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Formation of rationally heterogeneous expectations

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ABSTRACT

This paper models expectation formation by taking into account that agents may produce heterogeneous expectations because of informational frictions and differing levels of a capacity to process information. We show that there are two general classes of steady states within this framework: those where strictly dominated forecasting rules vanish, and those heterogeneous states where a positive proportion of agents uses a more costly perfect foresight. We demonstrate that intrinsic heterogeneity can also arise in a model where the forecasting rules are not equally costly and do not exhibit identical performance in the long run.

1. Introduction

New evidence on the limitations of the rational expectations hypothesis has led researchers to re-examine the process of expectation formation and its implications for macroeconomic models. In the theoretical literature, Evans and Honkapohja (2001) suggest the adaptive learning approach, i.e., the agents act as econometricians when forecasting. In these models the agents know the correct model of the economy but do not know the parameters. In addition, bounded rationality has been imposed in the form of sticky information models, e.g., Ball et al. (2005), where the agents update information infrequently, and consequently their forecasts produce systematic errors. However, different papers have recently advanced evidence for the heterogeneity of expectations (for a survey see Hommes, 2011). Generally, three main sources of heterogeneity have been documented: agents produce heterogeneous forecasts because (i) they are using different models, (ii) they have different information sets, and (iii) they have differing levels of capacity to process information. Furthermore, there are various reasons for agents to use different models. They may believe in different structures of the economy or they may be "forced" to resort to simpler models because of (ii) or (iii). The latter represents the focus of our paper. Theoretical models where the agents are allowed to choose from a set of alternative models to forecast are usually labelled rationally heterogeneous expectation models. They explore whether it is always optimal, from a utility maximization standpoint, to follow a rational (or more generally sophisticated) way of forming beliefs since they entail a fixed cost for processing information. Typically, in these frameworks the choice of belief formation is based on the predictors' past performance. In this scenario there might be a situation in which a fraction of the population prefers to commit systematic forecast errors. Examples of these models are Brock and Hommes (1997), Branch and McGough (2008), and Waters (2009).

In this paper we develop a model of a dynamic predictor that takes into account several roots of heterogeneity. Our goal is to develop a model in which the agents could potentially have different capacities to process information and different

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information sets, and this could lead them to use different forecasting models in equilibrium. However, we should not restrict the model to heterogeneity, and outcomes where the dominating predictor prevails should also be observed. In finance there is a long-standing debate about whether the chartist traders can survive in the long run together with the rational or fundamental traders or whether the rational traders will drive the chartist traders out of the market.[1] An another important question is how potential heterogeneity may influence the stability of the model. Similarly, when we introduce different expectation formation mechanisms in a forward-looking macro model, we must ask whether we can observe heterogeneity among the forecasting rules as an equilibrium outcome and how this heterogeneity would influence the stability and the dynamics of the model. Branch and Evans (2006) show that intrinsic heterogeneity is possible among agents with similar skills and abilities who choose predictors (that are costless) from a set of optimal misspecified econometric models, which produce identical long-run performance. We demonstrate that intrinsic heterogeneity can arise even among agents with different skills who use alternative rules that do not perform equally well in the long run, and there is a cost attached to the more sophisticated rule. This sort of heterogeneity has widespread empirical evidence, as reviewed below. Heterogeneity can also emerge in the setup of Brock and Hommes (1997) under finite intensity of the choice parameter, which is consistent with boundedly rational behavior. It is more difficult to present a model where heterogeneity also arises under an infinitely high intensity of the choice parameter, as in Branch and Evans (2006, 2007). In this case the agents rationally decide which model to use, and a simple balancing of costs and benefits will not be adequate in a model with self-referential properties, such as the cobweb model. Branch and Evans (2006, 2007) approach shows that heterogeneity might arise between agents who have similar economic skills (but believe in different models). We show that heterogeneity might also emerge as an equilibrium outcome between agents with different abilities or different economics skills (literacy) under both finite and infinite intensities of the choice parameter. In our framework, not all the agents have the capacity to perform the computations needed to estimate, for example, a vector auto-regression model. Depending on the parameterization of the model, we can also observe convergence to a strictly dominating predictor, thus maintaining the generality of the model. This is consistent with the positive correlation property that was advocated by Sandholm (2010) and Waters (2009),[2] where the dynamic predictors that are strictly dominated (in the long run) should be driven out of the market. Furthermore, this property requires designing the predictor so that in periods where the difference in the profitability of both alternatives increases (the volatility of the variable that is forecasted increases), more agents use the more accurate predictor. To compare our results with the existing literature on intrinsic heterogeneity, we investigate a special case of the choice between perfect foresight and naive expectations in a stochastic version of the cobweb model.

In contrast to Brock and Hommes (1997), Branch and McGough (2008) and Waters (2009), we present a dynamic predictor selection that takes into account the different roots of potential heterogeneity. A limited number of individuals can use the rational predictor since not all of them have a sufficient capacity to process information to form rational beliefs (perfect foresight). We believe that investing in knowledge or skills (the capacity to process information) is a long-term decision. Other predictors commonly used in economics fail to take into account the fact that some agents might not be able to switch immediately to a sophisticated predictor. In addition to long-run decisions regarding the capacity to process information, we also model information updating, which is a short-horizon decision. Agents have to regularly update their information sets to be able to forecast with perfect foresight. The predictor put forward in this paper is determined in two stages. In the first stage, the agents choose between the costly building-up of the capacity to process information and free riding, which decreases their capacity to process information. This stage is modeled using one of the standard predictors in the literature. In the basic example we use New Learning Dynamics (NLD), as in Waters (2009), but generalized replicator dynamics, as in Branch and McGough (2008), could be used without changing the main results. In the second stage, we model information acquisition, but in a very simple way. Even when agents build up capacity they might not observe all the relevant information to use perfect foresight.[3,4]

The idea of ability constraints, and the availability of information, was discussed in the economics literature of the late 19th and early 20th centuries and in the economics psychology literature at least from Herbert Simon onwards (Whalley, 2005). Heckman et al. (2006) show that cognitive and noncognitive skills explain several labor market decisions as well as schooling decisions. A potential shortcoming of previous models of the dynamic predictor selection is their assumption that all the agents are capable of using perfect foresight at any point in time. In reality they have to learn and build up the capacity to process information for a long period of time before they can use perfect foresight. It is possible to think about this as an investment in human capital, e.g., an investment in education or, more relevant to our case, economic literacy. However, by construction, all economic agents in our model have similar cognitive abilities since all of them can eventually build up their capacity to a level where they can use a sophisticated predictor. Burke and Manz (2011) show that subjects with a higher economic literacy make a better choice of the information to use for forecasting and better use the given information in the inflation forecasting experiment. Some evidence showing that education is an important determinant of

[1] See e.g., Friedman (1953), Brock and Hommes (1998), and Hommes (2013).

[2] The proposed predictor also satisfies the property of inventiveness proposed by the same authors, which guarantees that successful new strategies could be introduced in the population and that the extinction of a strategy does not necessarily have to be permanent. However, in this paper we focus on the analysis of the choice between perfect foresight and the naive predictor.

[3] Fig. A1 in Appendix A provides a simple explanation of the decision process.

[4] The latter root of heterogeneity has received much attention in macroeconomics because it can help to reconcile the standard models with the stylized facts, see e.g., Ball et al. (2005) and Branch et al. (2009).