Introduction: Behavioral and Evolutionary Finance

Igor V. Evstigneev · Klaus Reiner Schenk-Hoppé · William T. Ziemba

> "Although academic models often assume that all investors are rational, this assumption is clearly an expository device not to be taken seriously."
>
> Mark Rubinstein
> Financial Analysts Journal, May/June 2001, p. 15

Once upon a time there was a planet Π on which there was a financial market $\mathcal{M}$. All the inhabitants of Π were participants in the market $\mathcal{M}$. They traded stock, equity, derivative securities and other assets. They were heterogeneous and diverse. However, they all had a common feature. They all maximized expected utilities of their consumption subject to budget constraints. They were infinitely wise (or in the local language, *fully rational*), they had unlimited memory and computational possibilities as well as perfect foresight, and they had no other goals except establishing a *general equilibrium* in the market

The views expressed in the editorial are solely ours and are not necessarily shared by the authors of the papers in the special issue or the Editorial Board of the Annals of Finance.

I.V. Evstigneev
Economics Department, School of Social Sciences, University of Manchester, Manchester M13 9PL, United Kingdom.
E-mail: igor.evstigneev@manchester.ac.uk

K.R. Schenk-Hoppé
Leeds University Business School and School of Mathematics, University of Leeds, Leeds LS2 9JT, United Kingdom, and Department of Finance, Norwegian School of Economics, 5045 Bergen, Norway.
E-mail: k.r.schenk-hoppe@leeds.ac.uk

W.T. Ziemba
Sauder School of Business, University of British Columbia (Emeritus), Vancouver, BC V6T 1Z2, Canada, and ICMA Centre, University of Reading, Reading, RG6 6BA, United Kingdom.
E-mail: wtzimi@mac.com

$\mathcal{M}$. They always successfully achieved this goal, and the idyll on Π was not disturbed by financial crises, market imperfections, bank runs, and all that.

Most students have been told such, or similar, fairy tales, and everything would be fine except the embarrassing fact that in this world the idyll on Π has little in common with reality. Researchers have come to realize that human beings do not necessarily behave like inhabitants of Π.

This special issue collects papers pertaining to several lines of research related to this general idea.

The most radical departure from the above fictitious world marks the paper *Asset market games of survival: A synthesis of evolutionary and dynamic games* by Rabah Amir, Igor V. Evstigneev and Klaus R. Schenk-Hoppé. Their paper examines a game-theoretic model of a financial market. The approach is of an evolutionary nature: market selection decides 'what to maximize,' not the modeler. Investors use general, adaptive strategies (portfolio rules) depending on the exogenous states of the world and the observed history of the game. Asset prices are determined endogenously in terms of a short-run equilibrium: a framework in the spirit of Marshall and Samuelson. The main goal is to identify portfolio rules, allowing an investor to 'survive,' i.e., to possess a positive, bounded away from zero, share of market wealth over an infinite time horizon. Their model links two fundamental paradigms of game theory: it combines a strategic framework characteristic for stochastic dynamic games with the evolutionary solution concept of survival strategies.

Behavioral traits of investors, and the role these features play in the market is the common theme of several papers in the special issue.

Taming animal spirits: Risk management with behavioural factors by Grzegorz Andruszkiewicz, Mark Davis and Sébastien Lleo draws the inspiration for its title from Keynes' famous description of the incentives of entrepreneurs: "Most [...] of our decisions to do something positive [...] can only be taken as a result of animal spirits—a spontaneous urge to action rather than inaction, and not as the outcome of a weighted average of quantitative benefits multiplied by quantitative probabilities." How this can all go horribly wrong was illustrated to perfection for instance by the Irish property boom of the 2000s in which banks funded massive investments in property development on the basis of heroically optimistic valuations. Eventually, the banks collapsed. One feels that the banks—if not the developers—should indeed have multiplied benefits by probabilities, and the purpose of this paper is to outline an approach to risk management in which the 'irrational' factors are taken explicitly into account. A project finance model is presented in which a loan is collateralized by the value of the ultimately completed project that the loan finances. It is shown that such loans can be extremely risky if the bank insists on maintaining a minimum over-collateralization level over the term of the loan and the volatility of the project valuation is too high.

Risk classes for structured products: Mathematical aspects and their implications on behavioral investors by Ji Cao and Marc Oliver Rieger studies regulations for selling financial products that aim to help non-sophisticated investors avoid mistakes. The focus is on recent regulations for structured

products in Europe that enforce a standardized risk measurement (the value at risk) in order to improve transparency and make investment decisions for investors easier. They show that this regulation has unfortunate side effects in that it might motivate issuers to design tailor-made products that hide substantial risks. Ultimately behavioral investors can be mislead into investing in products that are even less suitable for them. The paper also presents alternative risk-return measures that cannot be outsmarted by clever product design. Their paper exemplifies a general problem in investor protection: when trying to help behavioral investors by providing standardized information (e.g. on risk), it is pivotal to keep in mind that issuers of financial products will adapt to this regulation, so that at the end the original purpose of the regulation might be undermined.

Evolutionary CAPM under heterogeneous beliefs by Carl Chiarella, Roberto Dieci, Xue-Zhong He and Kai Li starts from the premise that heterogeneity and evolutionary behavior of investors are two of the most important characteristics of financial markets. Their paper models the adaptive behavior of two types of investors, fundamentalists and trend followers, within the mean-variance framework and establishes an evolutionary CAPM. They show that the adaptive behavior of agents who switch to better-performing trading strategies can cause price instability of one asset, characterized by large price deviations from the fundamental prices, to spill-over to the other asset. This spill-over effect is also associated with high trading volumes and persistent volatility, characterized by significantly positive and geometrically decaying autocorrelations in volume and volatility over long time horizons. Correlations between trading volume and volatility of risky assets are positive and stronger than that of asset payoffs. The paper also shows that commonly used rolling-window estimates of time-varying betas may not be consistent with the ex-ante betas implied by the equilibrium model.

Inference for systems of stochastic differential equations from discretely sampled data: A numerical maximum likelihood approach by Thomas Lux aims to estimate behavioral models of financial markets. The paper advances an approach taken in previous work of the author by relaxing constraints imposed on the joint dynamics of sentiment and asset prices. This dynamics are described by stochastic differential equations (SDEs) which are derived through mean-field approximation (using the so-called Kramers-Moyal expansion developed in statistical physics) to move from the micro level of individual agents to the macro level of the market. Such diffusion approximations of agent-based models suggest an avenue towards parameter estimation: since the law of motion of the transient density of the process can be described by a Fokker-Planck equation, its numerical integration produces conditional state probabilities that can be used for maximum likelihood estimation. In the present paper, both causal as well as non-causal effects between sentiment and asset price drift, which operate via the diffusion term of the SDEs, can be captured. Using German stock market data, the author shows that distinguishing between the drift and diffusion channels for the influence of sentiment is important: part of what had been identified as a causal effect now appears in the covariances of inno-

vations in the drift function. The model generates out-of-sample forecasts for stock prices that are significantly better than random walk forecasts. In contrast, forecasts from a system of SDEs without the diffusion channel appear to erroneously attribute correlation of innovations to causal dependency.

Currency returns, market regimes and behavioral biases by Leonard C. MacLean, Yonggan Zhao and William T. Ziemba hypothesizes that the market can be classified into a number of regimes, defined by characteristics such as yield differentials, credit spreads, financial ratios and volatility. Depending on market characteristics, investors present biases in decisions by overreacting to information: actual decision behavior deviates from rational expectations. However, if the bias is a natural reaction to information, then conditioning on the prevailing regime will account for the bias and result in accurate predictions of decision behavior. The paper studies interest rate parity, an efficient market condition for currencies. If a currency is hedged with a futures contract, parity implies that the mean excess hedged returns are zero and currencies do not have a risk premium. However, empirical evidence indicates that higher yield currencies frequently tend not to decline as much as the future hedge predicts. This is known as the carry trade and is frequently used. But assuming a persistent behavioral decision bias in a regime, the mean excess hedged returns are equal but not necessarily zero within each regime, and different across regimes. This regime-dependent behavior effect is tested and confirmed with currency data from five major currencies covering the period 2002—2007. A regime-dependent equilibrium portfolio can be constructed whose returns are a close match to market indices. The market indices have the decision bias imbedded, whereas the equilibrium portfolio explicitly models the decision bias and the matching is a confirmation of the model.

Utilities bounded below by Roman Muraviev and Chris Rogers proposes a decision-making model with a worst-case scenario which leads to non-monotone consumption and investment behavior. No behavioral tweaks to preferences are needed: the model is described in terms of conventional von Neumann-Morgenstern utilities. Starting from the observation that an agent who is able to borrow can in principle enter negative wealth, the paper considers what may then happen. The authors make the assumption that utility is bounded below. To prevent the agent borrowing without limit, a random review of his finances is proposed. If this review takes place while he is in negative wealth, then he is severely punished but the punishment is independent of the size of the default. The authors show that for such an agent non-monotone consumption and investment behavior can be optimal.

Optimal portfolio choice for a behavioural investor in continuous-time markets by Miklós Rásonyi and Andrea Rodrigues explores the nexus between Tversky and Kahneman's prospect theory and the solution of the corresponding investment problem in the Black-Scholes model. The utility function and the probability distortion function are piece-wise power functions x^α with potentially different exponents for gains and losses. The question analyzed in the paper is under which choice of the (four) parameters the optimal investment problem is well-posed. The authors derive necessary conditions which turn

out to be (essentially) sufficient as well. The paper also proves existence of an optimal investment strategy under these conditions. The results apply to certain other financial market models too. The main step in this research is from existing one-period models to a model with repeated trade.

When the idea of this special issue first came to us, we immediately thought of the Annals of Finance as the ideal venue for it. We thank the Editor-in-Chief, Anne Villamil, for her invaluable support of this project and for her editorial strategy of openness to new ideas and approaches in financial research. We are grateful to those who responded to the call for papers for the special issue, the reviewers and the authors, who together made this issue a reality.