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Bounded rationality as a source of loss aversion and optimism: A study of psychological adaptation under incomplete information

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ABSTRACT

We develop a formal model to investigate the implications of bounded rationality for the origin and structure of loss aversion and optimism in marketplaces. Based on Simon's original description, we explicitly model bounded rationality as a decision mechanism that captures incomplete information, psychological adaptation, and rational behavior. We find that the endogenous loss aversion and optimism emerge when the degree of information incompleteness reaches a certain threshold, and both grow to be more prominent when information becomes sparser. Our results highlight that the psychological biases could be expected to take advantage of perceived information incompleteness in terms of value creation.

"*Life is the blended harmony of the yin and yang.*"—Zhuangzi

1. Introduction

Reviewing the recent literature indicates that loss aversion and optimism often appear as two systematic biases of individual investors in attaining their goals (e.g., Hirshleifer, 2001; Daniel et al., 2002; Barberis and Thaler, 2003; Dellavigna, 2009). These psychological biases are understood to be at the root of some robust financial phenomena, but their source mechanism is not yet well reconciled with the standard economic theory. Especially, a coherent way to illustrate the coexistence of the two seemingly mutually exclusive features and to appreciate explicitly how they arise in the first place is still lacking. The purpose of this paper is to propose a mechanism bearing on these issues from the perspective of the "bounded rationality of individuals" (Simon, 1957).

Bounded rationality has vast applications in a wide range of areas, and is also understood in different ways by different people.[1] Here, we choose an adaptive aspect of bounded rationality as the guiding principle of this paper. This principle is highlighted in Simon's own analogy between bounded rationality and a pair of scissors: "*Human rational behavior ... is*

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[1] Todd and Gigerenzer (2003) summarize three major interpretations of bounded rationality as optimization under constraints, cognitive illusions, and ecological rationality. The concept adopted in this paper is close to ecological rationality. Also relevant is the adaptive market hypothesis of Lo (2005).

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shaped by a scissors whose two blades are the structure of task environments and the computational capabilities of the actor" (Simon, 1990, P.7). This insight allows us to characterize bounded rationality as a mechanism through which those psychological features are shaped to cope with incomplete information, which arises from the gap between the complexity of the environment where people operate and their limited mental abilities. We refer to the optimal design stance toward human traits as psychological adaptation. The key question about the economic rationale of loss aversion and optimism then becomes: Can psychological adaptation drive individual decision making with incomplete information to occur in a way that reflects the psychological biases within the value-maximization hypothesis?

To address this question, we build a formal model on three key elements. First, investors have incomplete information regarding to the drift parameter (i.e., the expected rate of return) of the stock price process. Second, investors are completely ''Bayesian'' rational. They are both Bayesian and inter-temporally optimizers in maximizing subjective satisfaction. We construct their rational behavior by deriving explicit forms for the solutions of a dynamic allocation problem where investors are prone to preference bias (loss aversion), belief bias (optimism or pessimism), and incomplete information (parameter uncertainty). Third, psychological adaptation endows investors with the desired traits of loss aversion and optimism (pessimism) in terms of value maximization. Specifically, the psychological biases, if any, are endogenized in our model as the solutions of maximizing the objective expected growth rate of wealth accumulation. The solutions allow us to evaluate whether psychological adaptation plus incomplete information lead to systematic biases. By comparing the optimal belief and preference features of investors with different degrees of information incompleteness, we also see the causal relationship between incomplete information and the two psychological biases.

Our results show that endogenous loss aversion and optimism will emerge once the level of information incompleteness reaches a certain threshold. More specifically, there are two regions: the ''simple'' region where information is rather complete, and the ''complex'' region where information is rather incomplete. In the simple region, loss aversion and optimism cannot emerge as the optimal attitudes. In the complex region, some appropriate alignments of loss aversion and optimism are beneficial for making good decisions, and hence both arise in the optimal attitudes. In this region, it is also clearly shown that such endogenous biases will increase with the degree of information incompleteness.

Although incomplete information has similar implications for both loss aversion and optimism in our model, the relevant mechanisms are essentially different. Loss aversion itself, without the help of optimism, can benefit investors when information is rather incomplete. The basic reason lies in the way that loss aversion makes investors more cautious to take unrewarded risk due to information incompleteness. However, in our model, a belief bias (optimism or pessimism) itself is always a disadvantage, which is in accordance with a series of recent theoretical studies (Sandroni, 2000; Blume and Easley, 2006; Yan, 2008). But optimism can achieve a certain efficiency in its coordination with loss aversion as it can counterbalance the effect of loss aversion that leads to less allocations to stocks. As such, information incompleteness leaves ''rooms'' for loss aversion, and loss aversion makes ''rooms'' for optimism.

The contribution of this paper is thus to formalize the bounded rationality mechanism in an adaptive form, to demonstrate how it can reconcile loss aversion and optimism with the value-maximization hypothesis, and to derive a general relationship between incomplete information and the psychological biases. The explicit modeling of investor psychology helps us for the better understanding of the complexity of systematic psychological biases from standard rationality and how they arise in the first place. This also suggests several applications. For example, it offers an immediate justification for the premises of loss aversion and optimism in financial studies, e.g., Benartzi and Thaler (1995).

Our paper relates to the literature on natural or market selection. Our model accepts the key results that have been formally identified by the market-selection analysis in Blume and Easley (1992, 2006), the maximization of expected wealth growth rate and the Bayesian learning, as the basic assumptions. Accordingly, the selection pressure (e.g., from market power and/or evolution) can be regarded as a good reason that individuals behave as if they are endowed with psychological adaptation mechanisms about loss aversion and optimism, and our bounded-rationality research program can be viewed as an evolutionarily informed framework. On a technical note, however, our work is not a general survival analysis. Our functional argument about loss aversion and optimism primarily is of an adaptive, rather than survival, nature. In fact, the two approaches are complementary, but suited to different questions. Our results, although do not directly guarantee that loss-averse and optimistic agents can survive in the long run, immediately provide a microfoundation for the argument that bounded rationality serves as a source of loss aversion and optimism.

Our paper is closely related to the literature on parameter uncertainty and learning in financial markets. A number of studies have investigated the implications of parameter uncertainty and learning on various investment problems (see, Pástor and Veronesi, 2009). Our paper incorporates reference-dependent subjective expected utility into the works of Lakner (1995, 1998), and hence also belongs to the literature on dynamic problems with reference-related objective functions, e.g., Basak (1995), Carpenter (2000), Basak and Shapiro (2001), Berkelaar et al. (2004). However, none of these papers investigates the dynamic portfolio choice problem that we specifically address in this paper, that is, the problem that accounts for both nonstandard subjective expected utility and parameter uncertainty.

Our paper proceeds as follows. We introduce in Section 2 the continuous-time model we adopt for incorporating incomplete information, loss aversion, and optimism. Then we present in Section 3 the optimal solutions of the model, and offer some comparative statics analysis of how information incompleteness, preference bias, and belief bias determine investor behavior. In Section 4, we analyze the relationships among loss aversion, optimism, incomplete information, and other components in our framework. In Section 5, we discuss the model's predictions and their implications. We finally conclude our paper in Section 6.