Book review
Learning and Expectations in Macroeconomics
by George Evans and Seppo Honkapohja
Princeton University Press

Reviewed by James Bullard

Economic science differs from physical science in that the primary actors in the theories are human beings. Because people have some degree of understanding about the world around them, they can use this information to try to predict future events that will influence their economic well-being. Moreover, people can take actions today based on their expectations of the future, and these expectations can have important, even decisive, influence on what actions they may take. This is *the* central question of modern economic theory: What is the role of expectations in economic life? And it is not a matter of merely theoretical interest. It is very much an open question whether real macroeconomic events, such as the recent run-up in American equities prices, the decade-long stagnation of Japan, or the recent currency crisis beginning in Southeast Asia, were driven wholly or in part by the changing expectations of market participants.

There was a major theoretical advance in the treatment of expectations during the postwar era, in that the rational expectations hypothesis came to dominant all economic theorizing. Under rational expectations, the people (*a.k.a.* agents) in the theory form expectations in such a way that their expectations are validated by actual outcomes. As Evans and Honkapohja state, this is a fixed point of the process delineated by "my expectations influence economic outcomes, and economic outcomes influence my expectations." The rational expectations hypothesis serves as a crucial benchmark for all of the Evans and Honkapohja text, but at the same time leaves many important questions unanswered. Perhaps most importantly, the fixed point

logic of the rational expectations hypothesis does not tell us anything about how agents actually form their expectations using the information that might be available in a real economy.

This is where Evans and Honkapohja enter. They have written a marvelous text which lays out the methodology for—and the implications of—taking the next logical step in the theory of expectations formation. That step is to assume that the agents in the model behave like econometricians when forming their expectations of the future, and that they have the information which would normally be available to econometricians when they do so. This particular learning assumption—recursive learning—is not the only way to proceed, but I think it is the most natural way to proceed. In particular, economists need to know how to analyze systems under this type of learning assumption, and what kinds of results can be obtained, before moving on to explore other, more elaborate, learning assumptions. Evans and Honkapohja have fully worked out methods to analyze the resulting dynamics under this learning assumption for a wide variety of macroeconomic models. This is an important methodological and technical achievement.

Based on the Evans and Honkapohja analysis, we can reach some clear conclusions about the recursive learning assumption and its implications for macroeconomics. I will divide these into three categories. First and foremost, if agents use recursive learning rules to form their expectations, then they can often eventually achieve a rational expectations equilibrium—that is, agents can learn to have rational expectations. This provides an important justification for the rational expectations assumption and its wide use in macroeconomics today. It means that for macroeconomic systems which are structurally stable and that have a unique equilibrium, it may be reasonable to assume that actual agents could learn the equilibrium using readily

available econometric forecasts. The economist studying such a system does little harm by simply assuming that the agents have rational expectations.

But there is another way to view this main result. The Evans and Honkapohja analysis tells us economists precisely the conditions for stability in the recursive learning dynamics. If these conditions are not met, then we have a clear prediction that while a rational expectations equilibrium exists, it is not a learnable equilibrium, and we should not expect it to be achieved by agents using recursive learning algorithms. The dynamics would instead diverge away from the equilibrium, with unpredictable consequences. This unstable situation is possibly the most important contribution of the Evans and Honkapohja analysis: *not every rational expectations equilibrium is learnable.* I want to elaborate on this point for a moment.

In current macroeconomic methodology, one writes down a model meant to address an important issue, finds the rational expectations equilibria, and then makes predictions based on these results. There is no further analysis of whether the equilibria are reasonable in the sense that agents could use available information to coordinate on them. Always it is simply assumed that the equilibra can be achieved under some unspecified learning assumption. Evans and Honkapohja have provided the methodology to go beyond this simple assertion and actually calculate whether an equilibrium is learnable by agents using recursive learning schemes. This may lead to a dramatic change in the way macroeconomics is done. In the future, one may theorize by locating the rational expectations equilibria of a model, and then instead of stopping there, one might have go on to study whether the Evans-Honkapohja conditions for expectational stability hold, and thus show that not only does the rational expectations equilibrium exist, but that it is also a reasonable prediction for an actual economy because it is learnable. If such a

change in methodology comes to pass, then the Evans and Honkapohja book will come to be seen as one of the most important contributions to economic theory of the last 25 years.

I do not believe that the thinking of macroeconomists has come to this point yet. But I definitely believe that the thinking in the economics profession is moving in the direction of more explicit modeling of learning. I also think that the Evans and Honkapohja analysis of learning is the clear standard against which all other macroeconomic learning analyses must be measured.

There is a second category of conclusions from the Evans and Honkapohja analysis. An important problem with the rational expectations hypothesis as it is currently employed in macroeconomics is that, in many models, there is more than one rational expectations equilibrium. The theorist is left dangling in this situation, as there is currently no standard method for predicting which equilibrium will actually be achieved. The recursive learning analysis of Evans and Honkapohja can help to draw firmer conclusions in this situation. Possibly, some of the rational expectations equilibria are learnable, while others are not. In this way, we can use the theory of recursive learning to rule out some of the rational expectations equilibria when there are many of them. The Evans and Honkapohja text plays the leading role in showing how such an analysis can be carried out.

A final, third category of conclusions involves the learning dynamics themselves. If an economy suffers any type of important and unexpected structural shift—regime changes such as radically new government policy, war, or new technological developments—then there will necessarily be a period of adjustment to the new situation. The regime shift alters the underlying rational expectations equilibria in the economy, and the agents living in the

economy must learn the new equilibrium. In this situation, which might continue for a long period of time, the nature of the learning dynamics are empirically important. Even without regime shifts, learning dynamics may be interesting in their own right, because the systems under learning may give rise to endogenous cycles which match features of observed economies.

I have not placed emphasis on the technical accomplishment apparent in the manuscript, but the level of analysis is unsurpassed. I thought the organization was quite effective, and that the writing was clear and precise. The authors' decision to summarize much of what they do on a less technical level in the first four chapters was a good one in my view. With these chapters, the main ideas will be accessible to a wide audience and will give the book a wide readership.

In summary, then, I think this book is a significant contribution to the theory of learning in macroeconomic systems. It is the leading contribution in the methodology of analyzing recursive learning. As theories of learning continue to grow in importance within economics, this book will become a standard reference for many economists working in dynamic macroeconomic theory.