



# Modeling heterogeneous inflation expectations: empirical evidence from demographic data?☆



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## ABSTRACT

This study proposes the Idiosyncratic Adaptive Expectation model based on decision theory to explain how agents incorporate information about the past to form their inflation expectations. The empirical results suggest that both inflation perception and past actual inflation have significant effects on the formation of inflation expectations, and the Idiosyncratic Adaptive Expectation model is valid in capturing the dynamics of inflation expectations. Investigations of demographic groups provide robust supportive evidence for this novel model. The results suggest that agents are more concerned about inflation perception, which is less costly to understand, than about actual inflation, which entails higher costs. Furthermore, the Granger causality test reveals that more heterogeneous inflation perceptions cause statistically higher heterogeneity in inflation expectations. Compared with rational expectation, adaptive expectation, static expectation and idiosyncratic static expectation models, the Idiosyncratic Adaptive Expectation model is better at capturing inflation expectations empirically. The results have implications for macroeconomic modeling, stressing the significance of perceived and expected inflation.

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## 1. Introduction

The self-fulfilling feature of expectation implies that well-anchored inflation expectations are essential for price stability and economic development; thus, expectations have become pivotal in modern macroeconomic theory (Pfafjar and Žakelj, 2014). The theoretical role of inflation expectation formation is evident in the Phillips curve relationship, which has played a central role in applied macroeconomics in recent decades (Rudd and Whelan, 2007). If inflation expectations are adaptive, an impulse in inflation affects the unemployment rate (Friedman, 1968). If inflation expectations are rational, the effects of inflation expectations on unemployment vanish (Lucas, 1972; Sargent, 1973). Consequently, the theoretical implications of the Phillips curve

and implementing monetary policy depend on the formation of inflation expectations.

Many theoretical models concerning the expectation formation process suggest that informational frictions and the heterogeneity of expectations are important. However, there is no consensus on how household inflation expectations are formed (see Bernanke, 2007; Bachmann et al., 2015; Coibion and Gorodnichenko, 2015), and the heterogeneity of inflation expectations is difficult to capture empirically. Rational inattention theory, which argues that agents partly incorporate information because of high cost, and the explanation that agents learn from the information derived from their personal perception about inflation are widely accepted in investigations of inflation expectation heterogeneity (de Bruin et al., 2011; Malmendier and Nagel, 2015; Coibion and Gorodnichenko, 2015).

Inflation expectations are generally captured through surveys. Little research has been conducted on the dynamics of inflation expectations from a demographic point of view. According to the decision-theoretic models of perceptual choice that describe how probable and present information should be combined to make optimal choices (Summerfield and de Lange, 2014), this paper proposes a novel model, the Idiosyncratic Adaptive Expectation (IAE) model, to capture the formation of inflation expectations. We present empirical evidence using demographic

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data to disentangle the roles of inflation perception and rational inattention in the formation of inflation expectations. By comparing the IAE model with four commonly used inflation expectation formation models, we document that the IAE model performs better at capturing the formation of inflation expectations, followed by the adaptive expectations model. The rational expectations model is the least preferred model. This finding has significant implications for macro modeling, indicating that rational expectation might be inappropriate in capturing households' inflation expectations and therefore induces misleading conclusions of macroeconomic models, particularly the expectations-augmented Phillips curve. Moreover, our model considers both rational inattention and heterogeneous personal experience, making the model valid in describing the heterogeneity in demographic inflation expectations.

This study proceeds as follows. Section 2 is a literature review. Section 3 proposes a novel model in capturing the formation of inflation expectations. Section 4 proceeds a preliminary look at the data. Section 5 presents the empirical results and compares the novel model with some other commonly used inflation expectation formation models. Section 6 concludes.

## 2. Literature review

Various models that describe how agents form inflation expectations have been proposed. The most influential such model is the rational expectations model (RE; Muth, 1961), which is viewed as the standard assumption in most contemporary macroeconomic models of actual inflation (Gali and Gertler, 1999; Rudd and Whelan, 2007). Using household survey data, a large body of literature tests the RE hypothesis, with ambiguous conclusions. Whereas Forsells and Kenny (2004) and Mankiw et al. (2003) reject the RE hypothesis by testing U.S. and Eurozone household survey data, it is suggested that approximately 40% of individuals form expectations consistent with rationality (Pfajfar and Žakelj, 2014), and the RE is supported by the empirical study of Liu and Minford (2014). The rational inflation expectation is embedded in the New Keynesian Phillips curve (NKPC). Whereas Abbas and Sgro (2011), Bloch (2012), and Lee and Yoon (2016) support the NKPC empirically using the RE, Mazumder (2011) and Malikane (2014) casts serious doubt on the empirical viability of the model.

Two other commonly adopted expectation formation models are the static expectation (SE) and adaptive expectation (AE) models. The SE model assumes that the expected inflation equals the latest actual inflation, indicating that the inflation expectations are homogeneous, and the information sets across the agents are the same. The SE often serves as a benchmark in empirical studies (Mehra, 2002) and is employed in the hybrid New Keynesian Phillips curve which has been demonstrated to be effective at capturing the dynamics of the actual inflation in certain literature (Gali and Gertler, 1999). By illustrating the validity of the hybrid NKPC, Henzel and Wollmershäuser (2008) and Xu et al. (2015) tend to support the SE rather than the RE. Similar evidence approving the hybrid NKPC is provided in Narayan et al. (2009), Narayan and Narayan (2010, 2013), and Scharnagl and Stapf (2015). However, the hybrid NKPC faces some criticism (Rudd and Whelan, 2005; Fair, 2008), and the assumption of backward-looking behavior is unappealing theoretically (Dupor et al., 2010). The AE model assumes that the expected inflation is the weighted average of the past inflation expectation and the current actual inflation. With the development of the expectations-augmented Phillips curve and the accelerationist hypothesis, the AE is widely adopted in empirical and experimental studies. Nevertheless, only actual inflation is viewed as the information used to form inflation expectations, making the AE less attractive in explaining heterogeneity in inflation expectations.

Although the above models are widely used in theoretical and empirical investigations, the information sets used to form inflation expectations are assumed to be the same, and only homogeneous inflation expectations are generated from the models, which contradicts most current investigations. Bryan and Venkatu (2001) illustrate that female,

single, nonwhite, less educated, low-income, and young and old agents have significantly higher inflation expectations. Given the difference in income and marriage, females still tend to report higher inflation expectations than males. In investigating the U.S., de Bruin et al. (2010) find that whereas female, older, and single agents tend to report higher expectations, better-educated, low-income, and white agents have lower expectations. Armantier et al. (2015) conclude that female, lower income, and less educated agents tend to possess lower numeracy and financial literacy and are more likely to provide higher and more volatile inflation expectations. Similar conclusions are obtained by Palmqvist and Stroemberg (2004).

The above investigations demonstrate that demographic characteristics have a direct effect on agents' inflation expectations. Furthermore, the effects of demographic characteristics on the accuracy of inflation expectations are demonstrated in a vast body of literature. For example, higher expectation errors are demonstrated for young individuals, females, low-income agents, low-skilled workers, agents with a non-European background, and respondents from rural areas (Leung, 2009). Using qualitative and quantitative survey data for the U.S., Souleles (2004) reports robust results that show that the elderly, females, blacks, less educated people, low-income people, and agents with a growing number of children have larger forecast errors. Similar conclusions are obtained by Pfajfar (2013), showing that less educated agents have higher forecast errors. Studies on financial literacy (Lusardi and Mitchell, 2008; de Bruin et al., 2010) also provide evidence that demographic characteristics affect the accuracy and level of inflation expectations.

Consumer surveys indicate that household inflation expectations are significantly heterogeneous and are affected by demographic characteristics (Ranyard et al., 2008; Armantier et al., 2013). Three main explanations for the heterogeneity in inflation expectations are empirically and theoretically discussed in the literature. Some authors attribute it to the difference in information sets. Mankiw and Reis (2002) propose a sticky information model in which the information regarding macroeconomic conditions diffuses slowly among firms. The slow spread of information is caused by the costs of the acquisition of information or optimization and induces different information sets in agents, which generate heterogeneous inflation expectations. The model is further investigated empirically in Mankiw et al. (2003) to test whether it is capable of predicting the heterogeneity observed in the Michigan Survey. Significant differences in information update speeds are illustrated in their empirical research, indicating that the heterogeneity between household and professional inflation expectations could be explained by the heterogeneous information sets. An epidemic model proposed by Carroll (2003) assumes that consumers form expectations based on professional forecasts, and information about professional forecasts diffuses slowly. Therefore, the epidemic model is viewed as the micro-foundation for the sticky information model in Mankiw and Reis (2002). Although the information stickiness in the formation of inflation expectation is widely illustrated (Carroll, 2003; Doepke et al., 2008), only professional forecasts are viewed as the information source of forming inflation expectations.

Other authors argue that consumers' personal experiences (which can be inaccurate and diverse) are used to form inflation expectations (de Bruin et al., 2011; Madeira and Zafar, 2015; Malmendier and Nagel, 2015; Coibion and Gorodnichenko, 2015). Positive correlations between perceived and expected inflation are demonstrated in Ranyard et al. (2008), indicating that inflation perceptions are likely to be an important factor affecting inflation expectations. Furthermore, Palmqvist and Stroemberg (2004) find similar characteristics for perceived and expected inflation, i.e., agents' inflation perceptions and expectations are more accurate into middle age and then deteriorate when they become elderly, implying the same demographic characteristics for perceived and expected inflation. Moreover, Benford (2008) investigates a survey of attitudes towards inflation and notes that perceived inflation is the most important determinant of inflation

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