Moshe (Shiki) Levy – Research Statement

Overview

After completing my masters degree in physics, I started studying finance and economics in parallel to my ongoing studies at the physics department. I believe that the marriage of these two very different fields has offered me a unique view of both areas. This viewpoint has led to the development of a new scientific field: microscopic simulation of financial and economic systems. This field, which has been the focus of my Ph.D. thesis (joint economics and physics), is revolutionizing the way people in economics think and work. The development of the economic microscopic simulation methodology has driven my research interests into two other related areas: experimental economics and power-law distributions in financial markets.

Microscopic Simulations

Most models in economics and in finance assume homogeneous and rational agents for the sake of analytical tractability. These assumptions are very problematic, because people are obviously heterogeneous in their beliefs and preferences, and it has been extensively documented that people systematically deviate from rational choice. Yet, these assumptions have become standard practice in economic modeling, for lack of an alternative way to solve models. Researchers coming from a statistical mechanics background have realized that one could employ microscopic (or agent-based) simulation methods to analyze economic models without the necessity of making the homogeneity and rationality assumptions. The idea of microscopic simulation is simple: one can investigate a complex economic system with many heterogeneous and possibly boundedly-rational interacting agents by representing each agent individually in a computer program, and by recording the system dynamics resulting from the individuals' actions and interactions. This approach enables us to extend our modeling capabilities, and to investigate the effects of heterogeneity and bounded rationality.

One of the very first papers employing this methodology, "A Microscopic Model of the Stock Market", co-authored with professor Haim Levy of the Jerusalem School of Business Administration and professor Sorin Solomon of the Hebrew University physics department, was published in

1994. This initial breakthrough, latter dubbed ‘The LLS Model’ (for Levy, Levy and Solomon), has led to stream of papers that drew a great deal of attention both from the economics and the physics realms. The book “Microscopic Simulation of Financial Markets: From Investor Behavior to Market Phenomena” (Levy, M., H. Levy and S. Solomon, 2000), which is published by Academic Press, presents the developments of this exciting new field. Richard Roll, former president of the American Finance Association and one of the leading research authorities in finance, reviewed this book as follows:

> *“This book contains the first fully comprehensive treatment of Microscopic Simulation in Finance. The authors make a compelling case that this technique originally used in physics to solve otherwise intractable problems, is destined to become a standard tool in finance.”*

Harry Markowitz, Noble prize laureate in economics wrote of this book:

> *“Levy, Levy and Solomon’s ’Microscopic Simulation of Financial Markets’ points us towards the future of financial economics. If we restrict ourselves to models which can be solved analytically, we will be modeling for our mutual entertainment, not to maximize explanatory or predictive power.”*

Experimental Economics

The microscopic simulation paradigm frees the researcher from the bounds of assuming rationality and heterogeneity and allows us to investigate the market properties resulting from any type of individual behavior. This new modeling power raises the question of what is the best description of human economic decision-making behavior? The pursuit for an answer led to some very surprising results.

The most common assumption in economics regarding decision-making under uncertainty is that people are risk-averse. Indeed, many of our cornerstone models crucially depend on this assumption and break down once it is relaxed. Risk-aversion has been confirmed in many experimental studies. *However*, almost all of these studies have used extremely simple prospects (or gambles) with typically only one or two possible outcomes, and usually with either all possible outcomes being positive (positive prospects) or with all possible outcomes being negative (negative prospects). In Levy and Levy (2001) we employ the stochastic dominance approach to test for risk aversion. This approach allows us to employ complex mixed gambles, which are much more realistic, and still have a definite prediction regarding the choice of *all risk-averters*. The results are striking: we find that most subjects are *not* characterized by risk-aversion. Similarly, in Levy and Levy (forthcoming 2002) we show that Prospect Theory, the main theory competing with risk-aversion, also does not come close to explaining individual choice when realistically mixed prospects are involved.

Finding a model of human choice under uncertainty with greater predictive power than risk-aversion or Prospect Theory is not an easy task. However, preliminary evidence indicates that Roy's (1952) theory of "Safety First" plays an important role in decision-making. This issue is under current investigation.

Wealth Inequality and Power-Laws in Finance and Economics

The Pareto (power-law) wealth distribution, which is empirically observed in many countries, implies rather extreme wealth inequality. For instance, in the U.S. the top 1% of the population holds about 40% of the total wealth. What is the source of this inequality? Our microscopic simulation studies have allowed us to closely investigate the dynamics of wealth accumulation and the development of wealth inequality in capital market models. These investigations have led to an analytic explanation of the empirically observed Pareto (power-law) wealth distribution. We have shown that the Pareto wealth distribution is a robust consequence of a fundamental property of the capital investment process: it is a stochastic *multiplicative* process. We have further shown that the Pareto distribution implies that inequality is driven primarily by chance, rather than by differential investment ability (Levy, "Are Rich People Smarter?"). This result may have profound philosophical and political implications regarding the economic role and social desirability of wealth inequality. The anonymous *JET* referee termed this paper "ingenious". This finding is also closely linked with the concept of market efficiency, and is mathematically equivalent to the well-understood connection in statistical mechanics between the Boltzmann distribution and the property of thermal equilibrium (Levy and Solomon 1996). We also show that the Pareto wealth distribution can explain the Lévy distribution of stock returns, which has puzzled researchers for many years. This explanation connects between two very different research arenas: wealth inequality, which plays a central role in economics, and the distribution of stock returns, which of great importance in finance. This theory leads to the surprising prediction that the exponent of the Pareto wealth distribution and the exponent characterizing the return distribution should be equal. This prediction relating two very different and a-priori unrelated quantities is dramatically confirmed by the empirical evidence (Levy 2002, forthcoming).

Other Areas of Interest

Portfolio Optimization with Many Assets

Most finance academics and practitioners believe that constraining the weights of the assets in a portfolio increases the portfolio's out-of-sample performance. Professor Yaacov Ritov of the department of statistics at the Hebrew University and I (2001) demonstrate that this is not true for portfolios with many assets. We show analytically and empirically that the difference in in-sample performance (as measured by the Sharpe ratio) between constrained and unconstrained portfolios increases dramatically with the number of assets. For large portfolios this result carries through to out-of-sample performance as well. This result has very important regulatory implications: while short-selling is generally considered speculative, and is prohibited for many institutional funds, in the context of portfolios with many assets it has an opposite effect – for a given level of expected return short-selling can be employed to dramatically reduce risk.

Social Phase Transitions

This research topic is another example of the potential of harnessing physics tools and intuitions to the investigation of social systems, and may have great impact on our understanding of dramatic change in social systems. What do the market crash of 1987, the collapse of the Berlin wall, the outbreak of social cooperation and the instantaneous emergence of traffic jams have in common with boiling water at 100ºC ? In all of the above systems a small event (or parameter change) has triggered a dramatic transition in the system. In "Social Phase Transitions" I show that many social systems in which individuals have some inclination for conformity may undergo “phase transitions” very similarly to physical systems such as water starting to boil or spins aligning in a magnet. A general criterion which determines whether a given system may undergo a phase transition is developed, and it is shown that phase transitions are indeed possible in many diverse social systems. The heterogeneity of the agents comprising the system plays a crucial role in determining both the possibility of a transition and its magnitude. We further show that at the transition point the system is unstable and the transition may still be reversible (as in the unsuccessful 1989 uprising in China, or the Nasdaq crashing 13.5% and then climbing back 11.8% on the same day in April 2000). Knowledge about the distribution of individuals comprising a social system may allow prediction and even induction or prevention of a social phase transition.