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Evidence for ecological learning and domain specificity in rational asset pricing and market efficiency

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ABSTRACT

This article is interested in how efficiently individuals can use available information, and if this will translate into efficient outcomes at the market level. Our use of available information in markets is further specified by evolutionary psychology and behavioral ecology, which extend core theory and evidence in behavioral finance throughout the reviewed literature. The survey of the social, biological and physical literature is integrative, and demonstrates how evolved design at the individual level can interact with a market environment that evolves as a complex adaptive system. In general, the analysis also highlights the central importance of complex systems in the study of rational and efficient markets.

1. Introduction

The norm of rationality is often criticized as an abstract ideal. Yet, without it in consumption and investment decisions, the modern economy that one takes for granted would indeed be a figment of the imagination. Take, for instance, the interaction between the finance, product, and labor markets. A rational financial market will allocate capital into profitable enterprise, where an efficient asset price quickly and fully reflects all available relevant information as to the fundamental value of a firm (Fama, 1970). Over a longer time scale, the profitability of enterprise in the product market will allocate goods and services by demand, and interact with the labor market to allocate the labor demanded (Swann and McEachern, 2006). Ongoing interaction between these markets will cause feedback between the price level and output (Blanchard and Sheen, 2009), a system dynamic that is driven by interdependence between a network of networks (Gao et al., 2011), but is also prone to collapse (Buldyrev et al., 2010). Over the long term, however, growth would appear robust. Through specialization and innovation in profitable goods and services, rational consumption and investment thereby leads to increasing comparative advantage and interaction by trade in an evolutionary process of real growth (Ridley, 2010), and as a result, a greater amount of capital to invest in profitable activity. If the investment of capital does not fully reflect the fundamental value of an asset, limited resources will be less efficiently allocated, and therein rests the unavoidable relevance of a rational and efficient financial market in prosperity.

Although models of bounded rationality assume a less sophisticated decision process than rational models, acting on limited information with a limited cognitive capacity is efficient enough if price can approximate the fundamental value. For example, there is evidence that simple decision rules such as satisficing are adaptations to exploit the structure of available information, and lead to accurate decisions in a wide range of ecologically valid contexts where information is limited (Gigerenzer, 2007). The economic utility of an accurate decision, on the other hand, may not necessarily correspond to utility in evolutionary fitness, particularly in uncertain conditions (Haselton et al., 2009). To further complicate the market effects of individual decisions, market-level rationality and efficiency can emerge from diverse behavior at the individual level (Arthur, 1996; Chen and Yeh, 2002; Bao et al., 2012), where efficiency can naturally emerge in a market that evolves as a complex adaptive system (Lo, 2004; Mauboussin, 2005). Despite some irreducibility in emergent and complex economic patterns, it is shown to be a matter of degree (Harper and Endres, 2011), in which case individual behavior can still scale up and aggregate into market behavior to some extent. Even if market behavior only partially reflects the behavior of participants, system-level outcomes will depend on how well we are designed to interact with evolving and increasing socioeconomic complexity, something that is undergoing recent and rapid change from our evolutionary past (Dunbar, 2012).

That said, the goal of this article is not weigh into a debate on these particular issues, but to review evidence in the social, biological and physical literature that further explains rational and

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efficient interaction between an evolving market environment and its participants, where rational asset pricing is essential for the efficient allocation of investment capital. The motivation, ultimately, is that behavioral finance models do imply natural constraints, by assuming a lower level of rationality than the rational expectations hypothesis and efficient markets hypothesis. Although behavioral finance is mainly concerned with how people and markets actually behave, not the fundamental reasons why as such, the regular and sometimes catastrophic failure of markets provide many compelling reasons to look deeper at more elusive aspects of the forces at work.

At an individual and ecological level, investor–market interaction is a prime candidate for behavioral ecology and evolutionary psychology. Both fields extend core theory and evidence in behavioral finance throughout the reviewed literature, and information theory complements this integrative approach. In general, two issues in modern markets are highlighted: the dissemination of misinformation in a signal-rich environment, and a rate of information change that exceeds our ability to make rational decisions. The surveyed works establish the importance of these concerns, and justify interdisciplinary effort. To this effect, the aim is to encourage a more intensive examination of the diverse target literature. As a conceptual reference point throughout the discussion, Section 2 contrasts performance in using more or less information when interacting with complex systems. In Section 3, developments in information theory further specify the ecological contexts of personal and social information in learning the environment, and relate to evidence for interaction with the market environment as a complex adaptive system. In Section 4, evolutionary-recurrent features of socioeconomic organization in complex adaptive systems imply discrete adaptations to aspects of modern markets. This premise of domain-specificity in evolutionary psychology is seen in loss aversion and the endowment effect, and can provide insight into their adaptive contexts. In particular, evolutionary psychology also explains the ideal conditions in which life-like properties can emerge in market behavior, as defined by Arthur (1996). Section 5 concludes with a discussion of key points in the literature to be taken into consideration, and suggests directions for future work.

2. Performance in simple versus complex expectations

At the individual level, rational expectations are model-consistent. Rational expectations may not necessarily be correct, but cannot be improved by any available information (Black, 2003). At the market level, a rational and efficient asset price needs to quickly and accurately reflect all available information that is relevant to fundamental value (Jones et al., 2007). Behavioral finance does not consider the rational expectations hypothesis to be entirely realistic, and instead assumes less rationality in actual decisions and market outcomes. It is reasonable to assume a limited capacity for rational judgment. The market value of an asset does not always reflect all available information as to its intrinsic economic value, and regularly deviates from the rational price for current and expected future returns (Petty et al., 2009). These issues point to several problems with defining limits in rational expectations and strong-form efficiency. As a starting point, we should be interested in how the availability of all fundamental information is physically limited, and how quickly and accurately can human cognition model all relevant determinants of asset price. Asset value is determined by a very large number of interrelated variables at the micro and macro level (Viney, 2009; Jones et al., 2007), so our ability to model complexity can be viewed as a key aspect of rational investment. This demand on cognitive performance is not only influenced by fundamentals. Market value can also be affected by factors irrelevant to fundamental value, such as the psychology of investors (Blanchard and Watson, 1982) in a complex expectations ecology of mutually reinforcing and mutually competing hypotheses (Arthur, 1996). All features of any complex system are rarely, if ever, completely visible to active observation (Dorner, 1996), therefore our interest in rational performance should begin with our ability to accurately model a system, in relation to the physical aspects of information availability.

2.1. Performance demands in rational expectations

The Logic of Failure (Dorner, 1996) provides a detailed account of human performance in regulating complex systems. The work may better describe the demands on regulatory institutions, but nevertheless measures our cognitive limits in actively modeling a system. Complex situations are found to have four main characteristics that affect performance: complexity, dynamics, time, and intransparence (Dorner, 1996). The information demanded by a reality-consistent model of system organization is positive to the number of interrelated variables and causal relations that need attending to. To add to the challenge, all relevant features of a system are rarely accessible by direct perception, and complicated interaction between the variables will tend to be very dynamic and play out over time. When the time delays between cause and effect further diminish what can be understood at a point in time, the end result is a limited awareness of the actual organization and behavior. An accurate model of reality is unlikely, as it can only be based on whatever cues are available, similar to the intransparence of frosted glass: “planners and decision makers... must make decisions affecting a system whose momentary features they can see only partially, unclearly, in blurred and shadowy outline- or possibly not at all.” Intransparence leads to ignorance and mistaken hypotheses in the decision process, where error unfolds in a consistent and predictable manner, holding constant learning and experience. The supporting evidence in *Logic* is considerable, and can present an axiom of similar demands in modeling the interrelated determinants of asset value.

At a psychological level, these are real-time demands on our ability to model the statistical mechanics of a complex network (see Albert and Barabasi, 2002) of microstate variables. Our ability to observe a system at the micro level is limited by available signals at a given vantage point (Liu et al., 2013). As a result, available information has a degree of intransparence, reflecting entropy in a number of possible current and future microstates. This uncertainty refers to two independent factors: “the systems architecture, represented by the network encapsulating which components interact with each other, and the dynamical rules that capture the time-dependent interactions between the components” (Liu et al., 2011). How closed or open the system is or will be may not be entirely clear either, such as in the fundamental state of a financial asset. The economic environment grows and evolves as a system of coupled, interdependent networks (Farmer et al., 2012; Gao et al., 2011) that have asset-specific relevance. Instead of a fixed state, financial decisions are informed by signals that refer to an environment subject to change (Radner, 1982). The current and future state of fundamental value is therefore complicated, dynamic, and it is difficult to estimate the probability of an outcome from available information. An uncertain probability distribution is referred to as ambiguous risk or model uncertainty, where the accurate specification of risk-adjusted expectations is unlikely in real-world financial decisions (Anderson et al., 2003; Barberis and Thaler, 2003). However, the observability of all fundamental determinants of asset price can vary between market participants. Fractions of the market are more or less informed about the underlying state of an asset, depending on the ambiguity of the signals available to each participant (Ozsoylev and Werner, 2011). If all available signals are unevenly distributed in a market, then ignorance and mistaken