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# Dispersion of Inflation Expectations: Stylized Facts, Puzzles, and Macroeconomic Implications

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*Building on time-series and cross-sectional properties of survey forecasts, this paper documents a fruitful set of stylized facts of inflation expectations in Korea that a macroeconomic theory must aim to explain. Despite the fact that survey measures of inflation expectations have a similar central tendency, the amount of disagreement among different types of economic agents appears to be substantial and shows no clear relationship with relative price variability. The analysis of micro-level inflation expectations data suggests that inflation uncertainty measured by dispersion of households expectations relies not only on inflation regime but also on relative price variability. Each survey forecast has the ability to explain the path of future inflation, but surprisingly with the wrong direction from the rationality perspectives. Percentile regression analysis yields robust evidence of bounded rationality for the households.*

JEL Classification: D8, E3, E0, E5, C5
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## I. Introduction

This paper studies the dispersion of inflation forecasts among households and the extent of disagreement on inflation expectations across different types of economic agents by employing survey measures of inflation expectations data in Korea. We document a number of important empirical aspects of the data such as relative volatility between inflation forecasts and actual inflation and disagreement on the expected path of future inflation within and across economic agents, among others. There is the well-documented fact that inflation forecast rationality is routinely

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rejected in the survey data and thus the introduction of potential heterogeneity in inflation expectations by relaxing the assumption of fully-informed agents remarkably affects model outcomes and policy implications (Roberts, 1997; Orphanides and Williams, 2003; Sims, 2009; Del Negro and Eusepi, 2011; Badarinza and Buchmann, 2011). Nonetheless very little is known about the nature of inflation expectations in Korea. This motivates us to explore both time-series and cross-sectional properties of inflation expectations data and their relationship with some important macroeconomic variables.

Uncertainty plays an important role in many areas of economic behavior since it affects economic agents' decision-making process and thus social welfare. In particular, traditional macroeconomic models suggest that uncertainty about future inflation clouds consumers' inter-temporal choices and possibly reduces economic well-being.[1] Understanding inflation uncertainty that can be extracted from the distribution of survey forecasts of inflation is also crucial for evaluating central bank credibility and effectiveness of communications. In addition, as the focus of central banks shifts toward inflation targeting in which a central bank announces a projected inflation rate and then steer actual inflation towards the target rate, it becomes increasingly important to know households' perceptions of future inflation including central tendency and their distributional aspects. Specifically, as households' beliefs on future inflation influence the actual outcome, inflation expectations should be an object of interest for monetary policymakers.

Lack of subjective inflation expectations data has motivated a number of studies to use survey measures of inflation forecast. For example, Carroll (2003), Mankiw, Reis, and Wolfers (2004), Pesaran and Weale (2006), Capistrán and Timmermann (2009), Pfajfar and Santoro (2010), and Coibion and Gorodnichenko (2012), among others, rely on survey data to document some important features of professional and consumer inflation forecasts in the US and to assess how well a macroeconomic model with information frictions can account for the stylized facts about inflation expectations. Although details differ across the studies, the common conclusion is that survey forecasts are useful to understand economic agents' inflation expectations and there exist substantial interpersonal and intrapersonal variations in expected inflation due to informational rigidities preventing economic agents from making exact expectations.[2]

Notwithstanding its theoretical and practical importance, there is little work dealing with inflation expectations in Korea, mainly due to the fact that a sufficient

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[1] A discussion on the relationship between inflation uncertainty and inflation can be found in Golob (1994).

[2] It is clearly of interest to examine the nature of information rigidities faced by economic agents and thus potential sources of heterogeneity in inflation expectations. However, this analysis is well beyond the scope of the current paper. In addition, unlike US survey data, individuals' characteristics, such as income, education, and gender, are not available in the Consumer Survey in Korea.

number of data observations had not been available. To the best of our knowledge, this paper is the first attempt to rigorously investigate the nature of survey forecast data and their relationship with inflation and other macroeconomic variables. To address the questions discussed above, we employ survey measures of inflation expectations in Korea, Consumer Survey, Survey of Professionals, and Consensus Survey. In particular, micro-level data on households' inflation forecasts are extensively utilized to study the dynamic behavior of cross-sectional variations in inflation expectations.

By focusing on the one-year-ahead forecast of the CPI inflation rate, we first document some important aspects of those survey data. All survey measures of inflation expectations are found to be fairly stable during the sample period, 2002:M2-2012:M12, and display similar long-run central tendencies. In addition, the survey forecasts are much less volatile than actual inflation and exhibit substantial persistence.[3] Simple measures of forecast accuracy confirm that the indicator of central tendency has ability to predict the path of future inflation development. That is, the magnitude of forecast bias appears to be relatively small on average. However, the contemporaneous deviation of actual inflation from the survey forecasts found to be substantial and considerably persistent. Strikingly, each of the survey forecasts has an explanatory power to predict future changes in prices, but with the wrong sign from the rationality perspective.[4] This anomalous result has not been reported in empirical studies relying on high inflation periods. We name this new empirical finding 'inflation forecast anomaly' that future research must aim to explain.

In this paper, we also document some important properties of both interpersonal variation (disagreement across survey forecasts) and intrapersonal variation (inflation uncertainty) in inflation expectations. First, the extent of disagreement about inflation expectations between consumers and professional economists appears to be significantly large. During the sample period, the disagreement shows no clear relationship with the level of inflation, which is not consistent with earlier findings suggesting a positive association between them, e.g., Mankiw, Reis, and Wolfers (2004). As a cause of the disagreement, relative price variability (RPV) appears to be an important source of interpersonal variation in expected inflation. Next, inflation uncertainty tends to fall with the level of inflation, but to rise with the central tendency of expected inflation. In addition, it is positively associated with the volatility of inflation and displays a strong correlation with relative price

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[3] Note that consumers tend to over-predict future changes in prices and their expectations display higher volatility than relatively more sophisticated economic agents covered in the Survey of Professionals and Consensus Survey. This is in line with the findings of Palmqvist and Strömberg (2004), Lindén (2005), and Pfajfar and Santoro (2008).

[4] In Section IV, percentile regression analysis that tests forecast rationality evidently supports this finding, and this anomaly is found to be quite robust.

variability. Using micro-level data on households' inflation expectations, we present empirical evidence against forecast rationality. A series of rationality tests that are commonly used in the literature routinely reject the null of rationality. Percentile regression analysis suggests that only a relatively small fraction of households has an unbiased prediction of future inflation. Almost none of the households tends to use information efficiently to predict future inflation and thus does make systematic forecasting errors.

The remainder of this paper is structured as follows. The following section describes the survey measures of inflation expectations in Korea and presents time-series properties of the survey forecasts, such as central tendency, volatility, persistence, and forecast accuracy. The extent of disagreement across survey measures is extensively discussed. Section III is devoted to a discussion of inflation uncertainty by utilizing households' inflation expectations data. Section IV reviews forecast rationality tests and presents empirical findings and implications. Section V concludes this paper with a discussion of future research directions.

## II. Inflation Expectations in Korea: Facts and Puzzles

This section introduces survey measures of inflation expectations and discusses common features and differences by examining their time-series properties such as central tendency, volatility, and persistence. In addition, we examine forcastability of each survey measure and the extent of disagreement across inflation forecasts. Finally, the relationship between inflation expectations and dispersion of commodity-level inflation rates will be discussed.

### 2.1. Survey Measures of Inflation Expectations

Inflation expectations have been recognized as an important ingredient in the inflation process in a number of macroeconomic models. Yet there is little agreement about the best measure of inflation forecast mainly due to the fact that it is not always clear who the most relevant people setting prices and wages are (Mankiw, Reis, and Wolfers, 2004). As such, we consider the following three survey measures of inflation expectations regularly employed in the literature.[5] Some basic details about the structure of these surveys are presented in Table 1.

As the primary concern for our analysis of inflation forecasts, we first rely on

[5] Albeit its usefulness, break-even inflation rate, which is defined as the difference between the nominal yield on Treasury notes and the real yield on an inflation-indexed Treasury securities of the same maturity, is not explicitly considered in this paper. This is simply because there is no sufficient number of data observations as it covers only the period since March 2007. For potential shortcoming of this measure of inflation expectations, see Carlstrom and Fuerst (2004).

Consumer Survey conducted by Bank of Korea (BOK), which is the most widely used measure of expected inflation in Korea.[6] The Consumer Survey is a nationally representative survey of 1500–2200 households done monthly since February 2002. Given the information about average CPI inflation rate over the last 12 months, survey respondents are asked to report their CPI inflation forecast interval for the next 12 months.[7] From the consumers' inflation expectations data, we construct a measure of the average of subjective inflation expectations over the next year, $\pi_t^e$, the weighted average of median of each interval,

$$\pi_t^e = \sum_{j=1}^{J} \omega_{j,t} \cdot \pi_{j,t}^m, \tag{1}$$

where $\pi_{j,t}^m$ is the median inflation forecast for interval $j = 1,2,\cdots,J$ at time $t$. The relative importance of each interval is given by $\omega_{j,t} = N_{j,t} / N_t$, where $N_{j,t}$ is the number of respondents choosing interval $j$ as their inflation forecast for time $t$ and $N_t$ is the number of total survey respondents.[8]

**[Table 1]** Surveys of Inflation Expectations

| | Consumer Survey | Survey of Professionals | Consensus Survey |
|---|---|---|---|
| Survey Population | Cross-section of general public | Economists working in economic research and financial institutes | Business, finance, central bankers, market and government economists (international and local economists) |
| Survey Organization | Bank of Korea | Bank of Korea | Consensus Economics, London, UK |
| Average Number of Respondents | Roughly 1500 per month to June 2006, then about 2200 per month to present | 50 per survey | Over 180 per survey |
| Starting Date | 2002:M2 | 2005:Q3 | 1995:M1 |
| Periodicity | Monthly | Quarterly | Monthly |
| Inflation Expectations | CPI inflation rate over the next 12 months | CPI inflation rate over the next 2 quarters, one year, and five years | CPI inflation rate over the next 12 months |

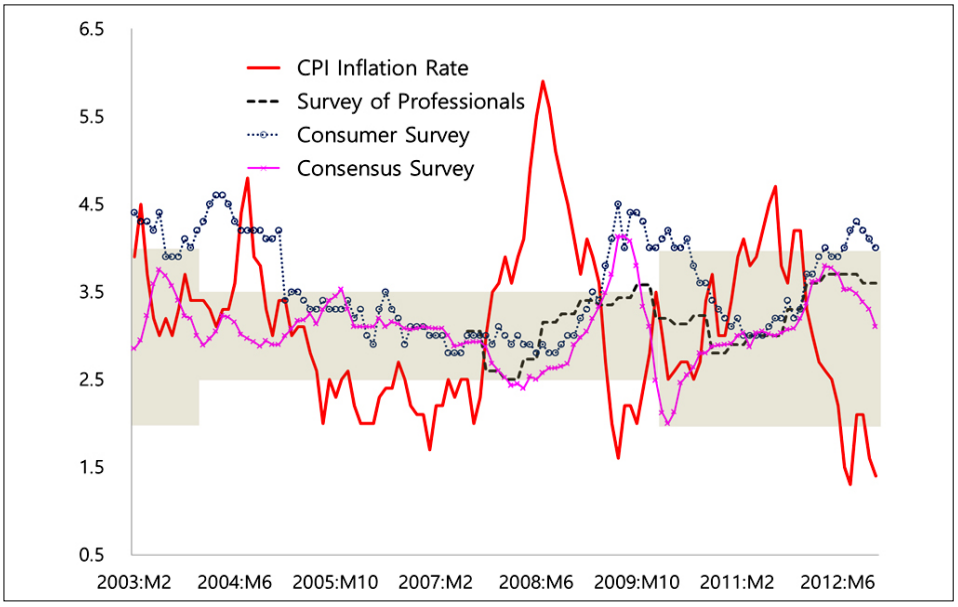
[6] For a more detailed description of Consumer Survey, see, for example, Lee (2012).

[7] Specifically, survey respondents are to choose one of 9 intervals ranging from -0.5% to 8% as of December 2012. The number of intervals has been changed several times since February 2002.

[8] Note that, since January 2013, the BOK has estimated expected inflation rate using a linear interpolation method to overcome potential bias due to asymmetric distribution of expected inflation. In addition to the estimation method, survey respondents are required to report their perception of inflation rate in the previous year instead of providing actual average inflation rate. However, the discrepancy between the two measures is found to be surprisingly minor.

The second source of inflation forecast is Survey of Professionals, some of the most informed economic agents. This survey may serve as a complementary measure of expected inflation. Starting from the third quarter of 2005, the BOK has collected forecasts on a variety of macroeconomic variables including CPI inflation rate. As of January 2012, this is a quarterly survey of 50 professional forecasters working in economic research and financial institutes. For consistency of Consumer Survey, we focus on one-year-ahead forecast of CPI inflation.[9] Finally, 12-month-ahead inflation forecasts published by Consensus Economics, an international economic survey organization, is utilized. Like Survey of Professionals, this survey covers more sophisticated analysts. In particular, Consensus Survey encompasses a wider range of expert economists such as investment managers, treasury executives, corporate planners, central bankers and government departments around the world. In addition, among the three measures of inflation expectations, this survey provides the longest time series observations.[10]

**[Figure 1]** Survey Measures of Inflation Expectations and CPI Inflation Rate




Note: The shaded areas represent the mid-term CPI inflation target band for the period of 2007-2010 and 2010-2013 (short-term (annual) CPI inflation target band for the period of 1998-2004, and core inflation target band for the period of 2004-2007).

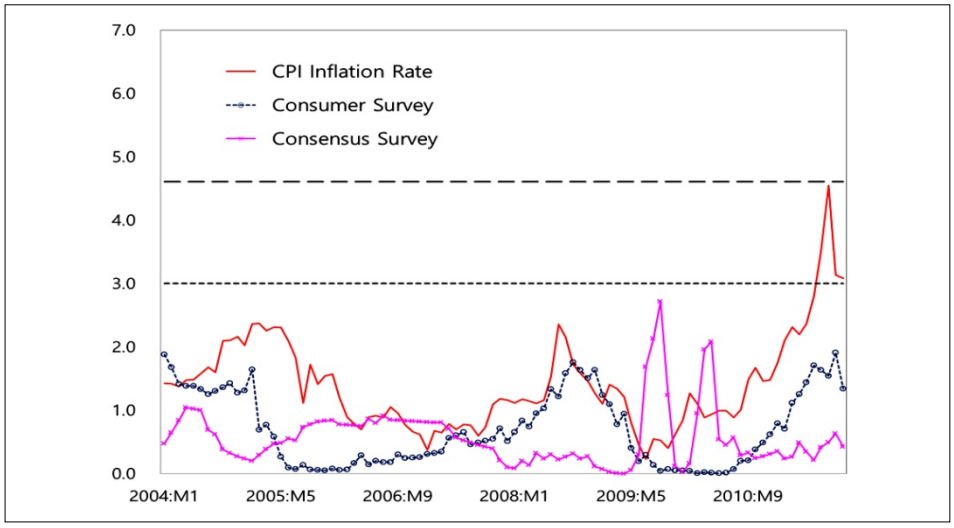
[9] We construct quarterly observation on one-year-ahead inflation expectations using quarter-to-quarter forecasts since CPI inflation forecast over the next 12 months is not available before 2009:Q4.

[10] Note that, as the indicator of expected inflation, both Survey of Professionals and Consensus Survey use cross-sectional mean of inflation forecasts.

## 2.2. Time-Series Properties of Inflation Expectations

Figure 1 presents the survey measures of inflation expectations together with actual 12-month CPI inflation rate. It is worth noting that, to compare the inflation expectations with actual inflation, the horizontal axis represents expectations at the endpoint of the corresponding forecast horizon, rather than at the time the actual forecast was made. During the sample period, 2003:M2−2012:M12, both actual inflation rate and inflation expectations are found to be fairly stable.[11] The time series of Chow test statistics for tests of stability of the intercept associated with a variety of potential break dates are presented in Figure 2. The Chow statistics for a mean break fall well short of the 5% critical value for the traditional $\chi^2$ distribution. This test result suggests that a sub-sample analysis of inflation expectations is unlikely to be necessary as expected inflation did not undergo any regime shift during the sample period.[12]

**[Figure 2]** Chow Test Sequences and Critical Values




Note: This figure plots the time series of Chow test statistics associated with the various potential break dates and the relevant 1% (dashed line) and 5% (dotted line) critical values.

Some important features of inflation expectations directly emerge from Figure 1. Notwithstanding the different types of economic agents being surveyed, all inflation

[11] Since the number of data observations is not sufficient, Survey of Professionals is not considered for the stability test. However, the data reveals that there appears to be no significant change in the expected inflation.

[12] The maximum Chow statistic for a mean break occurring at 2011:M8 and rejects the null of stability at the 5% significance level, but not the 1% significance level. Moreover, the sample period of the second regime is too short for any sub-sample analysis.

expectations demonstrate a somewhat common story. Overall, each inflation forecast tends to confirm long-term trend of actual inflation development.[13] In particular, as is apparent in Table 2, these survey measures have a similar central tendency measured by time-series sample mean. Since the differences across groups can be attributed to the different periods over which each survey has been conducted, we also consider the common sample period presented in Panel II of Table 2. Nonetheless there appears to be no significant difference between the two sample periods in every respect. Next, according to time-series sample standard deviation, all inflation expectations are much less volatile than actual CPI inflation. It is worth noting that households tend to form inflation expectations having an upward bias and their expectations display greater variations than more sophisticated agents.[14] Finally, both actual inflation and inflation expectations display substantial persistence, but the negative autocorrelations at 16 months suggest the possibility of mean reversion. In particular, Consumer Survey exhibits slightly more persistence than the other indicators.

**[Table 2]** Descriptive Statistics for Inflation Rate and Inflation Expectations

| | | CPI Inflation Rate | Consumer Survey | Survey of Professionals | Consensus Survey |
|---|---|---|---|---|---|
| Panel I: 2003:M2-2012:M12 | | | | | |
| Mean | | 3.12 | 3.57 | - | 3.08 |
| Standard deviation | | 0.94 | 0.54 | - | 0.39 |
| Autocorrelations | $\rho_1$ | 0.91 | 0.95 | - | 0.93 |
| | $\rho_4$ | 0.61 | 0.80 | - | 0.37 |
| | $\rho_8$ | 0.22 | 0.54 | - | -0.17 |
| | $\rho_{16}$ | -0.40 | 0.04 | - | -0.25 |
| Panel II: 2007:Q3-2012:Q4 | | | | | |
| Mean | | 3.27 | 3.50 | 3.19 | 3.02 |
| Standard deviation | | 1.07 | 0.52 | 0.35 | 0.49 |
| Autocorrelations | $\rho_1$ | 0.66 | 0.82 | 0.76 | 0.62 |
| | $\rho_2$ | 0.32 | 0.51 | 0.42 | 0.04 |
| | $\rho_4$ | -0.64 | -0.23 | -0.35 | -0.25 |

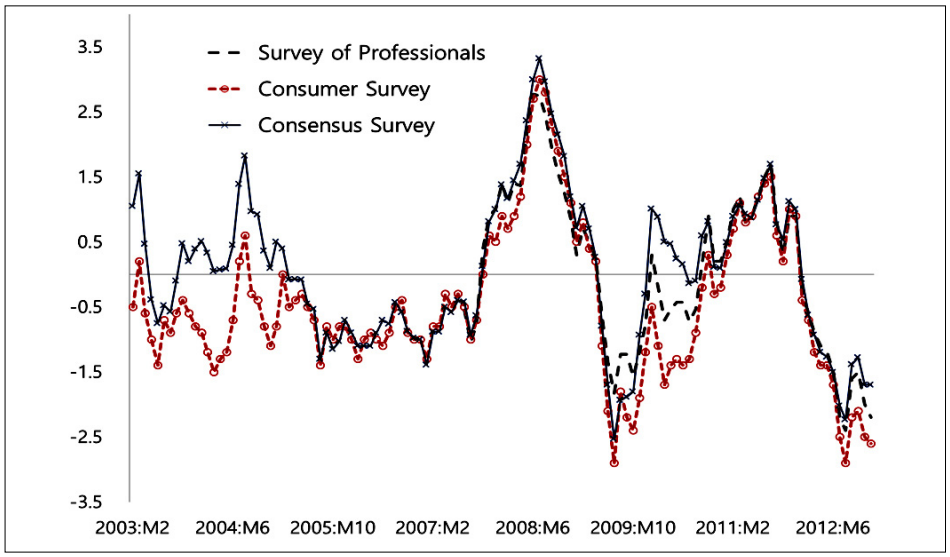
Note: $\rho_t$ is autocorrelation coefficient at $t$ month(s) for Panel I and $t$ quarter(s) for Panel II, respectively.

[13] One notable feature is that, in many instances, both actual CPI inflation and inflation expectations significantly deviate from target inflation rate. This may be because the BOK has paid much attention to output gap since the global financial crisis. It should prove useful to study the deviations of expected inflation from inflation target in greater detail, but this analysis is well beyond the scope of the current paper.

[14] For a related literature, Palmqvist and Strömberg (2004), Lindén (2005), and Pfajfar and Santoro (2008), among others, found that male, well educated, and high income survey respondents have lower inflation expectations and less volatile predictions than their counterparts.

We also scrutinize the behavior of deviations of actual inflation rate from each of inflation expectations. The main points that can be drawn from Figure 3 are as follows. First, despite the fact that the error-correction terms have all approximately zero mean over the sample period, the deviations are substantial in size and spacing. In particular, the deviation of actual CPI inflation from households' inflation expectations is consistently negative such a long period of time. Second, all deviations display sizable persistence. That is, once the inflation deviates from inflation expectations, and vice versa, it takes a long time to close the gap between them as the deviation appears to display large cycles.

**[Figure 3]** Deviations of the Actual CPI Inflation Rate from Inflation Expectations




**[Table 3]** Forecast Accuracy of Inflation Expectations

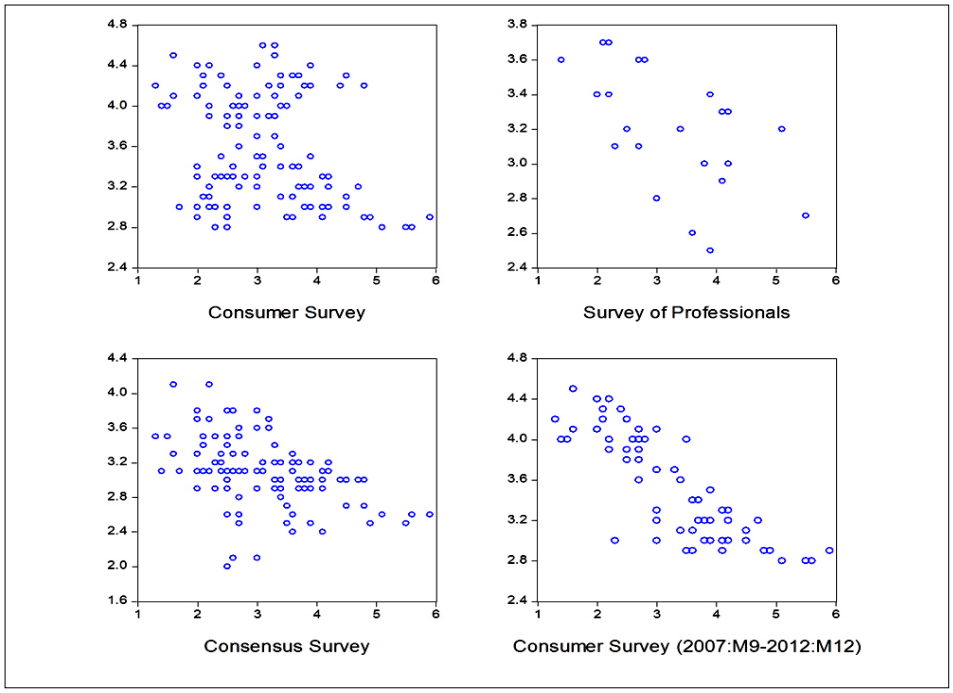
| | Consumer Survey | Survey of Professionals | Consensus Survey |
|---|---|---|---|
| | | Panel I: 2003:M2-2012:M12 | |
| MSE | 1.580 | - | 1.344 |
| MAE | 1.055 | - | 0.944 |
| | | Panel II: 2007:Q3-2012:Q4 | |
| MSE | 1.918 | 1.611 | 2.273 |
| MAE | 1.282 | 1.108 | 1.160 |

## 2.3. Forecast Accuracy

To evaluate the forcastability of survey measures of inflation expectations, we employ simple measures of forecast accuracy, the mean squared error (MSE) and the mean absolute error (MAE), as reported in Table 3. All three survey measures

are found to be quite fruitful, in the sense that they have a similar central tendency. Moreover, forecast accuracy tends to improve, albeit slightly, as the agent making the forecast becomes increasingly sophisticated, which is routinely documented in the literature (Carroll, 2003; Mankiw, Reis, and Wolfers, 2004). Nonetheless it is important to point out that this long-run central tendency alone cannot guarantee that inflation expectations are accordingly unbiased and efficient.[15] Strikingly, in terms of unbiasedness, any of those survey measures of inflation expectations may not be regarded as an accurate inflation forecast. As shown in Figure 1, any of inflation forecasts acts like a lagging indicator moving after the economy has already begun to follow a particular pattern since the mid 2000s.[16]

**[Figure 4]** Rationality of Inflation Forecasts




Note: The vertical axis represents actual 12-month CPI inflation rate and the horizontal axis represents expected inflation rates (2002:M2-2012:M12 for both Consumer Survey and Consensus Survey and 2007:Q3-2012:Q4 for Survey of Professionals). The scatter plot for Consumer Survey over the sample period, 2007:M9-2012:M12, is provided for comparison with Survey of Professionals.

[15] Stock and Watson (2007) also argue that a significant fall in the risk of inflation forecasts measured by mean squared forecast errors does not necessarily imply inflation has become easier to predict.

[16] This is probably because survey respondents place an excessively greater weight on recent inflation data when making inflation forecasts, which is hardly reconciled to the idea of rationality. This empirical finding could be consistent with the sticky-information model, e.g., Mankiw and Reis (2002), according to which some agents make forecasts based on outdated information.

**[Table 4]** Correlation across Inflation Expectations

| Panel I: 2003:M2-2012:M12 | | | | |
|---|---|---|---|---|
| | CPI Inflation Rate | Consumer Survey | Consensus Survey | |
| CPI inflation Rate | 1 | | | |
| Consumer Survey | -0.213 | 1 | | |
| Consensus Survey | -0.439 | 0.357 | 1 | |
| **Panel II: 2007:Q3-2012:Q4** | | | | |
| | CPI Inflation Rate | Consumer Survey | Survey of Professionals | Consensus Survey |
| CPI inflation Rate | 1 | | | |
| Consumer Survey | -0.805 | 1 | | |
| Survey of Professionals | -0.572 | 0.695 | 1 | |
| Consensus Survey | -0.446 | 0.462 | 0.629 | 1 |

One simple way to test forecast rationality is to use scatter plot exploring if there exists a systematic relationship between actual inflation and inflation expectations.[17] In particular, when economic agents are rational, actual inflation being forecasted does not differ systematically from expected inflation. Three striking features directly come from Figure 4. First, as apparent in these plots, the extent of the deviation of actual inflation from inflation forecast is substantial. That is, any survey measure fails to adjust one-for-one with inflation being forecasted. Second, there is little evidence of forecast rationality as each plot yields no systematic pattern between them. Moreover, all measures of inflation expectations reveal a highly anomalous result that there is a weak "negative" relationship, which has never been documented in the literature.[18] A negative correlation coefficient between the actual inflation and inflation forecasts reported in Table 4 also confirms that economic agents predict future inflation development with a wrong direction. Lastly, during the sample period, 2003:M2−2012:M12, this inflation forecast anomaly becomes even more robust with a more sophisticated group making the forecast since the negative relationship tends to be stronger for Consensus Survey. In addition, inflation becomes harder to forecast since the global financial crisis in the mid 2000s, because both Figure 4 and Table 4 evidently show the negative relationship between the actual inflation and inflation expectations has become much stronger.

[17] A more formal test of rationality will be extensively discussed in Section4.

[18] This puzzling finding may be due to measurement error, sample period, and sample countries, among others. However, this anomaly appears to be quite robust to the choice of measures of inflation expectations. Recently, Jang and Kim (2014) also found U.S. inflation expectations tell a somewhat similar story in the same sample period.

### 2.4. Disagreement across Survey Measures of Inflation Expectations

Most macroeconomic theories have assumed that every economic agent shares the same information and has the identical information processing capacity. Consequently, each agent is assumed to have the same expectations. Yet, due to serious empirical failures of full information models, a number of recent theoretical and empirical studies, such as Mankiw and Reis (2002), Mankiw, Reis, and Wolfers (2004), Woodford (2002), Sims (2003), Adam and Padula (2011), Coibion and Gorodnichenko (2012) to name a few, have underscored the importance of information frictions and limitations faced by economic agents and their implications for aggregate dynamics.

According to Zarnowitz and Lambros (1987), there is conceptual difference between uncertainty and disagreement. The former is related to intrapersonal variation in expected inflation and the latter implies interpersonal variation. We begin by analyzing the interpersonal disparities in inflation expectations.[19] Although we have found the fact that all survey measures of inflation expectations appear to display a similar central tendency, there exists some degree of disagreement about inflation forecast across economic agents. Figure 5 demonstrates that the amount of disagreement, especially between households and professional economists, is substantial. Households tend to consistently over-predict inflation than professional economists during the sample period, and this divergence is statistically significant.[20]

Next, the disparities tend to vary over time with the level of inflation.[21] A conventional thought is that the higher the level of inflation, the greater the extent of disagreement about inflation forecast across economic agents, which is consistent with a process of staggered adjustment of expectations (Mankiw, Reis, and Wolfers, 2004).[22] However, as apparent in Figure 5, this traditional positive relationship between the level of inflation and the extent of disagreement has collapsed since the 2000s. There is little evidence of the association between them as the correlation coefficient is virtually zero (0.178). Strikingly, for some episodes of relatively high

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[19] It is clearly of interest to consider differences in information frictions across economic agents and model implications and to investigate the primary sources of the disagreement, e.g., Mankiw, Reis, and Wolfers (2004), Pfajfar and Santoro (2010), and Coibion and Gorodnichenko (2012), but this is out of scope here.

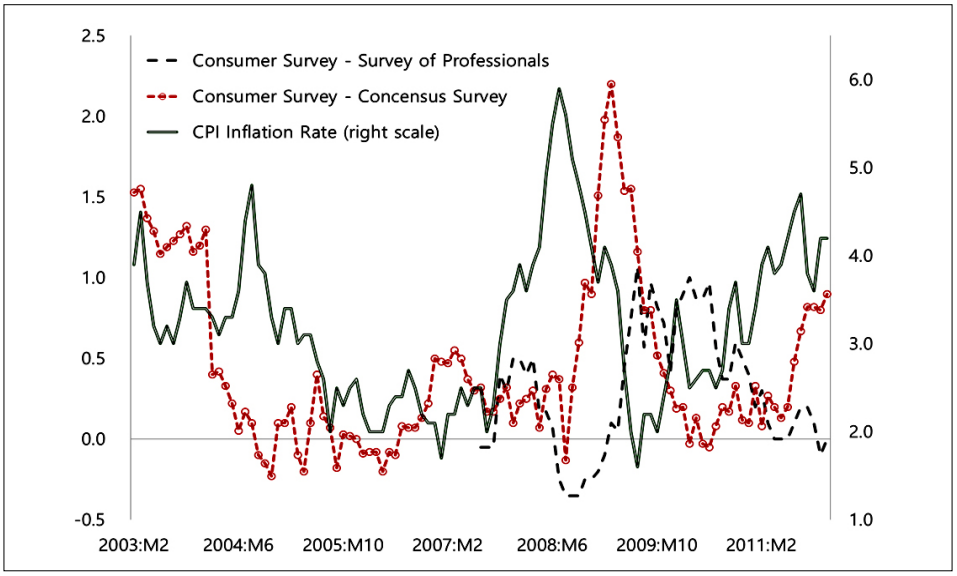
[20] A possible interpretation is that, in the context of sticky-information models, households update their information less frequently than professional economist as documented by Carroll (2003) and Hashmat and Zhu (2006).

[21] Note that, in order to examine how the amount of the disagreement is associated the level of actual inflation, the horizontal axis of Figure 5 refers to expectations at the time the forecast was actually made.

[22] For a relevant study, Lee and Choi (2014) show that the degree of information rigidity is state-dependent on macroeconomic conditions, for example, inflation regime.

inflation period, even a negative association appears in the data.[23]

**[Figure 5]** Disagreement about Inflation Expectations




## 2.5. Inflation Expectations and Relative Price Variability

Dispersion of price variability is regarded as an important channel through which inflation can cause welfare costs by impeding an efficient resource allocation. A sizable literature has documented a positive correlation between relative price variability and aggregate inflation (Fielding and Mizen, 2001; Lastrapes, 2006; Becker and Nautz, 2009). On the other hand, some empirical studies, such as Reinsdorf (1994), Silver and Ioannidis (2001), point out a negative relationship can be possible due to either a different sample period or an alternative measure of price dispersion.[24] Relative price variability (RPV) is conventionally measured by the standard deviation of disaggregate inflation rates,

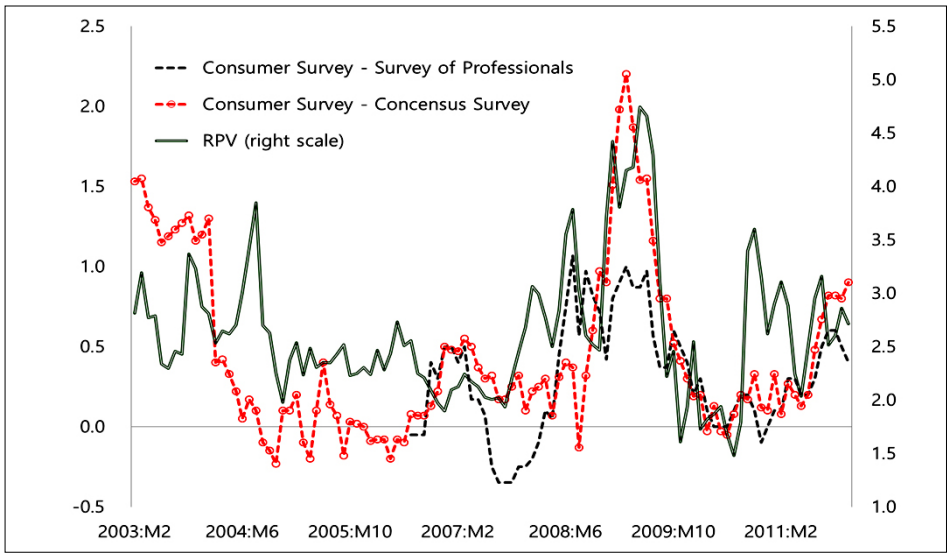
$$RPV_t = \sqrt{\sum_{i=1}^{N} \delta_i (\pi_{it} - \bar{\pi}_t)^2} \ , \tag{2}$$

[23] Using U.S. inflation expectations data, Carroll (2003) also found that disagreement across survey measures depends on inflation regime. For instance, during a high inflation period, the interpersonal disparities appear to be smaller due to high intensity of news coverage.

[24] Newer contributions, e.g., Choi and Kim (2010) and Choi, Kim, and O'Sullivan (2011), suggest the opposing empirical findings result from a misspecified model selection because the directions of the association can depend mainly on inflation regime.

where $\pi_{it}$ is the 12-month inflation rate of the $i$-th price item for $i=1,2,\cdots,N$ at time $t$, $\delta_i$ denotes the fixed expenditure weight of the $i$-th item, and $\bar{\pi}_t=\sum_{i=1}^{N}\delta_i\pi_{it}$ is the cross-sectional mean of the inflation rates at time $t$.[25]

**[Figure 6]** Relative Price Variability (RPV) and Inflation Expectations




During the sample period, the RPV appears to be fairly stable and the correlation coefficient between the RPV and the CPI inflation rate is 0.42 indicating a moderately positive association. More importantly, we investigate the relationship between our measure of dispersion of inflation rates across CPI components and disagreement about inflation expectations. Figure 6 suggests a relatively strong association between the level of inflation and disagreement.[26] It is important to note that the behavior of RPV can be regarded as either a cause or consequence of disparities in inflation expectations across economic agents. Nonetheless in empirical studies relative price variability is often used as a predictor of the extent of disagreement. Given this tradition, this finding suggests a rise in dispersion of price variability may cause an increase in interpersonal variation in expected inflation.

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[25] The RPV is calculated using 12 sub-aggregate items; food and nonalcoholic beverages, alcoholic beverages and cigarettes, clothing and footwear, housing, water, and fuels, furnishings and household equipment, health, transportation, communication, culture and recreation, education, eating out and accommodation, and miscellaneous. The data on CPI components and expenditure weights are obtained from Korea National Statistical Office.

[26] The correlation of deviation of Consumer Survey from Survey of Professionals and Consensus Survey with the RPV is 0.53 and 0.69, respectively. Mankiw, Reis, and Wolfers (2004) also find relative price variability is a consistently strong predictor of disagreement across all their empirical specifications.

# III. Dispersion of Households Inflation Expectations

In this section, we start by discussing the importance of heterogeneity in inflation expectations in macroeconomic models. Next, by employing micro-level data on households inflation forecasts, some distributional properties of inflation expectations are presented. The rest of this section is devoted to discover a useful set of stylized facts about intrapersonal variation in expected inflation.

## 3.1. Inflation Uncertainty

Having documented the novel evidence for deviation from full-information as well as the disagreement across survey measures of inflation expectations in the previous section, we now turn to analyzing intrapersonal variation in expected inflation, often referred to heterogeneity of inflation expectations or inflation uncertainty. A notable feature of the micro-level data on households' inflation forecasts is substantial heterogeneity of expectations. A number of studies have suggested that relaxing the assumption about fully-informed economic agents greatly affects model outcomes and policy implications (Roberts, 1997; Orphanides and Williams, 2003; Sims, 2009; Del Negro and Eusepi, 2011; Badarinza and Buchmann, 2011). As a consequence, understanding factors driving the heterogeneity, which in turn determine future path of inflation, is imperative and a macroeconomic model should take these into account.[27]

There exist essentially two competing lines of research with regard to informational rigidities preventing economic agents from having correct expectations and hence generating possible heterogeneity. The first class is the models of imperfect information, which goes back to Lucas (1973). In this strand of literature, e.g., Woodford (2002), economic agents are assumed to have imperfect knowledge about the current state and thus form a belief about the economic structure based on the data they can observe. Sims (2003) also suggests another important source of imperfect information, limited information processing capacity. Agents facing this type of informational friction endogenously allocate their attention to different variables, which may be fairly reasonable when they are placed in a very complex environment.[28] The second is the sticky information model in which economic agents are assumed to update information on economic

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[27] For example, Madeira and Zafar (2012) argue that tracking inflation uncertainty that directly influences households' inter-temporal decisions is crucial for estimating central bank credibility and effectiveness of communications.

[28] In the presence of rationally inattentive agents, Maćkowiak and Wiederholt (2011) and Paciello (2012) show that prices change more rapidly after a technology shock than a monetary policy shock as firms will pay more attention to the former.

environment only infrequently.[29] For example, Mankiw and Reis (2002) introduces a single form of information rigidity generating disagreement in expectations that is endogenously determined and correlated with macroeconomic variables. Since only a fraction of agents update their information sets and the others rely on outdated information, this type of model has intrinsic heterogeneity in inflation expectations. Accordingly, there is systematic relation between the extent of disagreement and macroeconomic condition as the evolution of the state of the economy over time endogenously determines the amount of the disagreement.[30]

Notwithstanding its importance, there is little work exploring the sources of heterogeneity in inflation expectations mainly due to lack of data on individuals' characteristics. The Consumer Survey data on households' expected inflation obtained from the BOK is not an exception. In this section, therefore we present stylized facts about the extent of uncertainty about future inflation and its implications on some important macroeconomic variables rather than searching for factors contributing inflation uncertainty.

### 3.2. Data

The data on households' inflation expectations reported in the Consumer Survey, conducted by the Economic Statistics Department at the BOK, have been available on a monthly basis since July 2006.[31] The survey covers a cross-section of about 2200 households per month. There are two questions regarding a household' subjective belief on future changes in general price level. First, households are asked whether they predict aggregate price level to rise, fall or remain the same in the next 12 months. Second, households are also asked to provide their one-year-ahead forecasts of inflation. Specifically, households are to report prices "stay the same or go down" or to choose one of 6 intervals, -0.5-1.5%, 1.5-2.5%, 2.5-3.5%, 3.5-4.5%, 4.5-5.5%, and 5.5-8%.[32]

### 3.3. Measuring Dispersion of Inflation Forecasts

Before introducing a measure of dispersion in households inflation forecasts, we study empirical distribution of inflation expectations by computing percentiles for

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[29] However, in contrast to imperfect information model, agents acquire complete knowledge about the economy when they update their information.

[30] Surprisingly, Mankiw, Reis, and Wolfers (2004) show that, in the US, there is no clear systematic relationship between the disagreement and measures of real activity such as output gap.

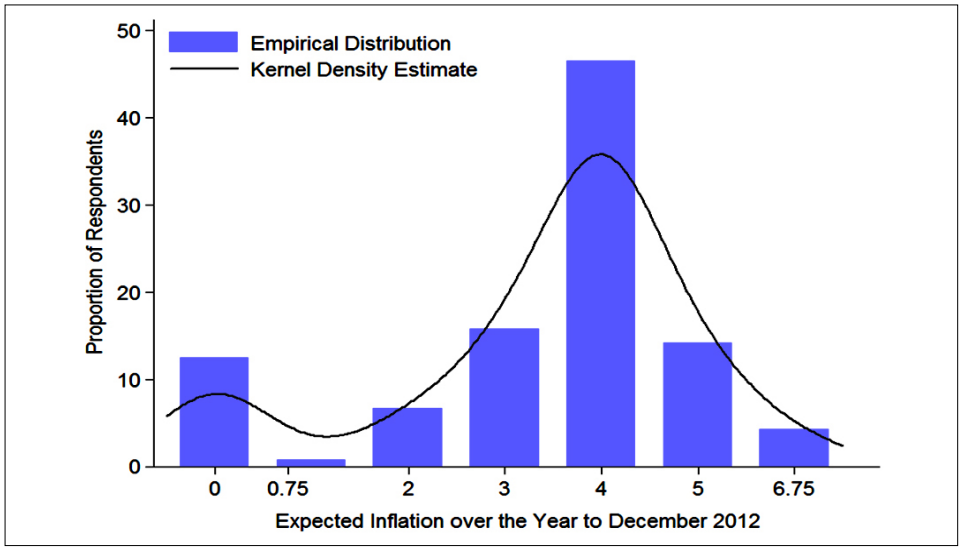
[31] Note that in this section households inflation forecasts are plotted at the realized date, not at the date the forecasts are set, unless otherwise stated.

[32] Following the recommendation by Curtin (1996), we regard the response "stay the same or go down" as 0. Note also that, starting from April 2008, the survey provides households with 9 intervals, and we have some intervals combined to be consistent with the old intervals.

each period. This is a particularly useful way of examining potential asymmetry in the distribution. Despite the fact that there exist notable differences across percentiles, each percentile appears to be fairly stable during the sample period.[33]

Inflation uncertainty is conventionally measured by cross-sectional dispersion of inflation forecasts. First, we employ cross-sectional standard deviation of inflation expectations, a popular measure of statistical dispersion. Next, since extreme observations of inflation forecast are often not highly informative (Curtin, 1996), an alternative indicator of inflation uncertainty, e.g., interquartile range (IQR), may be particularly appropriate.[34] Figure 7 presents simple histogram of inflation expectations for the coming year as of December 2011. This figure demonstrates intrapersonal variation in expected inflation. The IQR stretches from 3.5% to 4.5%, which is surprisingly small. On the other hand, the empirical distribution reveals moderately long left tail with approximately 10 percent of the households expecting deflation or the same inflation rate.[35] As discussed earlier, the use of IQR becomes increasingly important when survey respondents must provide a quantitative statement about their expected inflation, for example the Survey of Consumer Attitudes and Behavior by the University of Michigan. However, this is not the case for Consumer Survey in Korea because households ought to take one of

**[Figure 7]** Empirical Distribution of Households Inflation Expectations

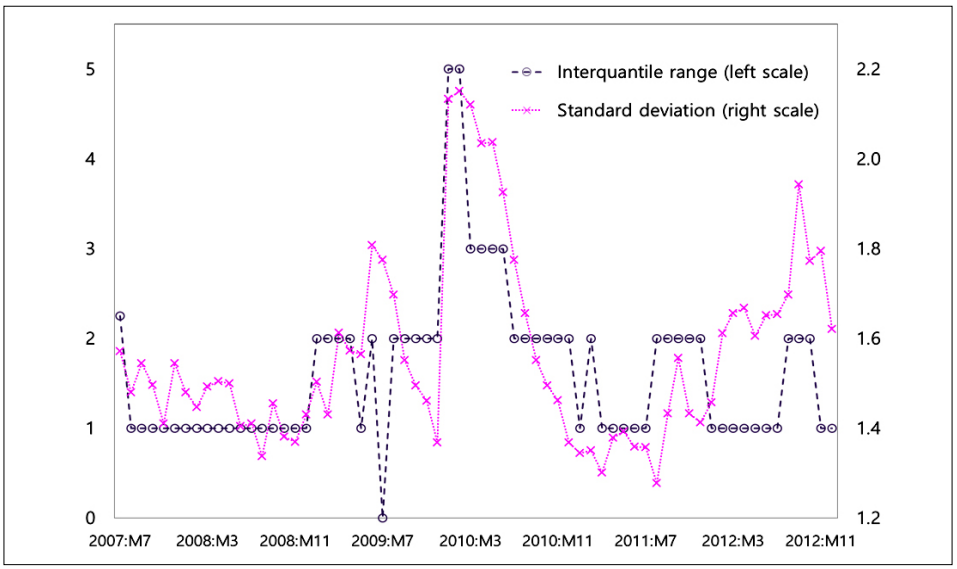



[33] To conserve on space, we did not report percentile forecasts (available from the authors upon request). Note also that because percentile forecasts are not reported by the same agents over time, they can be referred to the forecasts set by the same type of agents.

[34] The IQR is the difference between the upper and lower quartiles or a trimmed estimator defined as the 25% trimmed mid-range.

[35] This long left tail exists throughout the sample period but it becomes shorter over time.

**[Figure 8]** Cross-Sectional Dispersion of Households Inflation Expectations




predetermined intervals.[36] In addition, Figure 8 evidently depicts two measures are surprisingly similar. Therefore we use cross-sectional standard deviation as the measure of inflation uncertainty in this paper.

### 3.4. Stylized Facts and Implications

We now turn to investigate the evolution of inflation uncertainty in greater detail. As shown in Figure 9, the extent of disagreement among households varies considerably over time.[37] In addition, this dispersion in expectations has persisted over time. It has moderately high first-order serial correlation (0.81) and the negative autocorrelation occurs around 12 months.

There are some important aspects with regard to dynamic patterns of inflation uncertainty. First, the figure suggests a somewhat strong negative relationship between the level of inflation and the cross-sectional dispersion in expected inflation as the correlation coefficient is -0.546.[38] This may be due to the fact that, when the level of inflation is relatively high, households will pay close attention to both inflation and the variables influencing inflation as discussed in Carroll (2003). That

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[36] Since Consumer Survey covers a much narrower range of intervals than Michigan Survey, it presumably removes long tails of distribution of inflation expectations.

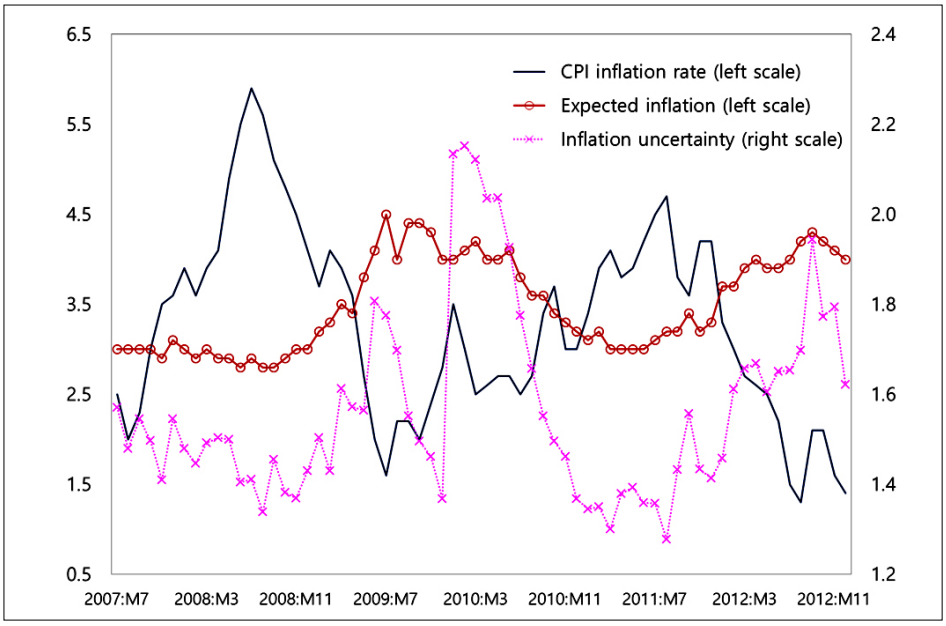
[37] Using US inflation forecasts from Survey of Professional Forecasters (SPF), Capistrán and Timmermann (2009) also found that disagreement in inflation expectations moves systematically over time in a way that reflects the level and variance of current inflation.

[38] Recall that, in the previous section, disagreement across survey measures of inflation expectations shows no clear relationship with the level of inflation.

is, if households are assumed to derive their inflation forecasts from the news media, they must be better informed when there are more news stories about changes in prices, which is typically true during a high inflation period. Beyond this simple empirical relation in levels, the cross-sectional dispersion tends to rise when inflation rate exhibits a higher volatility, which is measured by change in inflation from a year before. Figure 10 apparently illustrates a U-shaped relationship suggesting that greater changes in inflation in either direction are associated with an increase in inflation uncertainty.[39]

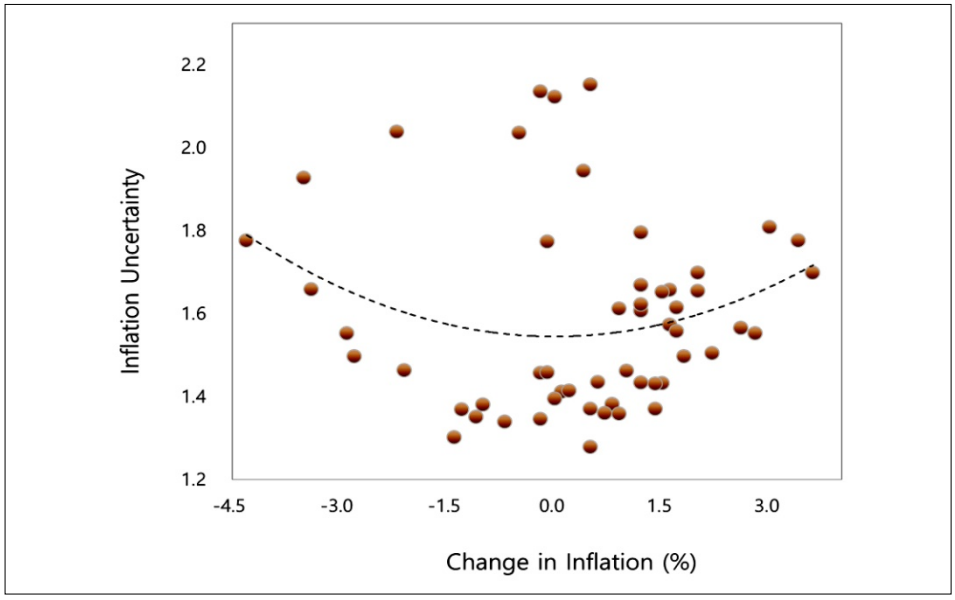
Next, a particularly interesting feature of the data is that the dispersion of inflation forecasts appears to be positively correlated with the central tendency of expected inflation. Overall, Figure 9 confirms that the extent of inflation uncertainty exhibits substantial co-movement with the central tendency. The correlation coefficient is 0.696. This indicates the asymmetric pattern of inflation uncertainty with expected inflation. That is, there is a relatively greater consensus on changes in future inflation when the majority of households expect inflation to fall (lower central tendency). On the other hand, inflation is expected to rise (higher central tendency), the disagreement among households tends to rise.

**[Figure 9]** Inflation and Inflation Uncertainty

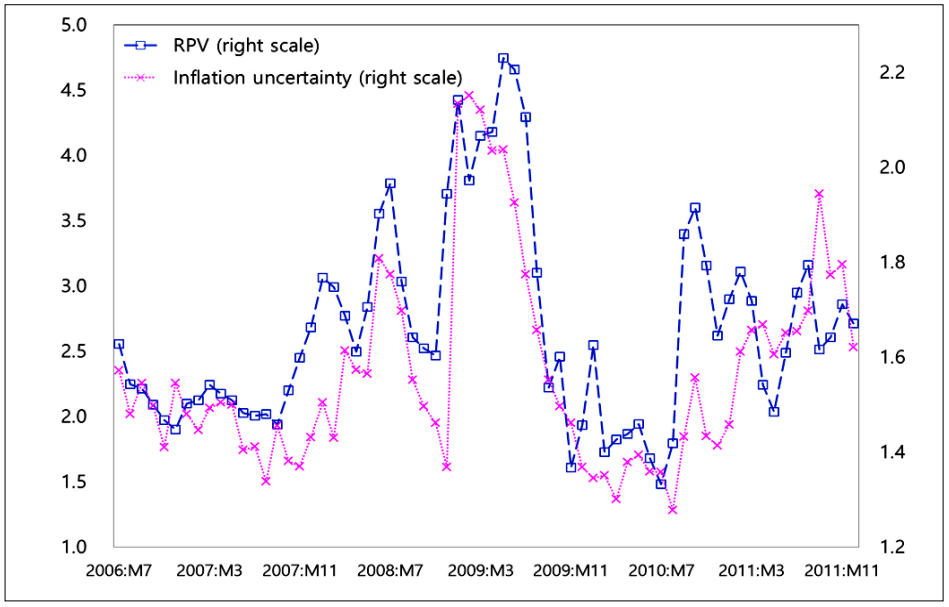



[39] This empirical finding is consistent with that found in the U.S. inflation expectations documented in Mankiw, Reis, and Wolfers (2004).

**[Figure 10]** Change in Inflation and Inflation Uncertainty




**[Figure 11]** Relative Price Variability (RPV) and Inflation Uncertainty




The final aspect of data that we scrutinize is the link between inflation uncertainty and dispersion of commodity-level rates of inflation. The RPV measuring the extent to which relative prices are changing is defined as Eq. (2) in Section 2. As we did for disagreement across different types of agents, we confirm

that intrapersonal variation in expected inflation is quite closely related to the RPV in Figure 11.[40] As we stated earlier, this finding does not necessarily reflect any theoretical causality. However, this may indicate that increased dispersion in inflation across commodities prevents households from having more precise inflation forecasts and thus creates higher inflation uncertainty.

In sum, our analysis suggests that inflation uncertainty appears to fall with the level of inflation, but to rise with the indicator of central tendency. In addition, it tends to rise when inflation moves considerably in either direction and exhibits a strong positive relationship with relative price variability. These empirical findings offer a fruitful set of stylized facts that a macroeconomic theory must aim to explain.

# IV. Tests of Forecast Rationality

A number of stylized facts regarding the dispersion of inflation expectations in the survey data and its relationship with other macroeconomic variables are described in previous two sections. In particular, the survey data were not consistent with rational expectations. The rational expectations hypothesis became the benchmark paradigm in most macroeconomic models. Since, under a standard assumption underlying rational expectations, agents are assumed to have a great deal of knowledge about economic structure, they can forecast future inflation efficiently and thus do not make a systematic forecasting errors. In this section, we now turn to reviewing the rationality tests regularly used in the literature, and to presenting empirical evidence against full rationality using survey measures of inflation expectations.

## 4.1. Specifications of Rationality Test

The standard rational expectations hypothesis involves statistically efficient forecasting, because economic agents utilize all available information optimally. Therefore the simplest test of forecast efficiency is to ask whether inflation expectations have the central tendency. Let $\pi_t$ denote actual inflation rate at time $t$. $\pi^e_{t|t-12}$ is expected inflation for time $t$ formed at time $t-12$. Thus this type of test for bias is to regress forecasting errors on a constant,

$$\pi_t - \pi^e_{t|t-12} = \alpha + \varepsilon_t, \tag{3}$$

where $\varepsilon_t$ is the projection error. Under the null of rationality, mean error must be

[40] The correlation coefficient is 0.752.

equal to 0, $H_0 : \alpha = 0$. That is, inflation expectations are centered on the right value and there is no predictable component of forecast errors.

Next, as a more general specification, we also consider the following regression model,

$$\pi_t = \alpha_0 + \alpha_1 \pi^e_{t|t-12} + \upsilon_t . \tag{4}$$

The composite null hypothesis of rationality is $H_0 : \alpha_0 = 0$ and $\alpha_1 = 1$. The assumption of rationality is refuted if $\alpha_1 \neq 1$. However, it does not necessarily imply expected inflation has no predictive power. Thus we also consider the null of $H_0 : \alpha_1 = 0$. This specification can be used to test whether inflation is predicted from inflation expectations. Moreover, by estimating the sign of $\alpha_1$, this regression model directly deals with the possibility of inflation expectations anomaly discussed in section 2. In the literature, an alternative form has been suggested to test whether there is useful information in expected inflation explaining forecast errors.

$$\pi_t - \pi^e_{t|t-12} = \beta_0 + \beta_1 \pi^e_{t|t-12} + \eta_t . \tag{5}$$

If information in the inflation forecast is fully exploited under the null of rationality, $H_0 : \beta_0 = 0$ and $\beta_1 = 0$.

Our last specification is to ask whether forecast error can be predicted from its own past values. This time-series implication of rationality can be tested by regressing this year's forecast errors on the realized errors over the previous year.

$$\pi_t - \pi^e_{t|t-12} = \gamma_0 + \gamma_1 (\pi_{t-12} - \pi^e_{t-12|t-24}) + \nu_t . \tag{6}$$

The null of rationality, $H_0 : \gamma_0 = 0$ and $\gamma_1 = 0$, can be rejected if forecasting error are persistent.

### 4.2. Rationality Test Results for Survey Measures of Inflation Expectations

As a preliminary analysis in section 2, we examined forecast rationality in survey measures of inflation expectations using scatter diagram and found any of the survey data fail to support rationality. Following Lee (2012), we now turn to introducing a series of formal statistical tests described above and investigate forecast rationality and disagreement across survey measures by carrying out the regression analysis. We focus on forecast accuracy of weighted mean inflation expectations for Consumer Survey and mean forecast for both Survey of Professionals and Consensus Survey as the relevant indicators of central tendency.

Table 5 presents the results of forecast rationality for full sample period,

2003:M2-2012:M12, as well as the common sample period, 2007:Q3-2012:Q4.[41] First, Panel I reports a test for bias scrutinizing whether inflation expectations are centered on the right value. Overall, survey measures of inflation forecasts appear to predict future inflation reasonably well since estimated constant terms, $\hat{\alpha}$, are all statistically insignificant even at 10% level.[42] This empirical test result implies the long-run central tendency of survey data, but not necessarily the direction of contemporaneous association. Therefore we consider a regression model given by Eq. (4). If economic agents correctly forecast future path of inflation, the slope coefficient should be positive. Panel II of the table reports ample evidence that the survey measures contains useful information for forecasting the future inflation in the significant estimates of $\alpha_1$. However, since $\hat{\alpha}_1$ is significantly less than 1, the null of forecast rationality is evidently rejected. It is worth pointing out the anomalous result is not that $\alpha_1$ is not equal to 1, but that it is negative. That is, the expected inflations clearly predict the future inflation, but with the wrong sign from the rationality perspective. Moreover, this anomaly has become much stronger in the common sample period.

Panel III tests whether information in the inflation forecast is fully exploited. Under the null of rationality, inflation expectations should have no predictive power. All survey measures reject the null even at 1% significance level since $\hat{\beta}_1$ is consistently less than 0. Finally, we study a time-series property of forecasting errors shown in Panel IV. Despite the finding that $\hat{\gamma}_0$ generally is not significant, the slope coefficients are significantly different from 0 implying potent evidence of autocorrelation. This undoubtedly violates the rationality null since there exists information in the previous period's forecast mistakes that is not being utilized in forming this period's inflation expectations. In particular, approximately half of forecast error remains in the expected inflation as $\hat{\gamma}_1$ is approximately 0.5.[43] Furthermore, the extent to which the errors made a year ago persist in this year's prediction appears to be greater in the common sample.

### 4.3. Rationality Test Results for Households Inflation Expectations

A series of regression analysis have confirmed that the forecast rationality is strongly rejected in the survey data, when the indicators of central tendency, such as mean forecast, are used. The remainder of this paper centers on the procedure tracking the distribution of survey responses to account for potential asymmetry in

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[41] Note that these results show that there is nearly no difference between them in terms of forecast rationality.

[42] As documented in section 2, we confirm that consumers tend to over-expect inflation and more sophisticated agents under-predict inflation.

[43] This may be due to the fact that agents cannot fully observe their forecast errors by the time they forecast future inflation.

**[Table 5]** Rationality Tests Results: Central Tendency Measures of Inflation Expectations

| | 2003:M2-2012:M12 | | 2007:Q3-2012:Q4 | | |
|---|---|---|---|---|---|
| | Consumer Survey | Consensus Survey | Consumer Survey | Survey of Professionals | Consensus Survey |
| Panel I: $\pi_t - \pi^e_{t\|t-12} = \alpha + \varepsilon_t$ | | | | | |
| $\hat{\alpha}$ | -0.45 | 0.39 | -0.26 | 0.06 | 0.23 |
| | (-1.64) | (0.15) | (-0.51) | (0.15) | (0.55) |
| Panel II: $\pi_t = \alpha_0 + \alpha_1 \pi^e_{t\|t-12} + \upsilon_t$ | | | | | |
| $\hat{\alpha}_0$ | 4.43** | 6.35** | 8.87** | 8.84** | 6.23** |
| | (2.67) | (4.35) | (7.67) | (6.36) | (3.29) |
| $\hat{\alpha}_1$ | -0.37 | -1.05 | -1.59 | -1.75 | -0.98 |
| $t(\alpha_1 = 0)$ | (-0.84) | (-2.38)* | (-5.23)** | (-4.22)** | (-1.74) |
| $t(\alpha_1 = 1)$ | (-3.13)** | (-4.65)** | (-8.51)** | (-5.51)** | (-3.53)** |
| Adj. $R^2$ | 0.037 | 0.187 | 0.631 | 0.294 | 0.159 |
| Panel III: $\pi_t - \pi^e_{t\|t-12} = \beta_0 + \beta_1 \pi^e_{t\|t-12} + \eta_t$ | | | | | |
| $\hat{\beta}_0$ | 4.43** | 6.35** | 8.87** | 8.84** | 6.23** |
| | (-2.67) | (-4.35) | (-7.67) | (-6.36) | (-3.29) |
| $\hat{\beta}_1$ | -1.37** | -2.05** | -2.59** | -2.75** | -1.98** |
| | (-3.13) | (-4.65) | (-8.51) | (-6.63) | (-3.53) |
| Adj. $R^2$ | 0.393 | 0.473 | 0.822 | 0.524 | 0.479 |
| Panel IV: $\pi_t - \pi^e_{t\|t-12} = \gamma_0 + \gamma_1(\pi_{t-12} - \pi^e_{t-12\|t-24}) + \nu_t$ | | | | | |
| $\hat{\gamma}_0$ | -0.56* | 0.10 | -0.44 | 0.08 | 0.36 |
| | (-2.02) | (0.35) | (-1.03) | (0.23) | (0.92) |
| $\hat{\gamma}_1$ | -0.46** | -0.40* | -0.57* | -0.59* | -0.58* |
| | (-2.94) | (-2.17) | (-2.49) | (-2.86) | (-2.51) |
| Adj. $R^2$ | 0.163 | 0.128 | 0.254 | 0.281 | 0.276 |

Note: ** and * denote statistical significance at the 1% and 5% levels, respectively. The numbers in parentheses are $t$ statistics based on Newey-West robust standard errors.

**[Table 6]** Rationality of Households Inflation Expectations: Percentile Regression Results

| percentile | 10% | 25% | 40% | 50% | 60% | 75% | 90% |
|---|---|---|---|---|---|---|---|
| Panel I: $\pi_t - \pi^e_{t\|t-12} = \alpha + \varepsilon_t$ | | | | | | | |
| $\hat{\alpha}$ | 3.19** | 1.12** | 0.35 | -0.06 | -0.15 | -0.50 | -1.15** |
| | (-10.90) | (3.06) | (0.78) | (-0.15) | (-0.38) | (-1.11) | (-2.81) |
| Panel II: $\pi_t = \alpha_0 + \alpha_1 \pi^e_{t\|t-12} + \upsilon_t$ | | | | | | | |
| $\hat{\alpha}_0$ | 3.26** | 4.70** | 6.16** | 7.86** | 7.73** | 6.22** | 7.04** |
| | (10.77) | (4.82) | (5.6) | (7.13) | (5.96) | (5.43) | (4.68) |
| $\hat{\alpha}_1$ | 0.18 | -0.67 | -0.99 | -1.38 | -1.03 | -0.78 | -0.85 |
| $t(\alpha_1 = 0)$ | (0.62) | (-1.70) | (-2.96)** | (-4.62)** | (-3.73)** | (-2.86)** | (-2.66)** |
| $t(\alpha_1 = 1)$ | (-2.80)** | (-4.25)** | (-5.95)** | (-7.98)** | (-6.59)** | (-6.51)** | (-5.84)** |
| Adj. $R^2$ | -0.012 | 0.126 | 0.343 | 0.420 | 0.360 | 0.251 | 0.241 |
| Panel III: $\pi_t - \pi^e_{t\|t-12} = \beta_0 + \beta_1 \pi^e_{t\|t-12} + \eta_t$ | | | | | | | |
| $\hat{\beta}_0$ | 3.26** | 4.70** | 6.16** | 7.86** | 7.73** | 6.22** | 7.04** |
| | (10.77) | (4.82) | (5.6) | (7.13) | (5.96) | (5.43) | (4.68) |
| $\hat{\beta}_1$ | -0.82** | -1.67** | -1.99** | -2.38** | -2.30** | -1.78** | -1.85** |
| | (-2.80) | (-4.25) | (-5.95) | (-7.98) | (-6.59) | (-6.51) | (-5.84) |
| Adj. $R^2$ | 0.059 | 0.495 | 0.683 | 0.686 | 0.642 | 0.643 | 0.609 |
| Panel IV: $\pi_t - \pi^e_{t\|t-12} = \gamma_0 + \gamma_1 (\pi_{t-12} - \pi^e_{t-12\|t-24}) + \nu_t$ | | | | | | | |
| $\hat{\gamma}_0$ | 5.03** | 1.86** | 0.43 | -0.04 | -0.19 | -0.80* | -1.72** |
| | (5.47) | (3.31) | (0.96) | (-0.09) | (-0.48) | (-2.01) | (-5.38) |
| $\hat{\gamma}_1$ | -0.56* | -0.55* | -0.42* | -0.56* | -0.59* | -0.41* | -0.53* |
| | (-2.58) | (-2.01) | (-2.52) | (-2.24) | (-2.30) | (-2.41) | (-2.25) |
| Adj. $R^2$ | 0.250 | 0.168 | 0.109 | 0.232 | 0.251 | 0.133 | 0.207 |

Note: ** and * denote statistical significance at the 1% and 5% levels, respectively. The numbers in parentheses are $t$ statistics based on Newey-West robust standard errors.

the distribution. Particular attention is paid to the fraction of households being rational. To this end, we rely on time series of percentiles, equidistant statistics describing the distribution. For example, the $k$th percentile forecast, $\pi^{k}_{t|t-12}$ is defined as expected inflation for time $t$ formed in time $t-12$ below which $k$ percent of survey responses lie. Thus, for each period, there are 99 percentiles. With the time-series of ordered statistics, percentile regression analysis can statistically test forecast rationality as well as the dynamic properties of cross-sectional distribution of households inflation expectations.

Forecast rationality test results using households' inflation expectations data for the period of 2007:M7-2012:M12 are presented in Table 6. To conserve on space, we report the results for some selected percentiles.[44] First, we study a test for bias. The regression model given by Eq. (3) indicates a substantial fraction of households, 37th-79th percentile range, is not biased at a 1% significance level. Recall that, using the indicator of central tendency as expected inflation, Panel I of Table 5 suggests households on average tend to predict future inflation correctly. By examining the distribution of survey responses, however we found that a sizable fraction of households have a biased forecast of inflation.[45] In addition, that households tend to over-predict future inflation in Table 5 is not the case for all percentiles. Only the 80th-99th percentile range has the estimate of $\hat{\alpha}$ that is negative at a 5% level of significance.

Second, Panel II reports the rationality test results based on the regression model of Eq. (4) dealing with both predictability and forecast direction. In line with our earlier finding in Table 5, none of the percentiles fails to support forecast rationality as the estimate of slope coefficient is consistently different from 1. Moreover, a non-trivial percentile range, the 1st-32nd percentile range, shows that expected inflation has no predictive power at a 1% significance level. Even when households inflation forecasts involve useful information for the path of future inflation, the rest of percentiles (the 33rd-99th percentile range) indicates $\hat{\alpha}_1$ is negative and this confirms the inflation forecast anomaly.

Third, Panel III shows a very strong evidence against forecast rationality since the slope coefficient estimate for any percentile is significantly different from 0 even at a 1% significance level. This implies that households do not fully utilize all available information making inflation expectations.

Finally, Panel IV evidently points out that, for any percentile, $\hat{\gamma}_1$ measuring the autocorrelation of forecast errors is significant at a 5% level. Since households make systematic mistakes, this can be interpreted as the violation of rationality. In addition, there seems to be little heterogeneity among households in terms of

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[44] The complete test results for all percentiles are available from authors upon request.

[45] Lack of a sufficient number of time-series observations, we did not investigate the dynamic pattern of the forecast bias by splitting the sample period.

persistence of forecast errors as the difference in slope coefficient estimate across percentiles is not substantial.

## V. Concluding Remarks

Notwithstanding the prevalence of interpersonal and intrapersonal variations in inflation expectations, the disagreement about inflation forecasts is conspicuously absent in most macroeconomic models in which economic agents are assumed to share a common information set and to predict the path of future inflation rationally. Instead of increasing the complexity of models, relaxing some informational assumptions in the model can be the most promising avenue to account for some important features of the data that a standard macroeconomic model has failed to explain.

Thus our goal in this paper is to document both time-series and cross-sectional properties of inflation expectations and its dynamic relationship with macroeconomic variables. We have established a number of stylized facts about inflation expectations. The amount of disagreement across economic agents is sizable. Even for the same type of agents, consumers, the extent of intrapersonal variation is found to be substantial and varies over time together with other macroeconomic aggregates. A series of formal statistical tests consistently reject the null of forecast rationality. We also discover some potentially important empirical puzzles in the survey forecasts. For instance, inflation expectations evidently predict future inflation, but with the wrong sign from the rationality perspective during our sample period, which we refer to inflation forecast anomaly. Our empirical findings may help policymakers design effective policy actions that enhance the efficiency of inflation forecasts.

Clearly, further research is needed in a number of directions. First, a macroeconomic theory with information rigidities can be explored to fully understand the dynamics of inflation expectations. In particular, to resolve inflation forecast anomaly, it may be optimal for economic agents to allocate their attention to seemingly more important macroeconomic aggregates rather than inflation during such a low and stable inflation period as suggested by Sims (2003) and Woodford (2002). Alternatively, the sticky-information model incorporating intrinsic heterogeneity in inflation expectations, e.g., Mankiw and Reis (2002), may account for why economic agents form their expectations in such an adaptive fashion. Second, despite its importance, this paper is limited to the dispersion of inflation expectations. For a complete explanation of inflation expectations, it should prove useful to evaluate different mechanisms of expectations formation (Carroll, 2003; Pfajfar and Santoro, 2010) and to develop better models of

expectations formation dealing with information acquisition and processing that are consistent with the stylized facts presented in this paper. Finally, by focusing on the relationship between the amount of disagreement and relative price variability, we have neglected some important measures of real activity such as interest rates, unemployment rate, and output gap (Mankiw, Reis, and Wolfers, 2004; Coibion and Gorodnichenko, 2012). In order to assess whether inflation expectations take sufficient account of publicly available information, it may be fruitful to examine if the survey forecasts show any dynamic relationship with those variables.

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