



Microfoundations for switching behavior in heterogeneous agent models: An experiment[☆]



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ABSTRACT

We run a laboratory experiment to study how human subjects switch between several profitable alternatives, framed as mutual funds, in order to provide a microfoundation for so-called heterogeneous agent models. The participants in our experiment have to choose repeatedly between two, three or four experimental funds. The time series of fund returns are exogenously generated prior to the experiment and participants are paid for each period according to the return of the fund they choose. For most cases participants' decisions can be successfully described by a discrete choice switching model, often applied in heterogeneous agent models, provided that a predisposition toward one of the funds is included. The estimated intensity of choice parameter of the discrete choice model depends on the structure of the fund returns. In particular, it increases with correlation between past and future returns. This suggests human subjects do not myopically chase past returns, but are more likely to do so when past returns are more predictive of future returns, a feature that is absent in the standard heterogeneous agent models.

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1. Introduction

The recent financial crisis has increased interest, both from academics and policy-makers, in agent-based models as a viable alternative to the classic rational choice model. Agent-based models have been relatively successful in describing bubbles and crashes and other stylized facts of financial markets, e.g., excess volatility, volatility clustering and fat tails, see [Lux \(2009\)](#). One important class of agent-based models is that of so-called *heterogeneous agent models*.¹ In this paper

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¹ Examples of heterogeneous agent models of financial markets include [Brock and Hommes \(1998\)](#), [Brock et al. \(2005\)](#), [Chiarella et al. \(2007\)](#), [Manzan and Westerhoff \(2007\)](#), [Gauersdorfer et al. \(2008\)](#), [Anufriev and Dindo \(2010\)](#), [Goldbaum and Panchenko \(2010\)](#) and [Anufriev and Tuinstra \(2013\)](#). For reviews see [Hommes \(2006, 2013\)](#) and [LeBaron \(2006\)](#). Heterogeneous agent (and agent-based) models have also been applied in macroeconomics. The

we contribute to the literature on heterogeneous agent modeling by providing microfoundations for these models through designing and running a novel laboratory experiment with human subjects. This experiment is aimed at validating the assumptions used in the models and calibrating their important parameters. The experimental results reported in this paper can help researchers using heterogeneous agent models and agent-based models by disciplining their choices in modeling and policy exercises.

Heterogeneous agents models assume that there is a large population of traders, with each trader behaving according to one particular trading or forecasting heuristic from a small set of available heuristics (for most applications the number of considered heuristics is only two or three). Past performance of these heuristics then determines the fraction of the population of traders that uses each of the heuristics. This choice process is typically modeled by the so-called *discrete choice model*. Since both the evolution of asset prices and the performance of the heuristics depend upon the distribution of traders over the heuristics, heterogeneous agent models give rise to low-dimensional, but highly nonlinear, dynamical systems. The interaction between heuristics typically features complex erratic dynamics, in particular when traders are sensitive to performance differentials between heuristics, and may show a striking resemblance with price dynamics observed on actual financial markets. Because heterogeneous agent models only involve a limited number of variables, describing the price and the distribution of traders over heuristics, their properties can still be studied analytically and, in comparison to other, large-scale, agent-based models, the results are typically easier to interpret.

Although heterogeneous agent models have been quite successful in explaining stylized facts of financial markets, they also exhibit an important drawback. The results obtained crucially depend both upon the set of heuristics considered, and on the way the choice between the alternative heuristics is modeled. Indeed, there are many degrees of freedom and ideally heterogeneous agent modeling is disciplined by empirical evidence on which heuristics are used by human decision makers, and how human decision makers switch between those heuristics.

Extensive research on so-called ‘Learning-to-Forecast’ laboratory experiments already provides substantial insight into the type of forecasting heuristics that are used by human subjects.² In the current paper we present results from a laboratory experiment that was designed to understand how human decision makers choose between different alternatives, and therefore complements the earlier Learning-to-Forecast experiments. By focusing on the question of *how* participants use the past performance in *switching*, we hope to provide further microfoundations for the growing literature on heterogeneous agent models.

In particular, we are interested in finding a specification of the discrete choice model that is able to explain participants’ decisions satisfactorily. In addition we will try to infer the appropriate value of the so-called *Intensity of Choice* (IoC) parameter of the discrete choice model. This parameter measures how responsive traders are with respect to differences in past performance of the heuristics and it plays a pivotal role in the dynamic properties of heterogeneous agent models. In particular, low values of the IoC are associated with stable dynamics, whereas high values typically lead to complicated phenomena and endogenous fluctuations in stock prices, volumes and trading positions. Learning the relevant range of values of the IoC is therefore crucial for a proper application of heterogeneous agent models. However, significant estimates of this parameter are difficult to obtain from empirical studies because, due to a lack of direct access to the strategies used, switching behavior can only be inferred indirectly.

Our laboratory experiment is designed such that it facilitates estimating the parameters of the discrete choice models. The advantage of running a laboratory experiment is that it provides a controlled environment where we can observe the choices of the participants directly. We study the switching behavior of human subjects between a small number of alternatives. The participants observe the past performance (framed as “financial returns”) of several (either two, three or four) investment alternatives (“funds”) and, in every period, are asked to choose one of the alternatives and are paid on the basis of the performance of the chosen alternative in that period. As in actual financial markets, participants do not know the data generating process of the returns, and their choice does not influence the return of the different alternatives.³ We use different data generating processes that result in differences in the autocorrelation structure (and therefore predictability) of the generated time series. Participants have to choose between funds for 40 consecutive periods for one set of funds, and then for another 40 periods for a different set of the funds. This allows us to study the effect of experience on choice behavior.

We find that participants often switch between funds. Given the information provided in the experiment, it is not surprising that switching is, to a large extent, driven by past performance of the funds. Answering the question of how exactly switching is driven by past performances, we find that a simple discrete choice model with a *predisposition effect* provides a good fit to the data, when there are two or three funds and there is no cyclical/periodic pattern in the time series of returns. If such a cyclical pattern does exist, more lags need to be incorporated in the model in order to provide a good description of the data. This suggests that participants recognize and exploit cyclical patterns in returns. Moreover, the estimated IoC is not universal, but positively related to the degree of autocorrelation in the time series of returns. From this we conclude

recent review of Fagiolo and Roventini (2016) discusses the issue of calibration and over-parametrization of agent-based models at length. We address this issue using a laboratory experiment.

² See Hommes et al. (2005), Heemeijer et al. (2009), Bao et al. (2012), Pfajfar and Žakelj (2014) and Bao et al. (2016). The review in Hommes (2011) provides additional references.

³ Anufriev et al. (2015) discuss a related experiment where subjects do know the data generating process.

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