Expectations, Learning and Macroeconomic Persistence

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Abstract

Monetary DGSE models under rational expectations typically require large degrees of features as habit formation in consumption and inflation indexation to match the inertia of macroeconomic variables.

This paper presents an estimated model that departs from rational expectations and nests learning by economic agents, habits, and indexation. Bayesian methods facilitate the joint estimation of the learning gain coefficient together with the 'deep' parameters of the economy.

The empirical results show that when learning replaces rational expectations, the estimated degrees of habits and indexation drop closer to zero, suggesting that persistence arises in the model economy mainly from expectations and learning.

Keywords: persistence, constant-gain learning, expectations, habit formation, inflation inertia, Bayesian econometrics, New-Keynesian model.

JEL classification: C11, D84, E30, E50, E52.

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1. Introduction

Dynamic stochastic general equilibrium (DSGE) models have become a popular tool for the analysis of the monetary transmission mechanism.[1] These models are built under the hypothesis of *rational expectations* and assume intertemporal optimizing behavior by economic agents. Being derived from explicit microeconomic foundations, they facilitate policy evaluation in terms of the welfare of private agents. Unfortunately, the canonical monetary models with rational expectations often cannot match the observed behavior of macroeconomic variables, and, in particular, they fail to match the **persistence** of aggregate output and inflation.

Economists have therefore proposed a number of extensions to the standard framework by embedding potential sources of endogenous persistence. They have incorporated features such as habit formation in consumption, indexation to lagged inflation in price-setting, rule-of-thumb behavior, or various adjustment costs. Christiano, Eichenbaum, and Evans (2005) incorporate several of these extensions and can account for the inertia in the data. Smets and Wouters (2003, 2005) estimate similar models by Bayesian methods, incorporating a mix of frictions and persistent structural shocks, and obtain a remarkable fit of the data. Also, Boivin and Giannoni (2005) and Giannoni and Woodford (2003), in smaller models, but which still incorporate additional sources of persistence, derive impulse responses that approximate those derived from VARs.

The cited extensions essentially improve the empirical fit by adding lags in the model equations. Researchers estimating these rich models under the assumption of rational expectations typically find that substantial degrees of habit persistence and inflation indexation are supported by the data. Those additional sources of persistence appear, therefore, necessary to match the inertia of macroeconomic variables.

[1] Clarida, Gali', and Gertler (1999), Goodfriend and King (1997), McCallum and Nelson (1999), and Woodford (2003) are standard examples describing dynamic general equilibrium models for monetary policy analysis.

1.1. ***Contribution of the paper***

This paper suggests a different direction, by revisiting the expectations formation of the agents. The paper departs from the conventional rational expectations assumption. Agents in the model form expectations using correctly-specified economic models, but they do not have knowledge about the model parameters. They use historical data to learn those parameters over time, updating their beliefs through constant-gain learning. The paper then evaluates the potential for **learning** as a mechanism that can endogenously generate persistence in the economy and improve the fit of current monetary DSGE models. More in detail, the paper aims to disentangle the role of learning versus 'mechanical' sources of persistence,[2] such as habits and indexation, in generating persistence in macroeconomic variables.

The paper starts by taking an agnostic view. The model *nests* different sources of persistence: learning by private agents along with the 'mechanical' sources of persistence, such as habit formation in consumption and indexation to past inflation in price-setting, which are essential under rational expectations to account for the observed persistence. It is left to the data to disentangle the role of the various sources. The scope is to test whether those mechanical sources of persistence are still necessary to match the data when the assumption of rational expectations is relaxed in favor of learning.

The model is estimated using likelihood-based Bayesian methods. The econometric approach allows me to *jointly* estimate the coefficients describing agents' learning, such as the gain coefficient (indicating their learning speed), together with the 'deep' parameters of the economy. This strategy responds to a potential criticism of models with learning, in which the results might depend on the parameters that need to be chosen by the researcher. Here the learning speed is, instead, jointly estimated with the rest of the system.

[2]The paper refers to them as 'mechanical' since in the case of habits, researchers need to alter the consumers' utility function to imply dependence on lagged consumption, and in the case of indexation, they posit a rule to induce inertia through the assumption that a fraction of firms simply adjust prices automatically, according to the past observed inflation rate.

In providing an empirical analysis of the importance of learning, the paper builds on previous literature on adaptive learning in macroeconomics. Not many studies have analyzed the empirical implications of adaptive learning. At the earlier stages, this literature was mainly theoretical and focused on convergence of the models to the Rational Expectations Equilibrium (REE).[3] More recently, a number of papers[4] have employed learning to analyze the evolution of U.S. inflation and monetary policy. These papers share the use of learning as a tool that can help in understanding some particular historical episodes, which are often harder to explain under rational expectations.

The present paper tries, instead, to provide a more general empirical study of the effects of learning. Its scope is akin to the work by Williams (2003), who studies the implications of learning for persistence and volatility in simple calibrated real and monetary business cycle models. The present paper shares his scope of studying the effects of learning, but it exploits, instead, actual time series data. This allows me to verify if learning is supported by the empirical evidence and to compare the model with learning with alternative descriptions of the economy. The paper is also related to the recent work by Adam (2005), who likewise assumes that economic agents use simple econometric models to forecast macroeconomic variables and shows how deviations from rational expectations may strengthen the internal propagation mechanism of a simple business cycle model.

Similarly to recent empirical papers in macroeconomics,[5] this paper adopts Bayesian methods in the estimation. The techniques are similar to those used by Schorfheide (2000, 2005) and Lubik and Schorfheide (2004, 2005), among others. But Schorfheide (2000), as well as several papers that share the same techniques, estimate DSGE models under rational expectations.[6] The current paper, instead, provides the first example of the use of Bayesian

[3] Evans and Honkapohja (2001), Bullard and Mitra (2002), and Preston (2005) are examples that verify the learnability of the REE in monetary models.

[4] Branch et al. (2004), Bullard and Eusepi (2005), Orphanides and Williams (2005b), Primiceri (2003), Sargent (1999), and Sargent, Williams and Zha (2004), among others.

[5] An and Schorfheide (2006) provide a first review of this literature.

[6] Schorfheide (2005) assumes an incomplete information model in which agents need to update their beliefs about the inflation target using a Bayesian learning rule. In his model, however, agents still form fully-rational expectations.