^0(\rho)}{\partial \omega_t}\left(\mathbb{E}_{t-1}\left(\mathbb{E}_t(\omega_{t+1})\right)\right)\right)^2 \mathrm{Var}_{t-1}[\mathbb{E}_t(\omega_{t+1})]$, where $\mathrm{S}_t^0(\rho)$ denotes the spread in the rational expectations benchmark ($\theta = 0$). Since no information arrived at $t-1$, we have $\mathbb{E}_{t-1}\left(\mathbb{E}_t(\omega_{t+1})\right) = \mathbb{E}_{t-1}\left(\mathbb{E}_t^\theta(\omega_{t+1})\right)$, and so the squared-terms in the two expressions are equal. Thus, to second order approximation in θ, Proposition 3 implies:

$$\frac{\mathrm{Var}_{t-1}\left[\mathrm{S}_t^\theta(\rho)\right]}{\mathrm{Var}_{t-1}[\mathrm{S}_t^0(\rho)]} \approx \frac{\mathrm{Var}_{t-1}\left[\mathbb{E}_t^\theta(\omega_{t+1})\right]}{\mathrm{Var}_{t-1}[\mathbb{E}_t(\omega_{t+1})]} = (1+\theta)^2$$

Cedit spreads display excess volatility, for any firm type $\rho > 0$. The same logic implies that any function of expectations, such as aggregate investment, also displays excess volatility.

We have seen above that positive information at time $t$ compresses credit spreads $S_t(\rho)$ at time $t$. Because no information arrived at time $t-1$, good news at $t$ cause spreads to compress too much, since by Equation (15) we have $\mu_t^\theta(\rho) > \mu_t(\rho)$. Average debt returns at time $t+1$ are then given by $\frac{\mu_t(\rho)}{\mu_t^\theta(\rho)}\beta^{-1}$ which are abnormally low (below $\beta^{-1}$). With negative information, the reverse happens.

■

**Corollary 2.** Consider an adverse shock $\Delta\mathbb{E}_t^\theta(\omega_{t+1}) < 0$ to investor confidence at $t$. This causes a drop in perceived creditworthiness $\mu_t^\theta(\rho)$, and investment $k_{t+1}(\rho)$, for all firms $\rho > 0$. Expected total output at $t+1$ is given by:

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

A drop in confidence about $\omega_{t+1}$ thus translates into $\mathbb{E}_t\left[\frac{\partial Y_{t+1}(\omega_{t+1})}{\partial \mathbb{E}_t^\theta(\omega_{t+1})}\right]\Delta\mathbb{E}_t^\theta(\omega_{t+1})$. Differentiating the expression above yields:

$$\mathbb{E}\left[\frac{1}{(1-\alpha)\beta}\cdot\int_{-\infty}^{\omega_{t+1}}\left[\alpha\beta\mu_t^\theta(\rho)\right]^{\frac{\alpha}{1-\alpha}}\frac{\partial\ln\mu_t^\theta(\rho)}{\partial\mathbb{E}_t^\theta(\omega_{t+1})}f(\rho)d\rho\,|\omega_t\right]\Delta\mathbb{E}_t^\theta(\omega_{t+1})<0$$

■

**Proposition 5.** We first derive Equation (16). We expand the identity

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

$$=\mathbb{E}_{t-1}[\mathbb{E}_t(\omega_{t+1})-\mathbb{E}_{t-1}(\omega_t)]$$

$$+\theta\mathbb{E}_{t-1}[\mathbb{E}_t(\omega_{t+1})-\mathbb{E}_{t-1}(\omega_{t+1})-\mathbb{E}_{t-1}(\omega_t)+\mathbb{E}_{t-2}(\omega_t)].$$

under the AR(1) process $\omega_t-\overline{\omega}=b(\omega_t-\overline{\omega})+\varepsilon_t$. We have:

$$\mathbb{E}_{t-1}[\mathbb{E}_t(\omega_{t+1})]=\mathbb{E}_{t-1}[\mathbb{E}_{t-1}(\omega_{t+1})]=b\mathbb{E}_{t-1}(\omega_t)+\overline{\omega}(1-b)$$

where the first equality follows from the law of iterated expectations. Putting it all together, we find

$$\mathbb{E}_{t-1}\left[\mathbb{E}_t^\theta(\omega_{t+1})-\mathbb{E}_{t-1}^\theta(\omega_t)\right]=\left(\overline{\omega}-\mathbb{E}_{t-1}(\omega_t)\right)(1-b)-\theta[\mathbb{E}_{t-1}(\omega_t)-\mathbb{E}_{t-2}(\omega_t)].$$

By assumption of the Proposition, $\mathbb{E}_{t-1}(\omega_t)>\mathbb{E}_{t-2}(\omega_t)$, so the second term on the right is negative. Thus, controlling for fundamentals (the first term), expectations about the future of the economy predictably (i.e. on average) fall at time $t$, as a consequence of good news at time $t-1$.

Because creditworthiness $\mu_t^\theta(\rho)$ is a strictly increasing function of expectations $\mathbb{E}_t^\theta(\omega_{t+1})$, for every firm $\rho>0$, it follows that (controlling for fundamentals), creditworthiness predictably falls at $t$ after good news at $t-1$ (point i). It then immediately follows from the definitions that spreads rise, and investment falls, on average at time $t$, and output predictably falls on average at time $t+1$.

■