Introduction to Finance and Econometrics in Complex Systems

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Article Outline

Introduction

Economics and finance have slowly emerged from the Walrasian, representative agent paradigm exemplified by the research agenda in general equilibrium theory. This program may have reached its pinnacle in the 1970s, with a highly abstract treatment of the existence of a market clearing mechanism. The normative foundation of this research was provided by powerful welfare theorems that demonstrated the optimality of the market allocations. Unfortunately, this abstract world had little economics in it. The models rarely provided empirical implications. Lifetime consumption and portfolio allocation plans were formed in infancy, unemployment was Pareto optimal, and the role for government was largely limited to public goods provision.

The demonstration by Benhabib, Brock, Day, Gale, Grandmont, [1,4,8,9] and others, that even simple mathematical models could display highly complex dynamics was the beginning of a new research program in economics. This section on finance and econometrics surveys some of the developments of the last 20 years that were inspired by this research.

Econometrics

Time series econometrics was originally built on the representation theorems for Euclidean spaces. The existence of a Wold decomposition in linear time series led to the widespread use of Box–Jenkins [3] style modeling as an alternative to structural or reduced form models.

A number of stylized facts about the economy emerged that simply could not be explained in this linear world. Rob Engle [2] and Tim Bollerslev [5] showed that volatility was quite persistent, even in markets that appeared to be nearly random walks. In ▶ GARCH modeling, Christian Hafner surveys the extensive development in this area.

James Hamilton [10] and Salih Neftci [11] demonstrated that the business cycle was asymmetric and could be well described by a Markov switching model. James Morley ▶ Nonlinear time series in macroeconomics and Jeremy Piger ▶ Models of regime changes describe the developments in this area. Virtually all the moments, not just the conditional mean, are now thought to be varying over the business cycle. These models help us to understand why recessions are shorter than expansions and why certain variables lead and lag the cycle.

Nearly all the business cycle models involve the use of latent or unobservable state variables. This reflects a reality that policy makers themselves face. We rarely know whether we are in a recession until it is nearly over. These latent variable models are often better described in a Bayesian rather than a classical paradigm. Oleg Korenok ▶ Bayesian methods in nonlinear time series provides an introduction to the frontier research in this area.

Markets are often drawn towards equilibrium states in the absence of exogenous shocks, and, since the 1940s, this simple idea was reflected in the building of macroeconometric models. In linear models, Engle and Granger [6] formalized this notion in an error correction framework. When the adjustment process is taking place between two variables that are not stationary, we say that they are cointegrated. Escanciano and Escribano extend the error correction framework and cointegration analysis to nonlinear models in ▶ Nonlinear cointegration.

Because we often know very little about the data generating mechanism for an economy, nonparametric methods have become increasingly popular in the analysis of time series. Cees Diks discusses in ▶ Nonparametric tests for independence methods to analyze both data and the residuals from an econometric model.

Our last two entries look at the data generated by individual consumers and households. Pravan Trivedi ▶ Microeconometrics surveys the microeconometric literature, and Jeff Wooldridge ▶ Panel data methods examines the tools and techniques useful for analyzing cross-sectional data.

Agent Based Modeling

The neo-classical synthesis in economics was built upon the abstraction of a single optimizing agent. This assumption simplified the model building and allowed for analytical solutions of the standard models. As computational power became cheaper, it became easier to relax

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Editor's or typesetter's annotations (will be removed before the final TEX run) these assumptions. Many economists underestimated the complexity of a world in which multiple agents interact in a dynamic setting. Econophysicists, as Bertrand Roehner describes in ▶ Observational econophysics, were not surprised. Roehner is just one of scores of physicists who have brought their tools and perspectives to economics.

Agent based modeling has had a large impact on finance. Financial economics had been led by a Chicago influenced school that saw markets as both rational and efficient. Behavioral finance has eroded the view that people always make optimizing decisions even when large sums of money are at stake. The boundedly rational agents in Sebastiano Manzan's ▶ Agent based modeling in finance are prone to speculative bubbles. Markets crash suddenly in agent based computational models and in large scale experimental stock markets.

Finance

The foundation of financial economics is the theory of optimal consumption and saving. The goal of the empirical literature was to identify a set of risk factors that would explain why certain assets have a higher return than others. Ralitsa Petkova ▶ The cross section of stock returns surveys the canonical model of Fama and French [7] and the extensions to this model in the last decade.

With risk averse agents, asset returns are often predictable. Stijn van Nieuwerburgh and Ralph S.J. Koijen ▶ Return predictability and market efficiency demonstrate the robustness of this result in a structural model and show that the dividend price ratio does predict future stock returns.

Mototsugu Shintani addresses in ▶ Sensitive dependence the concept of predictability from an information theoretic perspective through the use of Lyapunov exponents. The exponents not only tell us which systems display sensitive dependence on initial conditions ("chaos") but also provide a predictive horizon for data generated by the model. Shintani finds that financial data appear to not be chaotic, even though they display local dependence on initial conditions.

Mark Kamstra and Lisa Kramer's entry on ▶ Time variation in the market return primarily focus on the equity premium, the substantially higher return in the US and other countries on equities, over default free securities like Treasury bonds. They document its statistical significance and discuss some behavioral explanations. They demonstrate that behavioral moods can influence asset prices.

Terence Mills' ▶ Nonlinear time series in financial economics surveys the use of nonlinear time series techniques in finance. Gloria Gonzalez-Rivera and Tae-Hwy Lee look at the ability of nonlinear models to forecast in ▶ Financial forecasting in nonlinear time series. They also cover the methodology for assessing forecast improvement. The best forecast may not be the one that predicts the mean most accurately; it may instead be the one that keeps you from large losses.

Our last two papers in this area focus on volatility. Markus Haas and Christian Pigorsch discuss the ubiquitous phenomenon of fat-tailed distributions in asset markets in ▶ Fat-tailed distribution in financial economics. They provide evidence on the frequency of extreme events in many different markets, and develop the implications for risk management when the world is not normally distributed. Torben Andersen and Luca Benzoni ▶ Stochastic volatility introduce the standard volatility model from the continuous time finance literature. They contrast it with the GARCH model discussed earlier and develop econometric methods for estimating volatility from discretely sampled data.

Large Market Microstructure

Market microstructure examines the institutional mechanisms by which prices adjust to their fundamental values. The literature has grown with the availability of transactions frequency databases. Clara Vega and Christian Miller ▶ Market microstructure survey the topic largely from a theoretical perspective. Because disparate markets are likely to have different mechanisms and regulators, the literature has evolved by instrument. Carol Osler ▶ Market microstructure of the foreign exchange market examines the microstructure of the foreign currency market, the largest and most liquid asset market. Bruce Mizrach and Chris Neely ▶ Market microstructure of the us treasury market look at the government bond market in the US as it has evolved into an electronic market. Michael Piwowar ▶ US corporate and municipal bond market microstructure looks at two bond markets with a large number of issues that trade only very infrequently. Both the markets which he examines have become substantially more transparent through recent government initiatives.

Conclusion

This section covers a wide range of material from theoretical time series analysis to descriptive modeling of financial markets. The theme of complexity is a unifying one in the sense that the models are generally nonlinear and can produce a wide range of possible outcomes. There is complexity in the data which now evolves at a millisecond frequency. Readers should find a variety of perspectives and directions for future research in a heterogenous but interconnected range of fields.

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