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How does learning affect market liquidity? A simulation analysis of a double-auction financial market with portfolio traders

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Abstract

We study the relationship between liquidity and prices in an artificial financial market where portfolio traders with limited resources interact through a continuous, electronic open book. We depart from the standard asset pricing framework in two ways. First, we assume that investors have incomplete information about the distribution of returns. Second, we model the portfolio choice problem using *prospect-type* preferences. We model the utility function in terms of deviations of the portfolio growth rate from a specified target growth rate, and we assume that investors are more sensitive to downside movements. We show that the parameters defining the learning process affect the price dynamics through their impact on the variability of the market liquidity.

JEL classification: C61; C63; D83; G11; G12

Keywords: Learning; Portfolio choices; Liquidity; Automated auctions; Artificial markets; Returns dynamics

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1. Introduction

In the last years, there has been an increasing adoption of automated systems to trade financial securities (see Domowitz and Steil, 1999 for a taxonomy of automated systems). In these settings trading occurs through an electronic order book without involving financial intermediaries. Automated systems offer advantages in terms of operating and trading costs, but they depend on public limit orders for the provision of liquidity. The time variation in liquidity can affect the evolution of prices, and complex dynamics can arise between measures of market trading activity and measures of market volatility. This topic has been addressed by Domowitz in a series of papers analyzing the market behavior of real electronic markets (e.g., Coppejans et al., 2001; Domowitz and El-Gamal, 1999; Domowitz and Wang, 2002).

In this paper, we simulate an artificial electronic market where optimizing portfolio traders with imperfect information adjust their positions over time on the basis of the new public information becoming available.

The present work extends the model developed in Consiglio et al. (2005) introducing endogenous target individual portfolio holdings. In our previous paper we analyzed the impact on price changes of the trading mechanism by modeling an economy populated by agents homogeneous in terms of trading strategies. Each agent traded to reach an exogenously assigned target portfolio. We showed that the institutional setting of a double-auction market may by itself generate non-normal univariate marginal distributions of assets' returns and temporal patterns resembling those observed in real markets (such as serial dependence in volatility and in trading volume). Moreover, we analyzed the role played by the order-type submission strategy specifying a setting where agents selected the type of order to submit using the information revealed by the state of the book. We showed that the state of the book provides an implicit coordination device inducing agents to supply liquidity when the market needs it.

In this paper we introduce a scenario optimization model to determine endogenously individual portfolio allocations. That is, agents are not anymore noise traders whose trading is driven by exogenous liquidity shocks. On the contrary, here we assign cognitive abilities to the agents. Each agent, given the joint distribution of asset returns, his initial endowment, and a target wealth growth rate to reach within his investment horizon, will select the portfolio that maximizes his objective function, and, over time, will trade to reach his optimal portfolio.

The main ingredients of the model are the objective function used by the agents to select the optimal portfolio, the assumption of incomplete information, and the design of the trading mechanism.

We depart from the full rationality hypothesis assigning to the investors prospect-type preferences. That is, we define the investors objective function in terms of financial wealth fluctuations (Kahneman and Tversky, 1979). Additionally, we assume that agents do not know the stochastic process driving the fundamentals and they must learn recursively the unknown data generating process. We operationalize the idea of structural uncertainty allowing agents to hold arbitrary priors about the univariate marginal distribution of returns, and we make agents update correctly