Who Drives the Market? Estimating a Heterogeneous Agent-based Financial Market Model Using a Neural Network Approach

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24 June 2008

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June 2008

Working Paper

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The full paper including simulation and estimation results is available upon request.
See also http://www.whodrivesthemarket.com for continuously updated and derived results.

Abstract.

Introduction. The *objects of investigation* of this work are micro-level behaviors in stock markets. We aim at better understanding which strategies of market participants drive stock markets. The *problem* is that micro-level data from real stock markets are largely unobservable. We take an *estimation perspective* to obtain *daily* time series of fractions of chartists and fundamentalists among market participants. We estimate the heterogeneous agent-based financial market model introduced by Lux and Marchesi [1] to the S&P 500. This model has more realistic time series properties compared to less complex econometric and other agent-based models. Such kinds of models have a rather complex dependency between micro and macro parameters that have to be mapped to empirical data by the estimation method. This poses heavy computational burdens. Our contribution to this field is a new method for indirectly estimating time-varying micro-parameters of highly complex agent-based models at high frequency.

Related work. Due to the high complexity, few authors have published on this topic to date (e.g., [2], [3], and [4]). Recent approaches in directly estimating agent-based models are restricted to simpler models, make simplifying assumptions on the estimation procedure, estimate only non-time varying parameters, or estimate only low frequency time series.

Approach and computational methods. The indirect estimation method we propose is based on estimating the inverse model of a rich agent-based model that derives realistic macro market behavior from heterogeneous market participants' behaviors. Applying the inverse model, which maps macro parameters back to micro parameters, to widely available macro-level financial market data, allows for estimating time series of aggregated real world micro-level strategy data at daily frequency. To estimate the inverse model in the first place, a neural network approach is used, as it allows for a large degree of freedom concerning the structure of the mapping to be represented by the neural network. As basis for learning the mapping, micro and macro time series of the market model are generated artificially using a multi-agent simulation based on RePast [5]. After applying several pre-processing and smoothing methods to these time series, a feed-forward multilayer perceptron is trained using a variant of the Levenberg-Marquardt algorithm combined with Bayesian regularization [6]. Finally, the trained network is applied to the S&P 500 to estimate daily time series of fractions of strategies used by market participants.

Results. The main contribution of this work is a model-free indirect estimation approach. It allows estimating micro-parameter time series of the underlying agent-based model of high complexity at high frequency. No simplifying assumptions concerning the model or the estimation process have to be applied. Our results also contribute to the understanding of theoretical models. By investigating fundamental dependencies in the Lux and Marchesi model by means of sensitivity analysis of the resulting neural network inverse model, price volatility is found to be a major driver. This provides additional support to findings in [1]. Some face validity for concrete estimation results obtained from the S&P 500 is shown by comparing to results of Boswijk et al. [3]. This is the work which comes closest to our approach, albeit their model is simpler and estimation frequency is yearly. We find support for Boswijk et al.'s key finding of a large fraction of chartists during the end of 1990s price bubble in technology stocks. Eventually, our work contributes to understanding what kind of micro-level behaviors drive stock markets. Analyzing correlations of our estimation results to historic market events, we find the fraction of chartists being large at times of crises, crashes, and bubbles.

Keywords: *Stock market, heterogeneous agent-based models, indirect estimation, inverse model, trading strategies, chartists, fundamentalists, neural networks.*

JEL classification: C15, C32, C45, C81, G12

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