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Review article

# Ecology and finance: A quest for congruency

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ABSTRACT

John Maynard Keynes once argued that "animal spirits" can be used to guide human behaviour. In this paper we examine various ecological theories that can be utilised to explain behaviour in financial markets. Although animal behaviour has been used to describe financial markets (bull and bear markets, herding behaviour, etc.), we argue that many relevant ecological theories have been overlooked. We show that there is a potential to relate ecological principles and theories to financial markets, including foraging theory, marginal value theorem, prey size threshold, predation and foraging, the bet-hedging hypothesis, natural selection, weather and animal behaviour and propagule pressure.



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## 1. Introduction

The study of ecology, or natural systems, has attracted multidisciplinary interest because it provides a means whereby real-life behaviour and processes can be used to solve problems and develop a new strand of thinking. This approach is widely accepted because nature is "proven" in the sense that complex processes have demonstrated success, having evolved and persisted through time. Therefore, nature can provide unique solutions to problems in various fields and areas of knowledge.

In recent times, ecological principles have delivered value across a range of disciplines, including mathematics, computer science, urban planning, agriculture, biomed-

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ical science, psychology, chemistry, physiology, artificial intelligence, economics, and information technology (Kirkman, 1993; Reichman et al., 2011; Hossain and Ferdous, 2015). As an example, ant foraging patterns have been used to inform robot search (Koenig et al., 2001; Wagner and Bruckstein, 2001). Likewise, social insect organisation has provided insights for those working in information processing, computational problem-solving (Hirsh and Gordon, 2001), decision-making (Golman et al., 2015), and software development (Gaudiano et al., 2003).

Ecological principles have also been used to understand investor behaviour and decision making. For instance, herding behaviour in nature has evolved independently across a vast array of animals to reduce predation pressure, boost mating success, improve survival of the young, and enhance foraging rates (Western and Lindsay, 1984; Lee, 1987; Childress and Lung, 2003). This behaviour occurs when individual animals within the herd act as a single entity such that benefits are conferred because individuals follow others. In finance, this approach has been used to describe the activity exhibited by investors when they take action and make investments based on the decisions of others (market trends), rather than their own judgements, calculations and knowledge (Banerjee, 1992). It is believed that herding occurs in financial markets when individual investors believe that the market cannot be wrong or that other investors know better. In the finance literature, herding behaviour is frequently described as "irrational" since it is inconsistent with the efficient market hypothesis, which implies that identical information is available to all investors, such that significant gains can be made only by investing in risky stocks (Devenow and Welch, 1996). Since no one investor has any more (or less) information than any other investor, logic and rational thought should lead to the conclusion that the market does not necessarily know any more or less than the individual, therefore precluding herding behaviour. Yet, despite the negative repercussions of herding behaviour – such as overpricing, market instability and market inefficiency (Baddeley, 2010) – it has been observed in a variety of different markets worldwide (Messis and Zapranis, 2014), providing support for the theory that investors do, in fact, demonstrate herding behaviour under certain circumstances. A clear anomaly is that herding behaviour in nature provides value to individuals, but it is less clear what value it holds for investors, except perhaps the possibility of making gains when other investors do (but with equal risk of making losses). Another advantage of herding behaviour is to reduce the need for individuals to conduct their own analyses, since it is easier to mimic the behaviour of others.

Ecological principles can play a role in enhancing our understanding of financial markets. This paper identifies ecological principles, theories and hypotheses that could be applied to finance. It should be recognised that this is a preliminary discussion based on highly hypothetical and theoretical ideas about natural processes. Considerable work is required to test these theories against traditional finance principles and observed market behaviour. It is hoped that this paper will generate interest to conduct research for the purpose of confirming or refuting the underlying propositions relating finance to ecology. It should be noted that this paper is largely focused on identifying possible ecological theories that exhibit congruency with financial thinking, without undertaking extensive analysis.

### 1.1. Applying ecological theory to finance

In recent years, ecologists and economists sought approaches to put value on the natural environment. This is becoming increasingly necessary for policy development and budgetary allocation aimed at enhancing prioritisation relative to other issues. This approach has led to the application of financial models to natural systems and ecological processes (de Groot, 1994; Cesar and van Beukering, 2004; Liu et al., 2010) including the concept of net present value, which has been adapted to represent environmental valuation more appropriately, giving rise to the net present biodiversity theory (Overton et al., 2013).

Fewer examples are available of ecological principles that have been applied to finance, but several such cases do exist. For instance, May et al. (2008a,b)describe the use of the ecological information of natural catastrophes to suggest that they could be used to predict the effects of unforeseen circumstances on the banking system. They suggest that the inherent stability demonstrated by natural networks could be used to enhance the design of financial systems and reduce the impacts of systematic risk. Similarly, Sprout (2004) suggests that the Lotka–Volterra ecological model could be applied effectively to financial markets. Ecological principles have also been used to describe financial trends. A rising market is described as a "bull" market, reflecting the way that the bull attacks its prey, using an upward motion. A falling market is described as a "bear" market because a bear swipes its paws downwards when attacking its prey (Rhea, 1994). Ecological theory and principles can be used to generate new approaches and models, as has been the case in the fields of computer science, artificial intelligence and robotics. The application of ecological theory has much to offer the world of finance.

### 1.2. The optimal foraging theory

In nature, an animal's survival depends on the decisions it makes in relation to resource gathering and use (Schoener, 1971). An animal must decide whether investing time and energy into collecting particular resources is worthwhile. The optimal foraging theory (OFT) is based on the proposition that animals optimise their foraging by selecting the highest quality resources, using the most energy-efficient foraging techniques. While the OFT has been demonstrated across a range of different animals, it is well illustrated by the shrew, which is a small animal that has high energy demands, forcing it to forage constantly to meet its resource needs. For the shrew, it is imperative that foraging is optimised so that it does not waste unnecessary energy on locating and handling food items. To survive, the shrew must make numerous decisions about where to forage, how long to forage for, when to change sites, and which prey to pursue, as opposed to those that do not