Up Close It Feels Dangerous: 'Anxiety' in the Face of Risk

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Abstract

Motivated by individuals' emotional response to risk at different time horizons, we model an 'anxious' agent – one who is more risk averse with respect to imminent risks than distant risks. Such preferences describe well-documented features of (i) individual behavior, (ii) equilibrium prices, and (iii) institutions. In particular, we derive implications for financial markets, such as overtrading and price anomalies around announcement dates, as well as a downward-sloping term structure of risk premia, which are found empirically. Since such preferences can lead to dynamic inconsistencies with respect to risk trade-offs, we show that costly delegation of investment decisions is a strategy used to cope with 'anxiety.'

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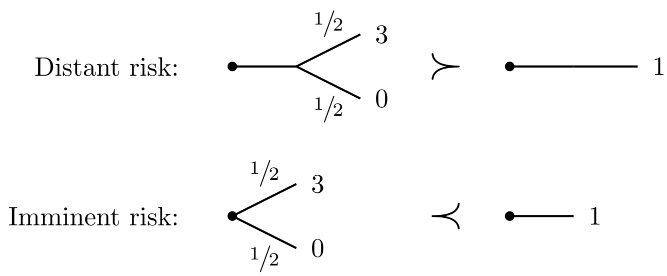

Figure 1: Proximity-dependent risk aversion

1 Introduction

Cognitive evaluations of risk do not depend on temporal distance to the event. In contrast, emotional reactions to risk such as fear and anxiety increase as the risky event draws closer. When such departures between thoughts and emotions occur, feelings often exert a dominating influence on behavior. As a result, agents tend to behave in more risk averse ways with respect to risks that are close in time compared to risks that are distant, even when cognitive evaluations of the risk remain constant (Loewenstein, Weber, Hsee, and Welch, 2001). We use the term 'anxiety' to refer to the set of feelings that leads to such proximity-dependent risk aversion (PDRA).[1] Despite abundant experimental and field evidence for PDRA, we do not have a way of formally thinking about such behavior, the associated interplay of rationality and emotions, and the implications for economics and finance. This paper takes first steps toward such a framework by modeling an agent whose risk aversion explicitly depends on proximity. First, we model the static choice behavior of a representative agent who has PDRA utility and derive equilibrium pricing implications. Then we investigate the quasi-dynamic behavior of a PDRA agent without commitment devices. Because PDRA utility implies the potential for dynamically inconsistent behavior with respect to intra-temporal risk tradeoffs, we investigate which institutions can arise as a result of sophistication of a PDRA agent.

Figure 1 illustrates PDRA. In both the top and the bottom comparison the agent has to choose between a risky alternative on the left and a safe alternative on the right. In the top comparison the risk is distant. As a result, the agent has low risk

[1]The New Oxford American Dictionary defines anxiety as "a feeling of worry, nervousness, or unease, typically about an *imminent* event or something with an *uncertain* outcome" (emphasis added). This paper does not discuss anxiety *disorder*, a psychopathological condition.

aversion and chooses the risky over the safe alternative. In the bottom comparison the risk is imminent. As a result, the agent has high risk aversion and chooses the safe over the risky alternative. The agent's preference implies different choices depending on the temporal distance of the risk. In particular, he may pull back from risks he previously intended to take, even absent new information and even if beliefs have not changed for any other reason.

As an example, consider a parachute jump. You may sign up for a jump several days or weeks in advance, thinking the thrill will be well worth the risk. However, when you look out the plane's door, you are likely to have an aversive emotional reaction strongly suggesting not to jump. You may not *think* that jumping is more dangerous now than when you signed up – but it *feels* more dangerous.[2]

This example illustrates that PDRA has implications in many real-life domains of decision-making under uncertainty. For the sake of clarity and to illustrate the quantitative importance of PDRA, we propose PDRA as an explanation for several patterns in financial economics, some of which are open empirical puzzles, and some of which are new predictions. First, we show that a representative investor with PDRA requires more compensation for short-run risks than for long-run risks. Therefore, the term structure of risk premia (TSRP) is downward-sloping, as Binsbergen, Brandt, and Koijen (2012) document. Standard asset pricing models predict a flat or upward-sloping TSRP. Second, we show that PDRA implies negative stock returns before earnings announcements. Risky asset prices drop even when no new information enters the market. Most of the related empirical literature has focused on the positive unconditional earnings-announcement return, and conditional *post*-earnings announcement drift. In contrast, we document an unconditionally negative *pre*-earnings-announcement dip, consistent with evidence in Bernard and Thomas (1989). Moreover, we predict that the dip is most pronounced for stocks with the highest announcement risk.

In addition, earnings announcements and other anticipated resolutions of uncertainty cause naïve PDRA agents to trade excessively, selling risky assets before risk events (at an endogenously low price) and buying them back afterwards (at a higher price). The results of Lamont and Frazzini (2007) suggest that individual investors trade in the way predicted by PDRA, and institutional investors take the other side.

[2]The emotional response of parachutists approaching the time of the jump, stagefright, and other examples have been studied extensively in the psychology literature. Section 2 provides a discussion.

Odean (1999) and others have empirically documented costly overtrading by individual investors more generally. While anxiety-prone investors experience lower returns than dynamically consistent agents in this example, the presence of anxiety-prone investors does not cause risk-free arbitrage. Anxiety simply causes a persistent demand for short-term insurance.

If an agent is 'sophisticated' about his dynamic inconsistency, he may seek to affect his future behavior with the help of commitment devices. Going back to the example of a parachute jump, you already may doubt your future resolve when signing up for the jump. A natural response would be to tell your friends about your plans, or take them along. Since chickening out in front of them comes at the cost of embarrassment, involving your friends can be interpreted as using a commitment device. A sophisticated PDRA agent can benefit from costly commitment also when participating in a financial market. Lacking the resolve to hold an equity portfolio himself, he will gladly pay a fee to an agent for holding it. Thus, PDRA preferences generate a demand for actively managed funds, even if these are known to underperform a passive index that is available to agents at a very low cost (Gruber, 1996).

The paper proceeds as follows. Section 2 presents experimental and field evidence for our main assumption: risk aversion increases with proximity. Section 3 contrasts PDRA with related non-standard preferences. Section 4 presents the basic model. Section 5 investigates the implications of PDRA on financial markets. Section 6 describes how a sophisticated agent responds to PDRA. Section 7 concludes.

2 Experimental and Field Evidence

This section reviews evidence that temporal distance affects both risk-taking behavior and the emotional response to risks.

Evidence on PDRA Behavior

Proximity-dependent risk aversion is very well documented experimentally. Subjects tend to be more risk averse when a risk is temporally close than when it is distant, both in across-subject and within-subject studies.

Jones and Johnson (1973) have subjects participate in a simulated medical trial for a new drug; each subject has to decide on a dose of the drug to be administered. The subjects are told that the probability of experiencing unpleasant side-effects increases with the dose – but so does monetary compensation. More risk averse subjects should then choose lower doses than less risk averse subjects. The study finds that subjects choose higher doses when they are to be administered the next day than when they are to be administered immediately. Interestingly, the difference disappears if the decision can be revisited the next day (no commitment), suggesting that subjects may anticipate their preference reversals. The study also measures higher stress levels for subjects deciding among immediate doses than for subjects deciding among delayed doses.

Welch (1999) documents preference reversals caused by stage fright. He finds that 67% of subjects who agree to tell a joke in front of a class the following week in exchange for $1 "chicken out" when the moment of truth arrives. In contrast, none of those who decline initially change their mind.

A widely used method in experimental economics to elicit risk aversion is the protocol of Holt and Laury (2002). Subjects are presented with a list of choices between two binary lotteries. The first lottery always has two intermediate prizes, e.g. ($10.00, $8.00), while the second lottery always has a high and a low prize, e.g. ($19.25, $0.50). Going down the list, only the respective probabilities of the two prizes change, varying from $(0.1, 0.9)$ to $(0.9, 0.1)$. As probability mass shifts from the second prize to the first prize of both lotteries, the second lottery becomes increasingly attractive compared to the first lottery. Subjects are asked to pick one of two lotteries for each of the probability distributions. The probability distribution at which a subject switches from the "safe" lottery to the "risky" lottery is a proxy for the subject's risk aversion. Noussair and Wu (2006) use this protocol for a within-subject design with real payoffs, having each subject make choices for resolution and payout to occur immediately and also for risks and payouts that occur three months later. The study finds that more than one-third of subjects are more risk averse for the present than for the future. Coble and Lusk (2010) use the protocol for an across-subject design and find the same pattern with average risk aversion increasing with the temporal proximity of the risk.

In a different type of experiment, Baucells and Heukamp (2010) let subjects choose between two binary lotteries, a "safer" and a "riskier" one. Different treatments vary the delay until the lotteries are resolved and paid out. The study finds that more subjects choose the riskier lottery as the delay increases. Sagristano, Trope, and Liberman (2002) also have subjects choose between two lotteries and find the same effect of temporal proximity.

Finally, some studies elicit risk aversion by asking subjects for their certainty equivalents for different lotteries; a lower certainty equivalent corresponds to higher risk aversion. In Onculer (2000), subjects state their certainty equivalent for a lottery to be resolved and paid immediately, as well as for the same lottery to be resolved and paid in the future. The study finds that subjects state significantly lower certainty equivalents for the immediate lottery than for the future lottery. Abdellaoui, Diecidue, and Onculer (2011) conduct a similar study with real payoffs and find equivalent results.

Evidence on Emotional Origins of PDRA

While unimportant for the revealed preference approach of modeling behavior that we follow in this paper, we find it appropriate to present suggestive evidence that emotions are indeed the driver of the behavior we describe. Monat (1976) and Breznitz (2011) inform subjects that they will receive an electric shock (presumably of an uncertain strength given a subject-specific scale). The temporal distance varies across different treatment groups. Heart rate, and in the latter study also galvanic skin response and self-reported anxiety are all higher when the shock is closer in time. Fenz and Epstein (1967), Fenz and Jones (1972) and Roth, Breivik, Jørgensen, and Hofmann (1996) investigate the emotional response of parachutists approaching the time of the jump. Novice parachutists exhibit a similar dynamic of physiological measures and self-reports of anxiety as in the above experiments, while expert parachutists have a somewhat attenuated response to the proximity of the jump, emphasizing the adaptive nature of 'anxiety.'[3]

Lo and Repin (2002) and Lo, Repin, and Steenbarger (2005) find similar psychophysiological responses to risk taking among securities traders. Consistent with our theory, (i) the immediacy of risk correlates with increased levels of emotional response in all participating traders, and (ii) traders that exhibit a stronger emotional reaction to immediate risks generate lower returns. Last, personality traits are not the driver of their results, suggesting that PDRA is not limited to a specific personality type.

[3]An interesting aspect of these and other studies documenting the impact of emotions on choice behavior is that fear increases with proximity, while cognitive assessments remain constant (Loewenstein, 1987, 1996; Monat and Lazarus, 1991; Paterson and Neufeld, 1987).

3 Distinction from Related Theories

In this section we distinguish 'anxiety' from existing theories that are related but conceptually orthogonal.

Preference for the Timing of Resolution of Uncertainty

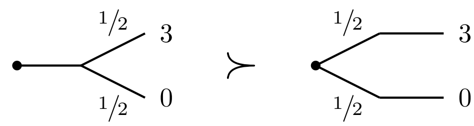

Figure 2: Preference for later resolution of uncertainty

The seminal paper by Kreps and Porteus (1978) is the first to consider a preference ranking between lotteries that differ only in the timing of resolution of a given risk, while the time of the payoff is held constant. Figure 2 illustrates such a preference. In contrast, PDRA ranks lotteries that are resolved and paid out at the same time, but it ranks them differently depending on temporal distance. Further, Kreps and Porteus (1978) explicitly rule out dynamically inconsistent behavior. In contrast, we allow for dynamic inconsistency.

Time-Changing Risk Aversion

Figure 3: Time-changing risk aversion

A large literature in asset pricing assumes that agents' effective risk aversion changes over time (Constantinides, 1990; Campbell and Cochrane, 1999).[4] Figure 3 illustrates the choices of an agent who is more risk averse in one period than in another. Note that, by comparison, PDRA preferences are not time-varying. An anxious agent's effective risk aversion changes as a function of temporal proximity to risk, but not of

[4]See Guiso et al. (2011) for an empirical study of time-changing risk aversion. Dillenberger and Rozen (2012) provide a model of history-dependent risk aversion.

calendar time. Further, models of time-changing risk aversion are typically dynamically consistent.

Dynamically Inconsistent Time Preferences

Agents with dynamic-inconsistency problems have been studied at least since Strotz (1955). Work such as Laibson (1997) focuses on inconsistent *time* preferences, e.g. originating in quasi-hyperbolic discounting. The agent resolves *inter*-temporal consumption trade-offs differently depending on the time horizon: if the time horizon is short, the agent is more impatient than if the time horizon is long. We study an orthogonal dimension by assuming that the agent's *risk* preferences are dynamically inconsistent. The agent resolves *intra*-temporal risk trade-offs differently depending on the time horizon: if the horizon is short, the agent is more risk averse than if the horizon is long. Thus we emphasize that agents can be dynamically inconsistent independently in the dimensions of consumption and risk.

Other Theories

PDRA belongs with a set of theories that emphasize the impact of salience on decision making – temporal proximity is but one dimension of salience. For example, in Bordalo, Gennaioli, and Shleifer (2012, 2013), the context makes certain aspects of lotteries more or less salient. This approach can account for several empirically relevant phenomena that are different from those accounted for by PDRA.

Epstein and Kopylov (2007) have a model of 'cold feet' in which agents become more *pessimistic* as risks approach, i.e. their subjective beliefs change. In contrast, PDRA is motivated by experimental evidence in which the objective probabilities are known to the subjects. Epstein (2008) provides an axiomatization for a two-period model similar to ours. In contrast to our work, he uses the term 'anxiety' when an agent is more risk-averse for *distant* risks, evoking a notion of anticipatory feelings. Such anticipatory feelings are also an important aspect in Caplin and Leahy (2001) who expand the prize space to mental states and explain a set of economic phenomena different from the ones addressed in this paper. In contrast, we leave emotions outside the model, and focus on the behavior arising as a consequence of emotions. Finally, since our agent may exhibit a preference for commitment, PDRA is also related to the model of temptation and self-control in Gul and Pesendorfer (2001).

4 Model

Consider an uncertain intertemporal payoff stream from period t onwards, $\tilde{x}_t, \tilde{x}_{t+1}, \tilde{x}_{t+2}, \ldots$. In period t, an anxiety-prone agent evaluates the payoff stream according to the utility function

$$U_t = E_t\big[u_0(\tilde{x}_t) + \delta u_1(\tilde{x}_{t+1}) + \delta^2 u_2(\tilde{x}_{t+2}) + \ldots\big], \tag{1}$$

where E_t is the expectations operator conditional on the information available at the beginning of period t and $\delta \leq 1$ is a discount factor. The only difference between our agent and a standard agent are the von Neumann-Morgenstern utility indexes $u_0, u_1, u_2, \ldots$ that depend on the horizon. In particular, we assume that risk aversion is decreasing in the horizon; using the Arrow-Pratt measure of absolute risk aversion we have for $\tau, s \geq 0$:

$$-\frac{u''_\tau(x)}{u'_\tau(x)} \geq -\frac{u''_{\tau+s}(x)}{u'_{\tau+s}(x)} \quad \text{for all} \quad x$$

To see the effect of this assumption, consider the evaluation of the same payoff stream in the next period $t+1$:

$$U_{t+1} = E_{t+1}\big[u_0(\tilde{x}_{t+1}) + \delta u_1(\tilde{x}_{t+2}) + \delta^2 u_2(\tilde{x}_{t+3}) + \ldots\big]$$

Compared to the evaluation in period t, all utility indexes are shifted forward one period so that now the lottery $\tilde{x}_{t+1}$ is evaluated with u_0 instead of u_1 and is therefore treated with more risk aversion.

This assumption introduces a dynamic inconsistency in the agent's preferences. It implies that he may choose differently from a given set of alternatives depending on the temporal proximity of the lottery. The following example illustrates this point.

Example: Let $u_0(x) = \sqrt{x}$ and $u_1(x) = u_2(x) = \cdots = x$ and set $\delta = 1$. Then the agent is risk averse with respect to current uncertainty and risk neutral with respect to future uncertainty. Now consider the following two lotteries:

$$\tilde{x} = \begin{cases} 4 & \text{with prob. } \alpha \\ 0 & \text{with prob. } 1-\alpha \end{cases} \qquad \text{and} \qquad \tilde{y} = 1$$

Then u_0 prefers the risky $\tilde{x}$ to the safe $\tilde{y}$ if $\alpha > 1/2$ while u_1 prefers $\tilde{x}$ to $\tilde{y}$ if $\alpha > 1/4$ and there is disagreement between the utility indeces for all $\alpha \in (1/4, 1/2)$. In particular, suppose that $\alpha = 1/3$ and that the lotteries are resolved and paid out in period t. Then the agent will choose the safe option $\tilde{y}$ in period t but would prefer to commit to the risky option $\tilde{x}$ in all prior periods $t' < t$. He is willing to pay up to $1/3$ to commit to the risky option before period t and is willing to pay up to $5/9$ to avoid the risky option in period t.

The potential for dynamic inconsistency raises the question of how to solve the model. The agent can be naive and not realize that in the future he will not want to follow through with plans made in the present. In that case, the agent simply maximizes (1) in every period t, choosing the optimal values for the future from the perspective of period t and (wrongly) assuming that he will not reoptimize and choose different values in the future. Alternatively, the agent can be sophisticated in the tradition of Strotz (1955) and optimize subject to the constraint that he will also optimize in all future periods. The dynamic inconsistency also raises issues for welfare analysis. Since there is no generally accepted welfare criterion for dynamically inconsistent agents, we focus on purely positive analysis in this paper.

5 Finance Applications

In this section, we examine the behavior of a anxiety-prone agent, both in the naive and the sophisticated form, in a stylized financial market.

5.1 Term Structure of Risk Premia

Recent empirical work by Binsbergen, Brandt, and Koijen (2012) finds a downward-sloping term structure of risk premia in the stock market. They price a claim on the dividends of the S&P 500 in the near future in contrast to the price of the S&P 500 itself which is a claim on *all* its future dividends.[5] The striking result is that the return from holding the claim to only the short-term dividends is much higher than the return to holding the claim to all future dividends, as displayed in Table 5.1 adapted from

[5]The authors price the dividend strips synthetically using the prices of options on the S&P 500 and a no-arbitrage condition (put call parity).

	ST claim	S&P 500
Mean	1.16%	0.56%
Std. dev.	7.80%	4.69%
Sharpe ratio	0.1124	0.0586

Table 1: Monthly returns of short-term dividend strip and of the S&P 500 itself. Adapted from Table 1 in Binsbergen et al. (2012).

Table 1 in Binsbergen et al. (2012). Not only is the return on the short-term claim higher – 14.8% vs. 6.9% annualized – but also the Sharpe ratios show that the risk adjusted return is almost twice as high for the short-term claim. These results reflect that the premium for risks in the near future is significantly higher than the premium for risks in the distant future. We now show how our model of anxiety can account for this phenomenon.[6]

We consider a standard asset pricing setup in discrete time with two periods $t = 0, 1$ and two assets. Asset 0 pays a random dividend d_0 at the end of period 0 while asset 1 pays a random dividend d_1 at the end of period 1. Each asset is in net supply of 1 and the dividends d_t are i.i.d. At the beginning of period 0, the agent has to form a portfolio $(\phi_0, \phi_1, \xi_0, \xi_1)$ of the two assets as well as borrowing/lending for $t = 0, 1$, given some initial wealth w to solve the following problem

$$\begin{aligned} \max_{\{\phi_0,\phi_1,\xi_0,\xi_1\}} \; & E[u_0(\tilde{c}_0) + \delta u_1(\tilde{c}_1)] \\ \text{s.t.} \quad & \tilde{x}_t = \tilde{d}_t \phi_t + \xi_t \text{ for } t = 0, 1 \\ & p_0\phi_0 + \xi_0 + p_1\phi_1 + \frac{\xi_1}{1+r} \leq w \end{aligned}$$

For simplicity we assume that the risk-free rate $r = 0$ and that the agent's discount factor $\delta = 1$. Then the first-order conditions for an interior solution are

$$\begin{aligned} & E\left[u_0'(\tilde{c}_0)\left(\tilde{d}_0 - p_0\right)\right] = 0 \\ \text{and} \quad & E\left[u_1'(\tilde{c}_1)\left(\tilde{d}_1 - p_1\right)\right] = 0. \end{aligned}$$

For an anxiety-prone representative agent we have $\tilde{c}_0 = \tilde{d}_0$ and $\tilde{c}_1 = \tilde{d}_1$ which gives us

[6] Note that a downward-sloping term structure of risk premia, which reflects prices of risk at different maturities, is not inconsistent with an upward-sloping term structure of interest rates, which reflects both prices and quantities of risk at different horizons.

the following result on risk premia. (All proofs are relegated to the appendix.)

Proposition 1. *If u_0 is more risk averse than u_1, the return on the short-term claim is higher than the return on the long-term claim:*

$$\frac{E\left[\tilde{d}_0\right]}{p_0} > \frac{E\left[\tilde{d}_1\right]}{p_1}$$

This result shows that the anxiety model can directly account for the downward-sloping term structure of risk premia documented in Binsbergen et al. (2012), in contrast to existing leading asset pricing models.[7]

5.2 Announcement Effects

We now turn to the effects of anxiety in the context of anticipated announcements. We continue to use the standard setup of the previous section with two periods $t = 0, 1$. However, we now consider only a single asset in net supply of 1 and with a random payoff d which is realized at the end of period 1. No uncertainty is resolved between period 0 and period 1. The uncertainty about the asset's payoff is meant to represent a scheduled earnings announcement which provides information about the stock's dividend. It can also be interpreted more generally as the resolution of payoff-relevant information for holders of the stock. The key element is that the timing of the resolution is fixed and known in advance.

The price of the asset in period t is denoted by p_t and borrowing and lending is possible at a risk-free rate of zero. At the beginning of each period t, the agent has to form a portfolio (ϕ_t, ξ_t) of stock holdings and borrowing/lending, given beginning-of-period wealth w_t.

In period 1, the agent chooses a portfolio (ϕ_1, ξ_1) to solve

$$\begin{aligned} &\max_{(\phi_1,\xi_1)} E[u_0(\tilde{c}_1)] \\ &\text{s.t.} \quad \tilde{c}_1 = \phi_1 \tilde{d} + \xi_1 \\ &\qquad\quad \phi_1 p_1 + \xi_1 \leq w_1 \end{aligned}$$

[7]Binsbergen et al. (2012) show that the term structure of risk premia is *upward-sloping* in both the habit formation model of Campbell and Cochrane (1999) as well as the long-run risk model of Bansal and Yaron (2004) which uses the recursive preferences of Epstein and Zin (1989).

Note that in period 1, when the agent chooses ϕ_1, the risk is immediate. As a result, the first-order condition for an interior solution is determined by the utility index u_0 for immediate risk:

$$E\big[u_0'\big(\phi_1\tilde{d} + w_1 - \phi_1 p_1\big)\big(\tilde{d} - p_1\big)\big] = 0. \tag{2}$$

In contrast, if the agent already makes the portfolio decision ϕ_0 in period 0, the risk is not imminent, so the less risk averse u_1 applies and the first-order condition is:

$$E\big[u_1'\big(\phi_0\tilde{d} + w_0 - \phi_0 p_0\big)\big(\tilde{d} - p_0\big)\big] = 0. \tag{3}$$

Note that in this first-order condition the agent assumes that the portfolio chosen in period 0 will not be changed in period 1. This is valid if the agent is able to commit or if the agent is naive. If the agent is sophisticated *and* unable to commit, the choice in period 0 is indeterminate. We illustrate the implication of this assumption in the discussion below.

Price Dip

First consider an anxiety-prone representative agent. In that case, we have $\tilde{c}_1 = \tilde{d}$ and the first order conditions (2) and (3) simplify to:

$$E\big[u_0'\big(\tilde{d}\big)\big(\tilde{d} - p_1\big)\big] = 0 \tag{4}$$

$$E\big[u_1'\big(\tilde{d}\big)\big(\tilde{d} - p_0\big)\big] = 0 \tag{5}$$

These imply the following result for the dynamics of the asset price p_t.

Proposition 2. *If u_0 is more risk averse than u_1, we have $p_0 > p_1$.*

This prediction is consistent with the evidence of Bernard and Thomas (1989), which is discussed below. For intuition, rewriting the expectations in conditions (4) and (5) allows us to write the prices explicitly:

$$p_0 = E\big[\tilde{d}\big] + \frac{\mathrm{Cov}\big(u_1'\big(\tilde{d}\big), \tilde{d}\big)}{E\big[u_1'\big(\tilde{d}\big)\big]} \quad \text{and} \quad p_1 = E\big[\tilde{d}\big] + \frac{\mathrm{Cov}\big(u_0'\big(\tilde{d}\big), \tilde{d}\big)}{E\big[u_0'\big(\tilde{d}\big)\big]}$$

The second term in the two price equations reflects a risk discount. It discounts expected dividends more strongly at $t = 1$ than at $t = 0$, as shown in Proposition 2. In particular, the covariances are negative and the expectations positive, as both u_1' and u_0' are positive but decreasing. As intuition suggests, increasing but risk-averse utility functions imply a price discount of the risky asset, relative to expected value. More risk aversion makes for heavier discounting, and vice versa.

In addition, the size of this pre-earnings-announcement dip depends on how much uncertainty is resolved, i.e., the announcement risk. For this cardinal statement we need to assume a specific functional form. Suppose the utility indexes u_0 and u_1 have constant absolute risk aversion γ_0 and γ_1, respectively, where $\gamma_0 > \gamma_1$. For tractability, assume that the payoff $\tilde{d}$ is normally distributed, $\tilde{d} \sim \mathcal{N}(\mu, \sigma^2)$ which yields the following new empirical prediction.

Proposition 3. *The size of the price dip is increasing in the announcement risk:*

$$\frac{d}{d\sigma^2}|p_1 - p_0| > 0$$

Overtrading

Now consider an individual anxiety-prone agent in an asset market dominated by standard agents with dynamically consistent risk aversion. Since there is no additional information revealed between period 0 and period 1, there is no reason for the price to change between the periods and we have $p_1 = p_0 =: p$. In addition, assume that the agent's wealth does not change so we have $w_1 = w_0 =: w$. Then, the first order conditions (2) and (3) simplify to

$$E\big[u_0'\big(\phi_1\big(\tilde{d} - p\big) + w\big)\big(\tilde{d} - p\big)\big] = 0$$
$$\text{and } E\big[u_1'\big(\phi_0\big(\tilde{d} - p\big) + w\big)\big(\tilde{d} - p\big)\big] = 0.$$

This gives us the following result adapted from Wang and Werner (1994).

Proposition 4. *If u_0 is more risk averse than u_1, we have $\phi_0 > \phi_1$.*

This result shows that our agent wants to hold more of the risky asset in period 0, with some distance to the risk, than in period 1, when the resolution of uncertainty is imminent. The implications of this result depend on the degree of sophistication of the agent. A sophisticated agent anticipates in period 0 that he will want to change his portfolio in period 1. If the agent has no way of preventing his future self from rebalancing, he may already choose the anticipated portfolio ϕ_1 in period 0 to avoid trading costs.

The more interesting case is that of a naive agent. In period 0, he will choose a portfolio ϕ_0, but once the resolution of uncertainty is imminent in period 1, he sells some of the risky asset to attain the portfolio $\phi_1 < \phi_0$. When we view the asset market as a sequence of periods with and without news about the asset, the agent overtrades, selling some of the stock before announcements and buying it back afterwards. Lamont and Frazzini (2007) find evidence that selling pressure before announcements indeed stems from small and supposedly unsophisticated traders, as does the buy pressure after announcements. Large traders take the other side of these trades.

Combining the insights of the last two subsections, in a market populated by both anxious and standard agents, there will be a price drop before any scheduled announcement but not as large as in a market with only anxious agents. Accompanying the price drop we should expect to see anxious agents selling part of their stocks to standard agents. Right after the announcement, prices should, on average, appreciate as anxiety-prone agents buy back their positions.

Realized Returns

The stylized model above is not suited for calibration. However, a reasonable estimate can be obtained based on the analysis in Bernard and Thomas (1989), which implies a pre-earnings announcement dip on the order of -0.5%. With four scheduled earnings announcements per year, a naive agent stands to lose about 2% per year by overtrading in the face of scheduled quarterly earnings announcements alone. This loss comes on top of transaction costs. This squares nicely with the empirical result by Lo et al. (2005), who confirm that more anxious agents generate lower returns.

A naive anxiety-prone investor's actual equity returns, i.e., the returns he enjoys from investing in equity after accounting for the losses imposed by anxious behavior, are therefore lower than buy-and-hold returns derived from market data may suggest. This insight may help explain the equity premium puzzle. In particular, in contrast to explanations focusing on high effective risk aversion, an anxiety-based explanation of high equity returns is compatible with the "risk-free rate puzzle": anxiety only distorts the price of locally risky equity, but not the price of locally risk-free bonds.

While these results are based on the analysis of a naive agent, sophistication does not undo the effect. The disutility implied by the use of a commitment device that a sophisticate may choose to use must be subtracted from the utility from equity returns of such an agent. For example, we show in Eisenbach and Schmalz (2012) how overconfidence can let an anxiety-prone agent make more dynamically consistent decisions. But then, the disutility from overconfidence, stemming from 'excessive risk-taking,' needs to be subtracted from the increased utility from holding equity without overtrading. Consequently, even a sophisticated anxiety-prone agent will find equity a worthwhile investment only at returns that are higher than the ones a standard consumption-based asset pricing model predicts.

Discussion

A rare feature of our theory is that it combines predictions about asset returns *and* trading volume. As Lamont and Frazzini (2007) explain, this has been a challenge for researchers of announcement anomalies. While they focus on explaining the price and volume patterns with the "attention grabbing hypothesis" (see Lee, 1992; Hou, Peng, and Xiong, 2009; Barber and Odean, 2008), their empirical results provide equal support for our theory. Our theory shifts the focus to the other side of the same medal that Lamont and Frazzini (2007) examine: We ask why prices tend relatively *lower before* the announcement, which is depicted by Bernard and Thomas (1989), and which we confirm in ongoing research with more recent data. We call this the 'pre-earnings announcement dip.' We thereby offer a possible "common underlying cause for both volume and the premium" which Lamont and Frazzini (2007) call for, and that also makes predictions about trading volume for the pre-announcment period. Investigating whether overtrading, as documented by Odean (1999), is concentrated around earnings announcements warrants further empirical study.

In sum, anxiety provides a framework that links equity premium, returns and volume patterns around earnings announcements, and overtrading by individual investors. In addition, it fits nicely with the results of Lo et al. (2005) on the relation of anxiety and trading performance.

6 Commitment Devices and Institutional Responses

An agent who plans according to preferences u_1, but is afraid his future self will disagree with these plans (because it will have preferences u_0), may try to find ways to commit his future actions to his presently chosen plan of action. While Schelling (1984) and others have discussed the ethical aspects such a possibility brings about, the present discussion is only concerned with that, and how the agent can restrict his future self's behavior – simply by virtue of having a first-mover advantage.

Hiring a manager to carry out risk-taking decisions in the future according to the current self's preferences is one way to prevent future selves' preferences from conflicting with the current self's plans. In an investment setting, it may be the case that the anxious self is too risk averse to invest in equity, although the agent realizes that doing so has long-run benefits. In this situation it makes sense for the agent to delegate investment decisions to a portfolio manager. Of course, effort costs of managing one's portfolio may also lead to delegation of investment management. However, effort costs cannot justify hiring a manager who underperforms the index on average, as buying index funds is virtually costless and free of effort. Yet, the mutual funds industry is huge, and active fund managers tend to underperform the market (Gruber, 1996).

While buying the index is free of effort, it is not free of anxiety. Self 0 may thus correctly anticipate that the anxious self 1 will underperform the market even more than a random portfolio manager by failing to invest in equity at all. Self 0 will therefore be willing to pay an investment manager, even if he expects him to underperform the market.[8]

The following model formalizes this intuition in a setting with two periods, $t = 0, 1$. Going backwards, at the beginning of period 1, the PDRA agent has to form a portfolio (ϕ_1, ξ_1) consisting of a risky asset and a risk-free asset. The price of the risky asset is p and it pays off a random $\tilde{d}$ at the end of period 1. The risk-free asset pays off $1 + r$. For simplicity, we assume that the agent's discount factor $\delta = 1$ and that $r = 0$.

In $t = 0$, the agent decides whether to delegate that investment decision to a manager. The manager charges a fee $f > 0$, and invests at time $t = 1$ as instructed at $t = 0$. The agent's degree of sophistication plays a key role in the delegation decision.

[8]To address the same puzzle, Gennaioli, Shleifer, and Vishny (2012) assume that agents delegate to "money doctors" because it reduces the perceived risk. Our model of anxiety predicts similar behavior based on a non-standard preference rather than a belief distortion.

At $t = 0$, a naive agent plans for $t = 1$ to invest in stocks an amount

$$\phi_1^{\text{self, plan}} = \arg\max_{\phi} E\big[u_1\big(w + \big(\tilde{d} - p\big)\,\phi\big)\big]$$

If instead the agent were to delegate his investment decision, he would advise the manager to buy

$$\phi_1^{\text{delegate}} = \arg\max_{\phi} E\big[u_1\big(w + \big(\tilde{d} - p\big)\,\phi - f\big)\big]$$

Note that the agent evaluates the risk to occur at time $t = 1$ according to u_1, whether investment is delegated or not. When considering delegation at $t = 0$, the naive agent thus compares

$$\underbrace{E\big[u_1\big(w + \big(\tilde{d} - p\big)\,\phi_1^{\text{delegate}} - f\big)\big]}_{\substack{\text{Naive expected utility} \\ \text{with delegation}}} \quad \text{vs.} \quad \underbrace{E\big[u_1\big(w + \big(\tilde{d} - p\big)\,\phi_1^{\text{self, plan}}\big)\big]}_{\substack{\text{Naive expected utility} \\ \text{without delegation}}} \tag{6}$$

Proposition 5. *A naive PDRA agent never delegates his portfolio decisions for $f > 0$.*

The naive agent's comparison (6) is flawed, however. Once period $t = 1$ arrives, the risk is imminent and is evaluated according to the more risk averse u_0. Contrary to his plans at $t = 0$, the naive agent, if left to his own devices at $t = 1$, will only invest

$$\phi_1^{\text{self, actual}} = \arg\max_{\phi} E\big[u_0\big(w + \big(\tilde{d} - p\big)\,\phi\big)\big] \tag{7}$$

Note that $\phi_1^{\text{self, actual}} < \phi_1^{\text{self, plan}}$ by Proposition 4.

A sophisticated agent takes the future self's optimization problem as given and therefore optimizes subject to constraint (7). He thus compares

$$\underbrace{E\big[u_1\big(w + \big(\tilde{d} - p\big)\,\phi_1^{\text{delegate}} - f\big)\big]}_{\substack{\text{Expected utility} \\ \text{with delegation}}} \quad \text{vs.} \quad \underbrace{E\big[u_1\big(w + \big(\tilde{d} - p\big)\,\phi_1^{\text{self, actual}}\big)\big]}_{\substack{\text{Expected utility} \\ \text{without delegation}}} \tag{8}$$

The left hand sides of (6) and (8) are the same; a naive and a sophisticated agent both correctly anticipate that a money manager will implement $\phi = \phi_1^{\text{delegate}}$. However, the right hand sides of (6) and (8) differ as $\phi_1^{\text{self, actual}} < \phi_1^{\text{self, plan}}$. This leads to the following proposition.

Proposition 6. *For a sophisticated PDRA agent, there exists $\bar{f} > 0$ such that the agent delegates his portfolio decision if $f < \bar{f}$.*

We impose two simplistic assumptions in deriving this result. The first assumption is that the agent cannot undo the delegation decision of period 0 once period 1 arrives. The commitment device an anxiety-prone agent uses for risk-taking must be illiquid to some degree, similar to commitment devices a present-biased agent uses for saving, e.g., the "golden eggs" of Laibson (1997). There are a number of institutional features we observe that provide such illiquidity in arrangements where risk-taking is delegated.

Fees are one obvious feature that discourages agent's from undoing delegation arrangements once they are set up. This is one explanation for why management fees are increasingly being competed away in the mutual fund industry, while redemption fees continue to feature prominently (Khorana, Servaes, and Tufano, 2009). Other variants of fees that help agents commit to risk taking include fees for changing the equities/bonds ratio of one's investment portfolio and fees that are imposed if the total exposure to a certain asset class falls below a threshold.

Another way to provide the desired illiquidity is to introduce delays. Especially high-risk forms of delegation such as hedge funds commonly impose initial lock-in periods and subsequent mandatory delays. The cost of having to provide liquidity cannot explain such restrictions since the fund could also directly charge the investor for this cost . Putting a temporal distance between the investor's decision to pull out and the valuation and payout of the investment prevents anxious investors from pulling out.

The second important assumption used in Proposition 6 is the two-period setting where delegation takes place in period 0 and the risk occurs in period 1. A more general setting with multiple periods with risks raises the question when, if ever, the agent will start using the commitment device.[9] The agent will have to trade off the benefit of desired exposure to risk in the long run with the cost of undesired exposure to risk in the short run. Thus, we expect to see greater fund flows to money managers when near-term risks are low, even if such a calm period is known to be temporary and does not carry information about future returns. Similarly, as negative returns tend to

[9]This question is analogous to the question of how a present-biased agent will ever start saving (Thaler and Benartzi, 2004).

increase risk estimates more than positive returns, periods of price declines should be associated with lower fund-flows to money managers, and vice versa (see, e.g. Sirri and Tufano, 1998 for evidence).

7 Conclusion

We define an anxiety-prone agent as one whose risk aversion is higher when risks are closer in time and discuss behavior of experimental subjects that proximity-dependent risk aversion predicts but which is inconsistent with existing modeling approaches. We link that behavior to established pricing puzzles and only partially explained patterns around earnings announcements. Sophistication about dynamic risk inconsistency and the associated costs triggers institutional responses such as delegation of investment decisions.

We discuss consequences for information acquisition and belief formation in a separate paper. Eisenbach and Schmalz (2012) show why it may be beneficial to a sophisticated anxiety-prone agent to hold overconfident beliefs, and how such self-delusion can be accomplished endogenously.

Appendix

Proof of Proposition 1. Since u_0 is more risk averse than u_1 we have

$$
\begin{aligned}
& -\frac{u_0''(x)}{u_0'(x)} > -\frac{u_1''(x)}{u_1'(x)} \\
\Rightarrow \quad & -\frac{d}{dx} \log u_0'(x) > -\frac{d}{dx} \log u_1'(x) \,.
\end{aligned}
$$

Integrating both sides yields

$$\frac{u_0'(d)}{u_0'(p)} < \frac{u_1'(d)}{u_1'(p)}$$

for $d > p$ and the reverse inequality for $d < p$. For general p, d we then have

$$\left(\frac{u_1'(d)}{u_1'(p)} - \frac{u_0'(d)}{u_0'(p)} \right) (d - p) > 0.$$

Taking expectations we get

$$\frac{E\big[u_1'\big(\tilde{d}\big)\big(\tilde{d} - p\big)\big]}{u_1'(p)} > \frac{E\big[u_0'\big(\tilde{d}\big)\big(\tilde{d} - p\big)\big]}{u_0'(p)}. \tag{9}$$

Substituting in p_0 the RHS is zero and we get

$$E\big[u_1'\big(\tilde{d}\big)\big(\tilde{d} - p_0\big)\big] > 0,$$

which implies that $p_0 < p_1$ and therefore

$$\frac{E\big[\tilde{d}\big]}{p_0} > \frac{E\big[\tilde{d}\big]}{p_1}$$

as desired. □

Proof of Proposition 2. The proof is analogous to that of Proposition 1. Substituting p_1 in equation (9) the RHS is zero and we get

$$E\big[u_1'\big(\tilde{d}\big)\big(\tilde{d} - p_1\big)\big] > 0,$$

which implies that $p_0 > p_1$. □

Proof of Proposition 3. In a CARA-normal framework the demand for the risky asset in $t = 0$ and in $t = 1$ is given, respectively, by

$$\phi_0 = \frac{\mu - p_0}{\gamma_1 \sigma^2} \quad \text{and} \quad \phi_1 = \frac{\mu - p_1}{\gamma_0 \sigma^2}.$$

For the representative agent, we have $\phi_0 = \phi_1 = 1$ which implies that the price dip is given by

$$p_1 - p_0 = -\left(\gamma_0 - \gamma_1\right)\sigma^2$$

which is negative and decreasing in σ^2 since $\gamma_0 > \gamma_1$. □

Proof of Proposition 4. See Wang and Werner (1994). □

Proof of Proposition 5. The fund management fee f effectively reduces wealth and the agent is always worse off with lower wealth:

$$\frac{d}{df} \max_{\phi} E\big[u_1\big(w + \big(\tilde{d} - p\big)\,\phi - f\big)\big] < 0 \tag{10}$$

Given the definitions of ϕ_1^{delegate} and $\phi_1^{\text{self, plan}}$, the behavior of a naive agent follows immediately from (6) which is equivalent to the following inequality:

$$\max_{\phi} E\big[u_1\big(w + \big(\tilde{d} - p\big)\,\phi - f\big)\big] < \max_{\phi} E\big[u_1\big(w + \big(\tilde{d} - p\big)\,\phi\big)\big].$$

Thus, a naive agent will never delegate. □

Proof of Proposition 6. Turning to a sophisticated agent, given the definition for $\phi_1^{\text{self, actual}}$ we have:

$$\max_{\phi} E\big[u_1\big(w + \big(\tilde{d} - p\big)\,\phi\big)\big] > E\big[u_1\big(w + \big(\tilde{d} - p\big)\,\phi_1^{\text{self, actual}}\big)\big].$$

From condition (10) follows that there exists an $\bar{f} > 0$ such that:

$$\max_{\phi} E\big[u_1\big(w + \big(\tilde{d} - p\big)\,\phi - \bar{f}\big)\big] = E\big[u_1\big(w + \big(\tilde{d} - p\big)\,\phi_1^{\text{self, actual}}\big)\big].$$

For any $f \in [0, \bar{f})$ we therefore have

$$E\big[u_1\big(w + \big(\tilde{d} - p\big)\,\phi_1^{\text{delegate}} - f\big)\big] > E\big[u_1\big(w + \big(\tilde{d} - p\big)\,\phi_1^{\text{self, actual}}\big)\big]$$

so the sophisticated agent will choose delegation. $\square$

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