



Heterogeneity, learning and information stickiness in inflation expectations[☆]

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ABSTRACT

In this paper we propose novel techniques for the empirical analysis of adaptive learning and sticky information in inflation expectations. These methodologies are applied to the distribution of households' inflation expectations collected by the University of Michigan Survey Research Center. To account for the evolution of the cross-section of inflation forecasts over time and measure the degree of heterogeneity in private agents' forecasts, we explore time series of percentiles from the empirical distribution. Our results show that heterogeneity is pervasive in the process of inflation expectation formation. We identify three regions of the distribution that correspond to different underlying mechanisms of expectation formation: a static or highly autoregressive region on the left hand side of the median, a nearly rational region around the median and a fraction of forecasts on the right hand side of the median formed in accordance with adaptive learning and sticky information.

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1. Introduction

This paper deals with the analysis of private agents' inflation expectations. Despite the fact central banks claim that managing inflation expectations is one of the most important prerequisites for attaining price stability and promoting sustainable growth, still very little is known about consumers' process of expectation formation. As noted by [Bernanke \(2007\)](#), reported private sector inflation expectations are important because they signal future inflationary risks and provide indications about agents' perception of these risks. Private inflation expectations often diverge from those of the central bank, and may represent a distinct source of information as well as a potential intermediate target for the conduct of monetary

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policy. We argue that valuable information can be extracted by analyzing the distribution of households' inflation forecasts, whereas a substantial number of studies have typically focused on measures of central tendency, such as the mean or the median forecast.

Our analysis is centered on the development of novel techniques for the assessment of different mechanisms of expectation formation which have been recently advanced in the theoretical literature. The common trait of these theories is to relax the hypothesis of perfectly informed agents, as assumed in the rational expectations paradigm. Some of these theories postulate the existence of informational frictions generating sticky expectations, while others conjecture that agents might act as econometricians when forecasting. The latter approach, widely known as adaptive learning, is extensively discussed in Evans and Honkapohja (2001). As to sticky expectations, a number of papers (e.g., Carroll, 2003a; Mankiw and Reis, 2002) show how to generate time dependent rules under which expectations are updated only at fixed intervals. Carroll (2003a,b) proposes an epidemiological framework whereby consumers update their inflation expectations from the media, which are assumed to transmit the expectations of the professional forecasters. Mankiw and Reis (2002) suggest that agents update information more frequently when inflation matters. We put forward novel techniques for the empirical assessment of adaptive learning and inattentiveness in inflation expectations.

We apply our methodologies, along with traditional tests for rational and adaptive expectations,¹ to the distribution of households' inflation expectations collected by the University of Michigan Survey Research Center. Our focus on the cross-section of private agents' forecasts is aimed at assessing different sources of heterogeneity in the process of expectation formation. In order to account for the evolution of the cross-section of inflation forecasts over time, we compute percentiles of the empirical distribution in each period. Therefore, we retrieve monthly time series for each percentile, which convey information on different agent-types over the cross-sectional spectrum of responses in the empirical density. We find that the null hypothesis of rationality cannot be rejected just for few percentiles, which are generally placed around or slightly above the median forecast. We estimate the sticky information model put forward by Carroll (2003a,b) for each agent-type. Only less than 10 percent of the forecasts reflect regular information updating. We then augment the epidemiological framework to account for the impact of the level of inflation on the frequency of information updating. The resulting framework is based on the assumption that agents are more likely to regularly update their information set when inflation "matters". We show that this mechanism fits rather well the forecasts in the upper end of the distribution, which reflect greater attentiveness in periods of high and volatile inflation.

We put forward a novel technique to detect the presence of adaptive learning in the distribution of forecasts. The initialization of the learning algorithm is of crucial importance in the estimation of the gain parameter that indexes the speed of learning. Previous estimation techniques of models under adaptive learning (Milani, 2007) have generally been pursued by splitting the time series into two subsamples. The first subsample is used to estimate the initial values of the parameters in the Perceived Law of Motion (PLM). In turn, these values represent the starting point for the recursive estimation of the gain parameter in the second part of the sample. The main practical inconvenience of this approach is that it does not allow the researcher to fully exploit the data available. In addition, this procedure still bears the risk that learning dynamics could result just as a statistical artifact due to a non-optimal initialization. Our approach abstracts from this criticism, as we search for the combination of initial values and gain parameter that provide the closest fit of the empirical density, thus preserving the sample structure and optimizing the initialization.² Our results suggest that consumers' expectations on the right hand side (RHS) of the median forecast display adaptive learning, whereas forecasts on the left hand side (LHS) of the median do not exhibit such behavior.

We propose an alternative mechanism of expectation formation, whereby households are assumed to update their forecasts with respect to (expected) future errors, which are reflected in the difference between their forecasts and those of the professional forecasters. This mechanism draws on the epidemiological view advanced by Carroll (2003a), and represents a combination of adaptive learning and sticky information.

Additional time series techniques take into account a wider set of explanatory variables for inflation forecasts and confirm a significant degree of heterogeneity and asymmetry in the underlying information structure. The forecast range at the center of the distribution is generally unbiased. However, our results suggest that the forecasts on the LHS of the median forecast are highly static and entail systematic forecast errors. It can be argued that expectations in this region of the empirical density are stable around certain digits and that they do not reflect movements in any of the macroeconomic statistics considered as relevant for the forecasting process. Conversely, forecasts on the RHS tend to over-react to changes in the current rate of inflation. These findings are in line with the evidence carried out by Curtin (2005), who points out that negative changes in inflation exert twice the impact as positive changes. As noted above, expectations on the RHS of the median forecast are consistent with adaptive behavior. In this forecast range information is updated only from time to time.

Three different roots of heterogeneity have been traditionally explored in the literature. Heterogeneous forecasts might be the consequence of agents (i) employing different models,³ (ii) relying on different information sets or (iii) entailing different capacities to process information. Some theoretical studies have introduced heterogeneous expectations in stan-

¹ See, for a review of these tests, Pesaran (1987), Bakhshi and Yates (1998) and Mankiw et al. (2004).

² Orphanides and Williams (2003, 2005a,b) and Milani (2007) have provided some empirical support for adaptive learning dynamics in DSGE models.

³ Namely, agents could have different underlying assumptions about the structure of the economy or different parameterizations (or priors) of the same model.

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