Heterogeneity in Korean Households' Inflation Expectations: Stylized Facts and Macroeconomic Implications

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Abstract

Households' inflation expectation has been very important information for monetary policy-making and operations of central bank because they signal future inflationary risks and provide the information about economic activity of individual economic agents and future inflation rate. There are a number of empirical studies in inflation expectations. But, economists typically assumed that private agent's expectations are rational and homogeneous. However, ample empirical evidences on inflation expectations suggest the assumption of homogeneity is not valid. That is, not everyone has the same expectation. In this study, we consider Korean households' inflation expectations from the public survey and professional survey data conducted by the Bank of Korea, and the Consensus survey data. We find that all survey data on inflation expectations show similar movement with actual inflation rate with somewhat different volatility and persistence, and the disagreement (cross-sectional dispersion) about inflation expectations, as a measure of the heterogeneity, is time varying and positively correlated with the rate of inflation expectations. In addition, all of the survey-based inflation expectations (even professionals) are not fully rational. To be specific, the household's inflation expectations is not rational, while the professionals' inflation expectations is limitedly rational. In this study, we find various abnormal phenomena in Korean inflation expectations, and there are a number of limitations in the research. Therefore, for the future research, we will propose a better measure of expected inflation as well, a better short-term and long-term inflation forecasting model, and new specific measures to improve the conditions for inflation targeting framework as monetary policy, so as to achieve the price stability.

Keywords: Heterogeneity, Rational expectations hypothesis, Cross-sectional dispersion, Inflation expectations, Percentile time series model.

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1 Introduction

Since Milton Friedman's renowned presidential address to the American Economic Association in 1968, expected inflation has played a central role in the analysis of monetary policy. As stated by Bernanke (2005), households' inflation expectation is very important information for monetary policy-making and operations of central bank which have to judge economic conditions. This is because the expected inflation can provide the information about economic activity of individual economic agents and future inflation rate. Thus, investigating the relationship between monetary policy and inflation expectations has been crucial for attaining the price stability. That is, it would be helpful in anchoring expected inflation rate in predetermined inflation target range under inflation targeting framework.

Under an inflation targeting framework [1] as a monetary policy frame, private inflation expectations may represent the goal for inflation within a pre-designated time horizon so as to achieve price stability. Moreover, inflation expectation of wage and price setters may change the actual price level (Mankiw, Reis, and Wolfers, 2004), that is, depending on their expectations, they make their production decisions and product prices, and so it may causes part of the change in the price level and output level. The individual economic agents determine their consumption decisions and financial transactions such as saving and lending decisions depending on the future inflation expectations, and thus expected inflation can provide the information about the economic activity. Furthermore, inflation expectations influence financing conditions and the sustainability of public finances because it affects the term structure of interest rates[2](Gnan, Langthaler, and Valderrama, 2011). In addition, Lee (2012) emphasizes that the stability of inflation expectations is important for the conduct of the flexible monetary policy by securing the inflation policy space.

[1]An inflation targeting framework was first started in 1990 by New Zealand as a new monetary policy frame, and the system was introduced in 1998 in Korea. In Korea, until 2003 the monetary authority has set yearly inflation target strategy for monetary policy, and when inflation targeting has set as medium-term strategy for monetary policy is after 2004. Specifically they designated three years as medium-term time horizon.

[2]The term structure of interest rates are often called the yield curve. The yield curve shows several yields or interest rates across different contract lengths for a similar debt contract in finance. The curve shows the relation between the interest rate and the time to maturity, which is known as the "term", of the debt for a given borrower in a given currency. The term structure of interest rates is more formal mathematical descriptions of this relation, and shows the different level of interest rate across different time to maturity.

According to Oh (2000), "an inflation targeting system[3] is a system of operating monetary policy in which the central bank sets up an inflation target within a predesignated time horizon and makes use of the available policy instruments preemptively to attain that target." Under inflation targeting, as a monetary policy framework, central bank decides inflation target in a medium-term perspective, and a future inflation rate is expected inflation. In addition, as an operating target for achieving inflation target taking into account the expected inflation, a short-term interest rate, such as call rate, is used. On the other hand, contrary to conventional usage in monetary policy, an explicit intermediate target is not set in inflation targeting framework. For the operation of inflation targeting as monetary policy, central bank first sets inflation target over the medium term. Once set the inflation target, central bank forecasts the future inflation rate by using economic information such as interest rates, monetary aggregates, key raw-material prices, and etc, and then implements monetary policy so as to make actual inflation rate converges on the established inflation target (or target band). Finally, the central bank reviews the performance of their monetary policy and then feedback into the next-term monetary policy.[4]

In case of the Korea, until 1997 the Bank of Korea had implemented an intermediate targeting system by using the rate of increase in the monetary aggregate.[5] However, after rapid innovation and liberalization of financial market in the 1980s, the effectiveness of the rate of increase in monetary aggregates had considerably decreased. Moreover, in the 1970-80s with relatively high inflation rates and stable demand for money the monetary channel was predominant, while the interest rate had a significant role in the early and mid 1990s with unstable money demand due to the innovation and liberalization of financial market. Therefore, the Bank of Korea has looked forward to find a new framework for the operation of monetary policy.

The act of inflation targeting system is concerned to establish monetary neutrality and autonomy with price stability, and the Bank of Korea has set inflation target

[3]There are necessary conditions for inflation targeting. (1) Central bank independence, (2) Capacity of inflation forecasting, (3) Controllability of monetary policy instruments over operating targets, (4) Effective channel of interest rates on prices, (5) Transparency, consistency and credibility of monetary policy.

[4]This feedback process is very important to lead to convergence of actual inflation rate on the inflation target over the long run as well, it introduces more reliable basis for price stability.

[5]From 1979 to 1996, M2 was employed, and in 1997 M2 and MCT ($M2 + CD + MoneyinTrust$) were employed.

annually since 1998. As the benchmark indicator, Consumer Price Index (CPI) was adopted in 1998 when inflation targeting framework was firstly implemented. This is because the CPI has been known to represent the most familiar indicator of inflation to the general public, and so it is thought most appropriate as the key anchor for the monetary policy operating. Moreover, the CPI was considered one of the most macroeconomic indicator since 1997 currency crisis.[6] However, as the benchmark indicator CPI has some problems in reviewing the performance of the monetary policy-making and operations and feedback process. The CPI is seriously affected by transitory and temporary supply shocks such as natural diasters or international oil price shocks.

To be specific, Korean inflation rate has been affected by a variety of the international supply shocks such as oil shock, financial crisis, and international grain price shocks, etc, and domestic demand shocks such as economic growth, house price, wage, etc. These inflation shocks cause soaring consumer price inflation beyond the upper bound of the inflation target range and bring about an economic recession. For example, the skyrocketing inflation rate at 2008 is explained by a high rise in the price of international raw materials such as petroleum and grains while the Korean currency turned higher. Therefore, the Bank of Korea took this into consideration, changed the benchmark indicator from the CPI to an underlying inflation rate. There are a variety of methods of measuring underlying inflation rates, but only the underlying inflation rate excluding most highly volatile items from the CPI is used in Korea. On the other hand, underlying inflation rate are lower and less volatile (stable) than CPI inflation rate in history. Therefore, inflation targeting system based on the underlying inflation rate as a benchmark indicator seems to improve the efficiency and accountability of monetary policy.

As we mentioned above, the Bank of Korea used a short-term inflation target with one year time horizon from 1998, but after The 7th Amendment of the Bank of Korea Act, 2004, mid-term inflation target was introduced instead of the short-term (annual) inflation target. The background of setting med-term inflation targeting is that there are long time lags before a monetary policy affects the price level and its effects felt in the various economic sectors. Therefore, in order to reconsider the validity of inflation targeting system, it is known that setting the inflation target and

[6]The International Monetary Fund (IMF) and the Government of the Korea Republic and the Bank of Korea have conducted annual consultations after 1997 currency crisis.

preemptive monetary policy beyond mid-term time horizon are desirable to achieve the price stability. In addition, even though inflation rate temporarily deviates from goal of inflation, a flexible operation of monetary policy is also considered to keep low and stable inflation in the long run, and further, to maintain macroeconomic stabilization. On the other hand, the benchmark indicator of Korean inflation target was changed again in 2007-2009 (mid-term time horizon) from underlying inflation rate to CPI inflation rate. This is because CPI inflation rate is more familiar with real life of the general public, and so it has higher popularity and satisfies universality for the international standards.

On the other hand, transparency and consistency of the monetary policy are crucial to strengthen the credibility. Transparency and consistency make the central bank responsible for the monetary policy, and it be publicly accountable. Therefore, the incentive to achieve inflation target would be increased, and therefore it increases the public confidence that inflation target will be achieved. In order to enhance the transparency and consistency of monetary policy, central banks have introduced various measures such as, publication of Inflation Report or Monetary Policy Report comprising inflation forecast and economic growth, disclosure of a minutes of the Monetary Policy Committee meetings, discussion between Governor or members of the Monetary Policy Committee and Parliament, and etc. If the monetary policy loss the credibility, it will increase inflation expectations, and it thus increases the costs of bringing inflation back to the inflation target. Therefore, a high level of credibility is crucial to operation of monetary policy.[7]

There are a number of empirical studies of the formation of inflation expectations. But economists typically assumed that private agent's expectations are rational and homogeneous, that is they used rational expectations models. This assumption has been criticized for the criticism that it does not resemble the real world. This is because not every agents pay much attention to macroeconomic matters and it can be costly to obtain and process the information. In addition, rational expectations model can not explain some robust stylized facts, such as the apparent inexorability of the tradeoff between the inflation and unemployment rate(Mankiw, 2000). Although the rational expectation models have these problems, it is still the dominant macroeconomic approach because it tends to be mathematically more tractable than other framework's

[7]For more information about the inflation targeting system in Korea, see Oh (2000)

assumptions.

However, ample empirical evidences on inflation expectation suggest the assumption of homogeneity is not valid. That is, not everyone has the same expectation. Three different roots of heterogeneity have been traditionally explored in the literature. First, households do not forecast the future inflation based on the same information sets (Branch, 2004, 2007; Mankiw, Reis, and Wolfers, 2004). Second, households do not entail the same capacity to process information (Branch, 2004, 2007; Mankiw, Reis, and Wolfers, 2004). Third, households do not employ the same model (Carroll, 2001, 2003; Mankiw and Reis, 2002). Some theoretical studies have introduced heterogeneous expectations in standard macroeconomic models, such as in the New Keynesian framework. In particular, Branch (2004, 2007) assesses the importance of the first two roots of heterogeneity and finds that data are consistent with both of them.

Before unfolding the thesis, we first need to know why studying heterogeneity in inflation expectations is important[8]. First, because the individual respondents indeed show substantially heterogeneous inflation expectations it is empirically relevant, and thus we can observe heterogeneity in inflation expectations empirically on the real data. Second, there are a lot of empirical studies showing that heterogeneity in inflation expectations might affect the behavior of individual economic agents. It can be explained through a number of channels. Mankiw, Reis, and Wolfers (2004) shows disagreement among individual economic agents about inflation expectations can explain the macroeconomic dynamics. Lucas (1973); Sims (2003); Woodford (2001); Phelps (1969) use the imperfect information model[9], and explain the real costs of nominal movements[10] may be related to heterogeneity in inflation expectations. More generally, the real costs of nominal movements (menu costs) can be thought of as resulting from costs of information, decision and implementation resulting in bounded rationality. Because of this expense, firms sometimes do not always change their prices with every change in supply and demand, leading to price stickiness.

[8]See Gnan, Langthaler, and Valderrama (2011) for detailed stories about the issue in heterogeneity in inflation expectations.

[9]Lucas aggregate supply function based on the Lucas imperfect information model accounts for the empirically based trade off between output and prices represented by the Phillips curve except for the case of only unanticipated price level changes. The model accounts for empirically observed short-run correlations between output and prices, but maintains the neutrality of money in the long-run.

[10]In economics, a menu cost is the cost to a firm resulting from changing its prices. In this broader definition, menu costs might include updating computer systems, re-tagging items, and hiring consultants to develop new pricing strategies as well as the literal costs of printing menus.

Mankiw and Reis (2006) show that there is an inattentiveness and stickiness of information on a part of firms, workers and consumers[11]. They said that information stickiness is just needed, but must also be pervasive, and it can reproduce empirical patterns such as the acceleration phenomenon and real wage smoothness. Sims (2009) said that if the agents infer monetary policy from the time series of policy rate changes and from terse and cryptic summaries of the rationale for the rate changes, they will introduce their own signal processing errors and thereby make diversity of views more likely. That is heterogeneous view about future inflation and interest rates can make the agents bet against each other. He explained this phenomenon by the rational inattention theory[12]. The idea of rational inattention is that individuals have a limited amount of attention and therefore they have to decide how to allocate their attention.

On the other hand, anchoring and focusing inflation expectations is a main objective of many monetary policy strategies. Actually a lot of studies have focus on measuring the effects of inflation targeting framework on the dispersion of inflation expectations and evaluating the the success of inflation targeting framework(Mishkin and Schmidt-Hebbel, 2007; Lin and Ye, 2007; Johnson, 2002; Capistran and Ramos-Francia, 2010). Therefore, it is necessary for the central bank to understand the process of inflation expectation formation of the agents, and thus they need to know what factors drive heterogeneity in inflation expectations and how to influence expectations formation. Furthermore, heterogeneous inflation expectations might affect the distribution of income and wealth. If the performance of some agents are worse than the other agents in inflation forecasts, they can make less optimal decisions. So, it is interesting to identify whether specific socio-demographic groups are subject to larger expectation dispersion and errors. We will study what factors make households' inflation expectations heterogeneous on the literature survey in detail in the section 2. Finally, according to the New-Keynesian Phillips curve, inflation expectations may influence current inflation. Thus heterogeneity in inflation expectations may give the indication about the conver-

[11]They use a model featuring staggered updating on a part of firms, workers and consumers and show that firms setting prices update their information on average about every six months, workers setting wages update about every four-and-a half months, and consumers update about every nine months.

[12]Compared to rational expectations hypothesis which assumes that people fully and quickly process all freely available information (such as all information published in books, magazines, newspapers, and scientific articles, and all information available on the internet, and knowledge available through colleagues, friends and family), under rational inattention theory information is also fully and freely available, but people lack the capability to quickly absorb it all and translate it into decisions.

gence or divergence of inflation among different agents (or countries). Therefore, as we mentioned above, it is crucially important to analyze and understand the heterogeneity in households' inflation expectations.

So far, we note the importance of studying heterogeneity in inflation expectations. Then, how we measure the heterogeneity? A number of measures of heterogeneity in inflation expectations have been proposed. From the European Commission (EC)'s qualitative survey data, Lacy (2006) proposed the d^2 index of ordinal variation and Maag (2010, chaptet 2.4.2) and Badarinza and Buchmann (2009) follow the measure of Lacy (2006)[13]. The measure is called "Lacy measure", and if all answers are same response category, it attains the minimum of 0. Otherwise, it reaches its maximum if the distribution of consumer's responses is polarized. They found considerable heterogeneity in inflation expectations over time, across the countries and demographic groups.

Mankiw, Reis, and Wolfers (2004) attest to the fact that disagreement is substantial by using the survey data (either households and professional forecaster) on inflation expectations. Mankiw, Reis, and Wolfers (2004) focus on the median and interquartile range as the relevant indicators of central tendency and disagreement, respectively. They give an example of the disagreement that "as of December 2002, the interquartile range of inflation expectations for 2003 among economists goes from $1\frac{1}{2}\%$ to $2\frac{1}{2}\%$. Among the general public, the interquartile range of expected inflation goes from 0% to 5%." To be specific, They analyze the distribution of inflation expectations and find that two professional surveys (Livingston survey, Survey of Professional forecasters (SPF)) show some agreement on inflation expectations, while the consumer survey reveals substantially greater disagreement.

Madeira and Zafar (2012) noted that including the heterogeneous lifetime experiences of inflation in individual agents' updating process allows us to measure the degree of heterogeneity in inflation expectations and the effects of new information about inflation on households' forecasts. In order to measure the (observable and unobservable) heterogeneity in households' inflation expectations, they use the panel data (Michigan Survey data)[14] in nature of their model to obtain two measure of heterogeneity. The

[13] *Lacy measure* = $\sum_{i=1}^{K-1} F_i(1-F_i)$ where $K = 5$. is the number of response categories in the question on inflation expectations of the EC Consumer Survey, and F_i is the cumulative response share in the category i.

[14] The Survey of Consumer Attitudes and Behavior, conducted at the University of Michigan (Survey

first measure of heterogeneity measures the variance of current inflation forecasts by using the inter-decile range of the inflation forecasts of the second interviews (as a measure of current heterogeneity in inflation expectations). The second measure is sticky expectations. This measure shows the speed of updating agent's idiosyncratic expectations term and documenting changes in the expectations over time. They highlight that these two measures are significant in explaining the inflation in the next quarter, and median inflation expectations has indiscernible effects on future inflation. These results imply that using only median or mean (the measures of central tendency) expectations and ignoring the heterogeneity and persistence of idiosyncratic beliefs may neglect important information.

On the other hand, Madeira and Zafar (2012) deal with both observable and unobservable[15] heterogeneity in inflation expectations updating process across different demographic groups. As to their models, the idiosyncratic individual information follows AR(1) process. In this AR(1) model, white-noise process with zero mean and variance, σ^2, can be interpreted as a measure of the unexplained heterogeneity or dispersion in agents' beliefs about future inflation. It can be interpreted as "disagreement" that Mankiw, Reis, and Wolfers (2004) denoted. They also report the interquartile range (a measure of disagreement) of the distribution of households' inflation expectations. They shows the interquartile range is quite large and reveals substantially heterogeneity in households' point forecasts like Mankiw, Reis, and Wolfers (2004) found.

In general, we call the (variance or) deviation from average as the heterogeneity. Van der Klaauw and Bryan (2008) said that the question of consumer survey focus on the point forecast, not the degree of uncertainty about future inflation outcomes of consumers. The degree of future inflation uncertainty (measured by the disagreement among the respondents in their inflation forecasts) is dealt with the research of the risk of inflation to use respondent heterogeneity as a proxy for risk. In these studies, disagreement is usually measured by the variance or interquartile range (Mankiw, Reis, and Wolfers, 2004) of the distribution of respondents' inflation forecasts.

As Mankiw, Reis, and Wolfers (2004) did, Van der Klaauw and Bryan (2008) use

Research Center) has been available on a monthly basis since January 1978. The survey comprises a cross-section of about 500 (on average) households per month.

[15]Observable information is that households differently place the importance on their lifetime experiences and have different bias for their expectation. Unobservable information is that households update information differently

the estimated parameters of individual density functions to compute both measures of central tendency (median) and individual uncertainty (interquartile range) as the relevant indicators of disagreement. They find that the point inflation forecasts and uncertainty of future inflation have positive correlation and this positive correlation is consistent with the well known empirical finding that high inflation periods have correspondingly high (cross-sectional) variance of inflation rate, while low inflation periods have correspondingly low variance of inflation.[16] They said the correlation may reflect the heterogeneity across the individuals in different information sets, beliefs, or in different capacity to process the information to forecast future inflation rate. This implies that the extreme response in point inflation forecasts with high uncertainty of future inflation may be due to a lack of knowledge of information or understanding of the survey question.

In the empirical work in Carroll (2001), he uses a mean of households' inflation expectations, and generates predictions for other statistics like the standard deviation of inflation expectations across households. Carroll (2001) shows that some households will form their expectations corresponding to the most recent information forecasts, while others will form expectations by using out-of-date information by varying amounts. He said that in their model, if professional forecasters (SPF)' inflation forecasts have been stable for a long time, then the standard deviation of households' inflation expectations should be low, while if inflation forecasts of professional forecasters have been substantially changed, cross-section variability in households' expectations should be high. This prediction was shown in Curtin (1996), and found to be true.[17] Carroll (2001) proposes agent-based version of the framework accounting for different demographic groups. Their approach is to assume that households differently pay attention to economic news about future inflation across the demographic groups (different λ's). As to their approach, if all expectations are purely rational, there should not be demographic differences in inflation expectations. Carroll (2001) measures the heterogeneity in different newspaper-reading propensities (λ's), which cause the het-

[16] Lahiri and Liu (2006) also shows the level of inflation is positively correlated with the median forecast uncertainty of professional forecasters.

[17] Curtin (1996) analyzed the sources of large standard deviation in households' inflation expectations. He found that part of extreme variability is due to very extreme expectations of small number of households. Curtin (1996) said that these extreme views stems from lack of information, and so proposed various way to extract the central tendency of the data to be robust to the presence of these outliers.

erogeneous inflation expectations, by using the underlying micro data of households inflation expectations in agent-based models.

In this study, we consider Korean household's heterogeneity in inflation expectations. First, we use the cross-section data of households' inflation expectations, and compare with the professional forecasters. In advance, we will start by analyzing the Korean expected inflation and actual inflation (Consumer Price Index; CPI inflation rate) and checking how much heterogeneity is in households' inflation forecasts and then investigates the origin of heterogeneity in inflation expectations. This analysis suggests that how the central bank should respond to the inflation risks and how set monetary policy and communicate with the public. In addition, we propose more desirable and reliable expected inflation survey methods.

The remainder of this paper is organized as follows. In the following section 2, a comprehensive review of the literature shows what factors make households' inflation expectations heterogeneous and the effects of heterogeneous expectations on the basis of literature survey. Section 3 describes the Korean survey data on expected inflation and reports descriptive statistics. In Section 4 we use the expected inflation cross-sectional data and employ percentile time series models (Pfajfar and Santoro, 2010) and analyze heterogeneity in inflation expectations. Section 5 reports rationality tests results. Section 6 concludes.

2 Literature Review

In the introduction section, we emphasize the importance of studying the heterogeneity in inflation expectations. In this section we study what factors make households' inflation expectations heterogeneous based on the literature survey in detail.

In recent studies, the socio-demographic backgrounds such as gender, income, location, education level, age, and so on, have known mainly related to the three different roots of heterogeneity: households have (1) different information sets (2) different capacity to process information (3) different forecasting model. We first summarize the literature survey related to the relation between the socio-demographic backgrounds and heterogeneity in inflation expectations.

A few studies have considered the effect of socioeconomic factors in the process of inflation expectation formation. Gomes and Michaelides (2008) said that we have a

life-cycle model and therefore young agents, mid-life households and retirees all behave differently. Pfajfar and Santoro (2008) said that what strikes about elderly respondents is that the proportion of elderly who have heard news about prices in the past month is very low. This indicates that they mostly rely on their own past experiences in producing inflation forecasts. This evidence could be explained by the fact that US public pension system is anchored to the price level through an indexation mechanism. Summers (1984) said that a major virtue of this system is to provide an asset with a fixed real rate of return. Thus, elderly respondents' real income is almost insulated by price changes and this could induce them to disregard inflation dynamics and its related information.

There are considerable differences in the forecasting performance of men and women. Some explanations for this evidence have been advanced in the past. Jonung (1981) and Bryan and Venkatu (2001a,b) show that there are considerable differences in forecasting performance across the gender, and inflation expectations of male is more accurate than that of female counterpart. Jonung (1981) suggests that differences in the expenditure habits are a root of heterogeneity in inflation expectations. Actually, women are usually responsible for day-to-day food purchasing (necessary goods), and this food prices tend to be more volatile and (relatively) largely rise compared to those experienced by the general CPI. As such, female entail a higher degree of awareness about changes in the price of necessity goods, and their forecasts should be inevitably influenced by this factor. On the other hand, on average, a higher proportions in the variation of the bias of female can be captured by the bias of professional median forecast, while the bias of male forecasts can be captured by the change in the inflation rate. Another possible explanation relies on the fact that women generally read newspapers less often than men (Pfajfar and Santoro, 2008). This fact makes women rely too much on the professionals' forecasts when form their forecasts, and they have surely not very much information about inflation compared with the that of men. Moreover, this results in the lower capacity to process information, and therefore their forecasting performance is worse than that of men.

Some of economists suggest that the individuals heavily rely on their own experiences in forming their inflation expectations. DUNN and MIRZAIE (2006) use consumer confidence measures and indicators from a US manufacturing sector to proxy to individual agents' private information. They investigates the relation between the

the manufacturing sector and the consumer confidence, and find that the confidence in a manufacturing state (mainly North East, NE, of US) leads national confidence, whereas non-manufacturing states have a confidence lagged behind the national confidence. These findings coincide with the view that individual's private information reflects underlying economic conditions. Their analysis is based on the conjecture that the employees of a particular manufacturing sector may have better information sets about that sector, and receive different signal of a economic (structural) change compared with employees of other sectors to forecast future economic trends. Interestingly, DUNN and MIRZAIE (2006) find that individuals living in the manufacturing sector (NE) of the US update their information set more frequently (regularly) than those who live in the rest sector of US. Pfajfar and Santoro (2008) also find that households located in the manufacturing belt might have more information about the manufacturing sector. They suggest that the variability in the median forecast of households living in NE of US, not elsewhere, is highly accounted for the variability in the professional forecaster (SPF).

Souleles (2004) tests the implications of systematic heterogeneity in the forecast error. In addition, he notes that households' forecast errors were correlated with their socio-demographic backgrounds, and emphasizes that group-level shocks and aggregate shocks do not hit all households equally. He suggests that high-income households might on average have been more optimistic about future than low-income households and might have happened to receive disproportionately positive shocks to household's income and financial position, business conditions, and inflation over the same period. Pfajfar and Santoro (2008) show that high income households stand out in their forecasting performance and traditionally exhibit less heterogeneity than other income groups, as pointed out by Curtin (2005). And they suggest that these results seem to be on account for the differences in the expenditure pattern across the income level. As a matter of fact, low income households tend to spend a higher proportion of their income on necessity goods. In addition, poorer households may actually consider their group-specific inflation[18] when forecasting inflation.

[18]McGranahan and Paulson (2005) releases group-specific price indexes by using Consumer Expenditure Survey data and item-specific Consumer Price Index data from 1982-2004. They construct monthly chain-weighted CPI inflation measures for thirty-one different demographic groups and for the urban population as a whole from 1983-2005. We call this price index as "group-specific CPI inflation rate"

On the other hand, McGranahan and Paulson (2005) show that inflation experiences of different groups are highly correlated with those of the overall urban population. However, the elderly households' inflation expectations is generally higher than those of the overall urban population. Furthermore, inflation volatility of relatively less advantaged groups of respondents (e.g. elderly, less educated, bottom income level) is higher than the most advantaged ones (e.g. not elderly, high educated, top income level). Pfajfar and Santoro (2008) argue that this effect might result from higher expenditure shares on necessary goods which are generally more volatile, especially when food and energy are considered, among less educated agents.

Meghir and Pistaferri (2004) allow for the possibility that individuals with different education levels face different income levels. This fact explains that different expenditure patterns across the education level are the roots of heterogeneous inflation expectations. And also this allows for the changing returns to observable skills. Pfajfar and Santoro (2008) shows that households with higher educational attainment have strong interest in news media on inflation and the cost of collecting and processing information declines in the level of educational attainment. They show that on average, respondents with some college education (intermediate educational attainment) update their expectations more frequently, although the fit of the epidemiological model for these agents is not as good as that obtained for the respondents with a college degree (highest educational attainment). Moreover, the bias of the median SPF (Survey of Professional Forecaster) forecast increases its importance in explaining households' bias variability as the level educational attainment increases, and thus signalling that the forecast error of highly educated households moves in line with that of the professional forecasters, which are usually regarded as nearly rational agents. Souleles (2004) shows group-level shocks affect all households within an education group the same way but hit each group differently. Likewise the case of high-income households, the households with high education level received relatively good shocks but the households with low education level received somewhat negative shocks.

Inoue, Kilian, and Kiraz (2009) said that "as the consumer's educational attainment can be expected to be correlated with his ability to articulate expectations in response to survey questions, these disaggregate results are helpful in assessing the empirical plausibility of the new implicit inflation expectations measure." By using households' expenditure data from the Consumer Expenditure Survey (CEX), they propose an

alternative approach to recovering households implicit inflation expectations. They show that these implicit expectations are better predictors of CPI inflation than survey responses except for the households with high education. They highlight the speed of adjustment to the news about inflation in the households' inflation expectations is different with the level of educational attainments. According to their findings, the response of households expectations to inflation news tends to increase with their level of education. This result supports the sticky information model.

De Grauwe (2011) assumes that there are two types of agents, optimists and pessimists regarding to the output gap, with the fraction being determined endogenously each period according to their forecasting success. That is the agents learn from their mistakes in an adaptive way. De Grauwe (2011) use simple rules to forecast the future inflation and output. He defined the optimist and pessimist differently, as optimistic agents are systematically bias the output gap upwards and pessimistic agents are systematically bias the output gap downwards. This differences of definition can be interpreted as the divergence in beliefs among agents about the output gap. In additions, De Grauwe (2011) also assumes this divergence in beliefs is a function of the volatility of the output gap. On the other hand, he said that there is an additional dimension to uncertainty in the "behavioral model"[19]. This implies that the effects of the same policy shock depend on the economic conditions about the future. Furthermore, his results show that the inflation targeting framework is of great importance to stabilize the economy in a behavioral model. In particular, the volatility of inflation and output are decreased greatly when the inflation targeting is credible.

Some of studies have concentrated on assessing the heterogeneity that cannot be explained by rational expectations model[20]. Some of these theories postulate the existence of informational frictions generating sticky expectations, while others conjecture that agents might act as econometricians when forecasting.

Evans and Honkapohja (2001) discuss the latter approach widely known as adaptive

[19]Behavioral model reproduces the required behavior of the original analyzed system, such as there is a one-to-one correspondence between the behavior of the original system and the simulated system. That namely implies that the model uniquely predicts future system states from past systems states.

[20]Rational expectations frameworks, led by the Lucas, Sargent, Barro, and others, assume that all economic agents are not merely rational, but also share identical beliefs about the economic structure. Moreover, the frameworks assume to be have instantaneous and costless accesses to all of the latest economic information or data. The framework results in all economic agents have identical beliefs and information sets, and therefore forecasts.

learning model (adaptive expectations). This model assumes that agents behave like econometricians using all of the available information at the time of the forecast. As to Evans and Honkapohja (2001), adaptive expectations means that economic agents develop forecasts of future inflation based on past actual rates adjusted for their own past expectations. For example, if inflation has been higher than expected in the past, people would revise their expectations for the future. Specifically, the current expectations of future inflation is determined by the past expectations and an "error-adjustment" term, in which current expectations of future inflation is raised (or lowered) according to the previous forecast error (the gap between actual inflation and previous expectations)[21]. Therefore, once the agent makes the forecast error, due to a stochastic shock, they will be unable to correctly forecast the future inflation again even if the inflationary shocks are transitory. For example, the inflation expectations will never catch up to the actual inflation rate during a period of accelerating inflation.

As to sticky expectations model, a number of papers show how to generate time dependent rules under which expectations are updated only at fixed intervals. Carroll (2001, 2003) and Mankiw and Reis (2002) advanced the sticky expectations model, which shows the existence of informational frictions. They note that sticky information model is empirically more plausible than menu costs or other sources of ad hoc frictions.

Carroll (2001, 2003) designs an epidemiological framework that assumes that households update their inflation expectations by using news media on inflation, which are influenced by the views of professional forecasters who may themselves make rational forecasts. He found that the Michigan Survey for US households has a mean square error on average almost twice that of the professional forecaster (Survey of Professional Forecaster, hereafter SPF), and points out that news about inflation spread slowly across population (specially, the information about inflation corresponding to the latest rational forecast of inflation.) reaching only a fraction of population in each period. That is, not every economic agent pays close attention to all macroeconomic news, and individual agents absorb the economic information of news probabilistically.

[21]This simple equation states the adaptive expectations: $\pi_t^e = \pi_{t-1}^e + \lambda(\pi_{t-1} - \pi_{t-1}^e)$ where π_t^e is the current expectations of future inflation at period t, and π_{t-1}^e the past expectations of future inflation at period $t-1$, and π_{t-1} is actual inflation rate at period $t-1$. In this equation, λ is between 0 and 1. This means that the rate of which economic agents adapt to accelerating inflation depends on the value of the weight λ assigned to past inflation expectations in developing current expectations of the future inflation. If this weight λ is equal to one, then the current expectations of future inflation is exactly equal to the previous forecast error.

Furthermore, he said that rising inflation, which is usually accompanied by greater news coverage, should be associated with a higher frequency of information updating. Also, when the news coverage of inflation is higher, the news spread faster and the households forecasts is closer to the rational expectations. He found one striking feature that during high inflation periods with high news coverage, the early 1980s, the difference between the SPF forecasts and the households' forecasts is distinctly smaller than the difference in low inflation periods with less news coverage of inflation, the later period. One obvious justification is that the costs of acquiring information about the economy is likely to be lower when news coverage is high. On the other hand, unlike Mankiw (2000)[22], that does not provide an explicit costs micro-foundation in collecting and processing information, Carroll (2001) provide an explicit micro-foundation for aggregate expectations equation. Actually, collecting and processing information from the new media, such as television, newspaper, or the radio, is not costly in either time or money, and economic agents need not to be supposed to form their forecasts if the news media provides such forecasts for free. Therefore, the epidemiological framework of Carroll (2001) is more attractive than the loose collecting-and-processing-costs micro-foundation motivated by Mankiw (2000).

Mankiw and Reis (2002) considered a similar framework with Carroll (2001, 2003). They first approve the fact that agents update their information sets only occasionally in macroeconomic model and suggest that households update their information sets more frequently when inflation matters. This is due to the cost of collecting and processing information that must be paid every time. These costs decrease when inflation matters because a vast pool of information is formed and spreads, and thus the public can easily get the information. Mankiw, Reis, and Wolfers (2004) shows either households or professional forecasters can attest to substantial disagreement, and the disagreement among the professional forecasters changes (or rises and falls) with the disagreement among economists and the households. To be specific, Mankiw, Reis, and Wolfers (2004) use three survey data sources, the Michigan Survey of Consumer Attitudes and Behavior, The Livingston Survey, and the Survey of Professional Fore-

[22]Mankiw (2000) emphasizes the point that expectations which are not fully and instantaneously forward-looking profoundly can changes the behavior of macroeconomic models. Also he shows that if consumers update their expectations very slowly, they may give a cause for important deviations between rational expectations model and macroeconomic reality.

casters (SPF), and finds three important patterns in the data[23]. First, the disagreement between naive and expert populations about future inflation forecasts is substantial. Second, households show higher levels of disagreement than experts. Third, the levels of the disagreement of professional forecaster, economists, and households is different, but this disagreement shows similar time-series patterns even though it shows different amplitudes.

CAPISTRAN and TIMMERMANN (2009) design a formal model on the basis of asymmetric loss function. They explain disagreement in inflation expectations systematically time-varying and it reflects the level and variance of the current inflation by using the survey data (SPF). CAPISTRAN and TIMMERMANN (2009) find that the cross-sectional dispersion in inflation beliefs is positively correlated with the level and variance of inflation rate (see Carroll (2003); Mankiw, Reis, and Wolfers (2004); Souleles (2004) for the evidence) in their model, and this reflects differences in information sets. He said that the asymmetric loss captures the differences in the costs of over- and under-predicting inflation. In addition, they introduce a constant bias component capturing agent's tendency to over-predict inflation, and by using this constant bias component, they explain systematically under- and over-predicting inflation in US. Prior to 1982, inflation was very volatile and so the constant bias component was dominated by the asymmetric effects, and therefore the overall effect made the agents to under-predict inflation. On the other hand, After 1982 when inflation became somewhat stable, the constant bias component dominated the asymmetric effects, and therefore, individual economic agents under-predicted inflation. CAPISTRAN and TIMMERMANN (2009) mainly focus on the variance in inflation expectations across forecasters with heterogeneity in information sets, and they show the cross-sectional dispersion in inflation expectations under disagreement of the variance of future inflation and asymmetric loss[24]

On the other hand, Gnan, Langthaler, and Valderrama (2011) divides households' inflation expectations framework into four stages during which heterogeneity might arise, and integrates the possible feedback from the decision of resulting behavior in a final stage. The four stages are following[25]:

[23]See Mankiw, Reis, and Wolfers (2004) for more information about the data descriptions.

[24]Regarding other empirical evidence on asymmetric loss, see Capistran (2008); Ito (1990); Elliott, Komunjer, and Timmermann (2008).

[25]See Gnan, Langthaler, and Valderrama (2011) for more detailed explanation by stages. Chart

Stage 1: Economic Data; Differences in Macroeconomic Data: There are differences in available "objective" data in forecasting inflation. In this stage, individuals use different macro fundamentals such as current inflation rate, the output gap, unemployment rate, relative prices for imported goods, and these differences may generate different inflation expectations across Euro countries and different demographic groups. Moreover, we can get the information on income developments (aggregate and relative terms[26]) in the objective economic data.

Stage 2: Information filtering: We choose an information or data to use in forming their inflation expectations. In the stage of information filtering, individuals select the indeed relevant data, not all available information, for inflation expectations formation. As a result, there are some differences in the information sets (relevant prices and economic data) across individual agents, and it will cause heterogeneity in inflation expectations. In fact, information availability may differ across demographic groups as well. Especially, some specific data, such as online information, academic thesis, international data, and etc, might only be available in a part of individuals.

Stage 3: Expectations formation; information processing: The information is processed, and we choose a model of inflation expectations formation. There are two ways to form expectations. One is theoretical economic approach and another is psychologically inspired explanations. In the sense of the theoretical economic approach, many economic models are introduced, such as a rationally heterogeneous expectations model in Branch (2007), a formal model on the basis of asymmetric loss (CAPISTRAN and TIMMERMANN, 2009), and a Bayesian learning model (Maag and Lamla, 2009), and New Keynesian framework (Mankiw and Reis, 2002), and so on. According to the psychologically based explanations, individual agents depend on their experience rather than the statistical information. This can be found by using relative price variability because it introduces the heterogeneity in information sets (individual consumption basket vs aggregate consumption basket).

Stage 4: Action: The economic agents decide the behavior such as consumption, work/leisure, saving. Individual agents consume, work, and save or invest based on their future expectations.

2 (Heterogeneity of Consumers' Inflation Expectations: Stylized Framework) shows the process of consumers' inflation expectations and the relationship between the four stages.

[26]For example, 'aggregate' is the term for a country income as a whole and 'relative' is the term for an individual or a group income

3 Stylized Facts of Korean Inflation and Expected Inflation

The major objectives of monetary policies of the Bank of Korea (BOK) are to achieve sustainable economic growth and price stability in the economy. The central bank pursuing the price stability have made much efforts to measure expected inflation of individual economic agents. Because it is impossible to examine the expected inflation directly, a variety of methods, such as a survey method, a method of using the information on financial products, a method of using economic models, are used to measure expected inflation. Especially, survey methods have an advantage of measuring the expectations of various economic agents, such as general public, professionals, economists, enterprisers, etc directly. Thus, a survey method is the most widely-used method, and Korea only depends on the survey method in order to measure the expected inflation. The BOK has conducted a consumer survey for the general public about inflation expectations from February 2002. But, because there is a limitation of seizing enough time series data, it is lack of the research on inflation expectations.

In this study, we consider the time window 2002:M2-2011:M5 of the expected inflation data and 2003:M2-2012:M5 of the actual inflation data because the expected inflation data is one-year ahead inflation expectations, and so we need to adjust this one-year time lag. We use CPI inflation rate as the actual inflation rate and deal with three surveys as expected inflation rate. First, households expected inflation rate is the public survey data conducted by Bank of Korea (hereafter BOK). As to the professional forecasters' inflation expectations, we use two survey data, professional survey data conducted by BOK and Consensus survey data conducted by Consensus Economics. The detailed data descriptions are followings.

3.1 The Data

3.1.1 The Public Survey

The public expected inflation data in the Consumer Survey, conducted by the Bank of Korea, has been available since February 2002. From February 2002 to June 2006, the survey was conducted on a cross-section of about 1500 households per month through

the national attitude survey regarding inflation. And, since July 2006 the survey has been conducted a cross-section of about 2200 households through the consumer survey.

The public survey[27] investigates the expected inflation rate in the next 12 months for given information of annual average CPI (Consumer Price Index) inflation rate for one year. These publicly available data are summarized in intervals. We calculate the weighted average value by using the median of each interval and the weight is the number of respondents. The Korea uses this weighted average value as expected inflation index. However, the response intervals[28] about expected inflation rate have been modified several times, and now are divided into 9 intervals between -0.5 and 8.0%. Therefore, we first need to adjust each response interval to be the same over all time-series. In this study we make each response interval be same with the intervals in April 2008. In the data, we might be confused about the category "expect price to down or stay the same". In this section, we regard this response as 0 and use the data excluding this response.

On the other hand, the public survey have some limitations that the survey results can be changed according to the survey method. Also, credibility problem could be raised because the survey respondents may respond to the survey questions regardless of their profit. Nevertheless, because the public survey represents inflation expectations based on the information that directly obtained from general public, this survey is used extensively as the expected inflation index. Hereafter, we call this survey data BOK public survey

3.1.2 The Professional Survey

Since the third quarter 2005, the BOK has surveyed Korean economists engaged in economic research institutes and financial institutions (now fifty person) about the CPI inflation expectations in the next two quarters, two years, one year, and five years.

[27]There are two relevant questions about expected price changes: (i) Whether they expect price to go up, down or to stay the same in the next 12 months, (ii) Provide a quantitative statement about the expected change

[28]e.g., (2002.02): go up by 1-2 percent, 2-3 percent, 3-4 percent, 4-5 percent, 5-6 percent, 6-7 percent. 1st change (2004.02): go up by less than 1 percent, 1-2 percent, 2-3 percent, 3-4 percent, 4-5 percent 5-6 percent, 6-7 percent, more than 7 percent. 2nd change (2005.05): go up by -0.5-1.5 percent, 1.5-2.5 percent, 2.5-3.5 percent, 3.5-4.5 percent, 4.5-5.5 percent, 5.5-8 percent. 3rd change (2008.04): go up by -0.5-1.5 percent, 1.5-2 percent, 2-2.5 percent, 2.5-3 percent, 3-3.5 percent, 4-4.5 percent, 4.5-5.5 percent, 5.5-8 percent

The survey of the expectations in the next one year started after fourth quarter 2009 and the survey of the expectations in the next five years (long-term expected inflation) started after first quarter 2011.

In order to compare with other expected inflation index, the BOK uses the average value of expectations of CPI inflation in the next one year which professionals respond as a short-run expected inflation rate. In the survey data before fourth quarter 2009, when the survey on one-year ahead inflation expectation was not conducted, we calculate one-year ahead expectations by using the weighted average method of quarterly or yearly expectations. That is, first quarter survey is equivalent to the current year expectations (one year ahead expectations), second quarter survey is weighted average of current year and next year expectations(3:1), third quarter survey is weighted average of next two-quarters expectations and next year expectations(1:1:2), fourth quarter survey is weighted average of current quarter and next year expectations(1:3).

This quarterly survey was recently introduced to make up for low credibility of BOK public survey, and the survey results has been reported in the monetary policy report twice a year. On the other hand, the available time series data of this survey is short compared with monthly survey data, public survey and consensus survey, and there is a limitations in research. Hereafter, we call this survey data BOK professional survey.

3.1.3 The Consensus Professional Survey

The survey has conducted by Consensus Economics which is an international economic survey organization that specializes in forecasts for major macroeconomic index survey such as GDP, private consumption, total fixed investment, etc across the survey lists of countries, and located at London in United Kingdom. The Consensus Economics has monthly surveyed over 180 influential international and local economists who are engaged in investment banks, security corporations, economic research institutes, etc about CPI inflation expectations for current year and next year.

The survey calculates the weighted average value of the mean of current year or next year expectations that the professionals forecast by using the number of months for each year (next a year) from the time of the survey, and use this weighted average

value as expected inflation index.[29] The survey has the most longer time series among Korean expected inflation indexes. Hereafter, we call this survey data consensus survey.

3.2 Descriptive Studies

In this section, we consider monthly BOK public survey data spanning from 2002:M2 through 2011:M5 indicating the sample size of 112. The BOK professional survey data is used from 2006:Q3 to 2011:Q2. The consensus survey data is used from 2002:M2 to 2011:M5. We use CPI inflation rate (2010=100) and core inflation[30] rate data from 2003:M2 to 2012:M5 because the survey data is one-year ahead inflation expectation rate. The core inflation is the headline (CPI) inflation rate excluding agricultural products except for the grains and the petroleum.

Figure 1 plots BOK public expected inflation rate against CPI (actual) inflation rate[31]. We find that public inflation expectations shows similar movements with CPI inflation, but looks relatively less volatile and more persistent. Furthermore, the public fails to account for the inflationary pressure and shows a consistent delay in reacting to the inflation shock during overall period. Especially, during 2008, when US sub-prime mortgage crisis erupted, the price was skyrocketing but the public expected inflations was quite stable and the rising inflation pressure were reflected after fourth quarter 2008. We interpret that this is because the public survey index tends to accompany with the actual inflation at the time of expectations formation, not at the time of prediction target (next 1 year). One of interesting founding is that the public inflation expectations has a lower bound in the target band of price stability.

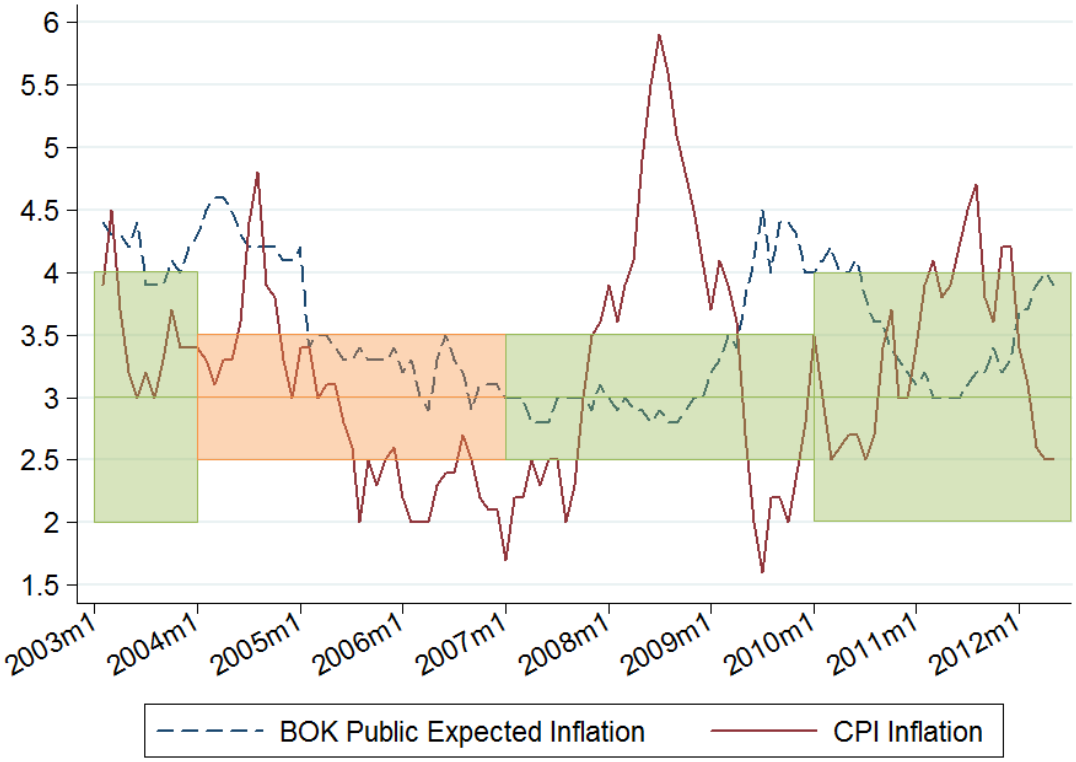
Korean inflation rate has been affected by a variety of the international supply shocks such as oil shock, financial crisis, and international grain price shocks, etc,

[29] For example, the average of forecasts of yearly CPI inflation rate at 2011 and 2012 is 4.2% and 3.5%, respectively. In this case, expected CPI inflation rate in next 1 year is 3.5% ($= 4.2 \times \frac{4}{12} + 3.2 \times \frac{8}{12}$)

[30] We can measure underlying inflation rate by a variety of way. For examples, underlying inflation is simply measured by excluding changes in food and energy prices. Another approach is statistical measure, which throws out the most volatile component in CPI component on a basis of statistical criteria, both positive and negative changes. Other approaches are theory-based measures. These measures employ common trends, particular models, or unobserved components. The major advanced countries use both "exclusion" measure and a variety of measures simultaneously. However, the Korea use only "exclusion" measure.

[31] As we explained at data descriptions, BOK public survey is one-year ahead expectations, and so the time series are plotted with a one year time lag.

Figure 1: Public Expected Inflation and CPI Inflation



Note: The shaded area is the target range of price stability (1998-2004 and after 2007: CPI inflation rate basis, 2004-2007: core inflation rate basis). A dotted line in the shade area is the center line of the target of price stability. The public expected inflation rate is the one-year ahead expected inflation rate.

and domestic demand shocks such as economic growth, house price, wage, etc. In particular, the skyrocketing inflation rate at 2008 is explained by a high rise in the price of international raw materials such as petroleum and grains while the Korean currency turned higher.

On the other hand, as we mentioned section 1, the Bank of Korea used a short-term inflation target with one year time horizon from 1998, but after The 7th Amendment of the Bank of Korea Act, 2004, mid-term inflation target was introduced instead of the short-term (annual) inflation target. The reason for setting med-term inflation targeting is that there are long time lags before a monetary policy affects the price level and its effects felt in the various economic sectors. Therefore, in order to reconsider

the validity of inflation targeting system, it is known that setting the inflation target and preemptive monetary policy beyond mid-term time horizon are more desirable to achieve the price stability. In addition, even though inflation rate temporarily deviates from goal of inflation, a flexible operation of monetary policy is also considered to keep low and stable inflation in the long run, and further, to maintain macroeconomic stabilization.

The benchmark indicator of Korean inflation target was changed from underlying inflation rate to CPI inflation rate after 2007. This is because CPI inflation rate is more familiar with real life of the general public, and so it has higher popularity and satisfies universality for the international standards. The BOK set annual inflation target at 2003 as 3 percent (target range is $3 \pm 1\%$) and set mid-term inflation target from 2004 to 2007 as 3 percent (target range is $3 \pm 0.5\%$) based on the Core inflation rate, and after 2007 set mid-term inflation target as 3 percent (target range is $3 \pm 0.5\%$) based on the CPI inflation rate. From 2010, mid-term inflation target is 3 percent (target range is $3 \pm 1\%$) based on the CPI inflation rate.

In the Figure 1, we can also find that actual inflation rates and expected inflation rate were off the target range several times. The first year of implementing the mid-term inflation targeting, 2004 (-2007), Core inflation rate was adopted as an inflation indicator, and as its annual rate was 2.9% on average, and thus it closed to inflation target rate 3.0% (in figure 3). But, as to the CPI inflation rate, in spite of sagging domestic demand it showed high level of inflation rate and was off the inflation target. we interpret this as a result of high oil prices and high prices of agriculture, fishery and livestock products. After 2005, the expected inflation rate have shown well anchored at inflation target range. In case of actual inflation rate, both CPI inflation rate and Core inflation rate showed slower growth and were below the bottom of inflation target range. This is due to drastically dropped exchange rate and stable rices of agriculture, fishery and livestock products. During 2008, when US sub-prime mortgage crisis erupted, the CPI inflation rate was skyrocketing and highly exceeded the inflation target but the public expected inflations was quite stable and the rising inflation pressure were reflected after fourth quarter 2008. This skyrocketing inflation rate at 2008 is explained by a high rise in the price of international raw materials such as petroleum and grains while the Korean currency turned higher. 2009's CPI inflation rate was drastically fell after it reached the highest rate of CPI inflation. This is because the prices of

international raw materials decreased and the global economic slowdown from the global financial crisis shrank the domestic demand pressure. The expected inflation rate exceeded the inflation target after 2010, and back to the inflation target range in in the second half of 2011. The CPI inflation rate was also off the inflation target range during 2011. This is due to the foot-and-mouth (FMD) disease, abnormal weather phenomena, and a sudden rise in the prices of international raw materials. In addition, 2012's expected inflation rate was off the inflation target again.

We want to say that these failures of anchoring the households' expected inflation rate at the inflation target ranges decrease the credibility of monetary policy (credibility problem). Under inflation targeting, the transparency, credibility and accountability of monetary policy is very important. The reason is that they increase incentive for the central bank to achieve inflation target, and therefore it increases the public confidence that inflation target will be achieved. If the monetary policy loss the credibility, it will increase inflation expectations, and it thus increases the costs of bringing inflation back to the inflation target. Therefore, a high level of credibility is crucial to operation of monetary policy. The Bank of Korea also have introduced various measures to increase the credibility of monetary policy. The BOK have submitted a Monetary and Credit Policy Report to the National Assembly and have published the minutes of Monetary Policy Committee meetings. In addition, the BOK officially announces their operation plan for the monetary policy after they set a price stability target. However, the effectiveness of these measures is are skeptical. We consider these inefficiency of the measure for enhancing the credibility of monetary policy is due to insufficiency of the necessary conditions for inflation targeting.

In order for inflation targeting to be successfully carried out, the central bank should satisfy the several necessary conditions (Central bank independence, Capacity of inflation forecasting, Controllability of monetary policy instruments over operating targets, Effective channel of interest rates on prices, Transparency, consistency and credibility of monetary policy.) Especially, the instruments of the monetary policy and financial markets should be developed and the government should not intervene in the financial market so that the effectiveness of the interest rate channel on prices is strengthened. In addition, the central bank's independence should be more enhanced in legal and operational term, and the controllability of the central bank's monetary policy should be more increased, too. Furthermore, the central bank should increase

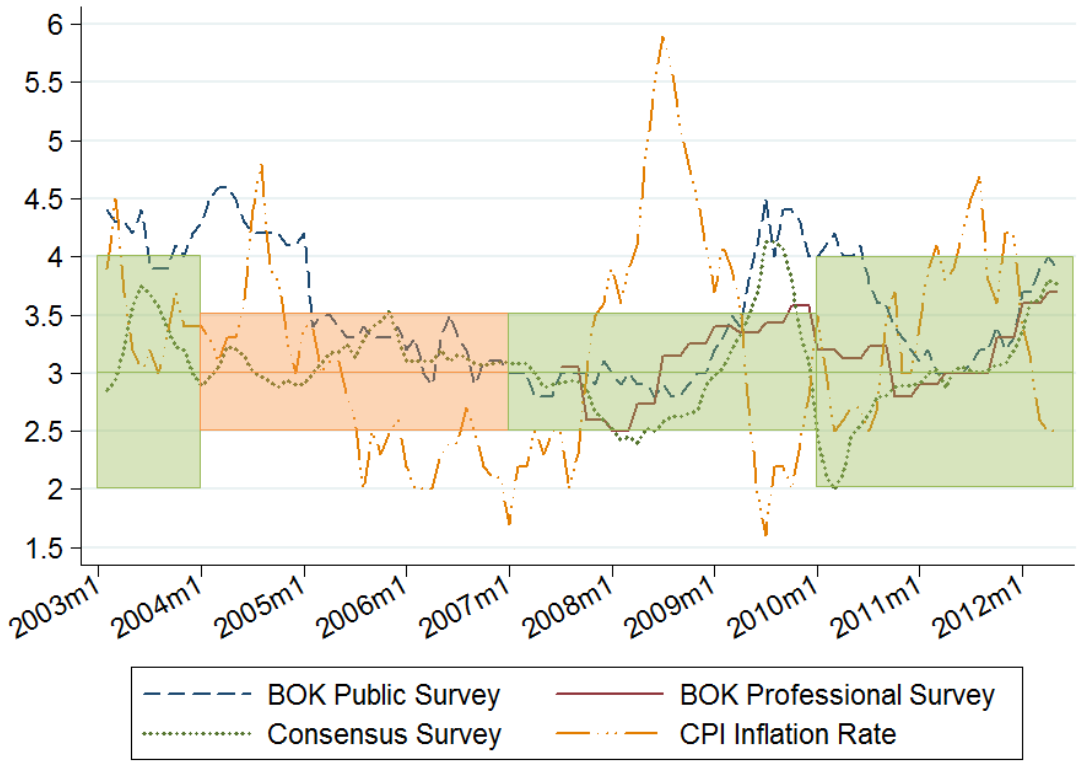
the credibility of monetary policy and strengthen the capacity to forecast inflation.

We come up with new specific measures to improve the conditions for inflation targeting. As to effectiveness of the interest rate channel, the central bank should improve a model of an interest rate (call rate or base rate) as an operating target, and develop more useful information variables. For the capacity to forecast inflation, the BOK should develop various techniques for forecasting inflation, inflation pressure indexes. It is desirable to connect with underlying inflation, too. Finally, monetary policy should be conducted more transparently and consistently as well, the central bank should also communicate with the public more frequently and make the public understand of an operation of the inflation targeting to strengthen the credibility of monetary policy. We think that the improvement of the conditions for inflation targeting depends on the central bank's aggressive stance about the monetary policy, and we sure that this aggressive stance of the central bank about the monetary policy will improve the conditions for the inflation targeting in Korea.

Figure 2 reports BOK public and professional expected inflation rate and consensus survey on inflation rate against actual inflation rate.[32] The public survey is higher than other surveys and actual inflation rate on average. All surveys of inflation expectations show similar movements with CPI inflation, but they move somewhat differently. In addition, As we found at Figure 1, we also find that all surveys seem to fail to account for the inflationary pressure perfectly. Figure 2 shows that the CPI inflation rate is the most volatile. The professional survey shows well-anchored inflation expectations, and it almost never was off inflation target range. The professional survey looks relatively less volatile and more persistent than the other survey. We interpret that this well-anchored professionals' inflation forecasts is because the professionals have more information about inflation target and higher capacity of inflation forecasting. Moreover, the professionals seem to put higher confidence in the central banks' monetary policy. One of interesting findings in Figure 2 is that despite the professionals' forecast, it looks not rational and shows somewhat heterogeneity. On the other hand,

[32] According to Choi (2012), the Households' inflation expectations and the Professionals' inflation expectations are positively related with inflation rate from 11 months before to 4 months after, and from 4 months before to 7 months after, respectively. That is, the public agents tend to be backward looking and the professionals are tend to be forward looking relatively. In addition, by testing Granger-causality (time series: 2002.2 $\sim$ 2012.6) he notes that after the actual inflation rate changes the inflation expectations is moved with time lags, and inflation expectations changes again, then actual inflation rate is moved in the future.

Figure 2: Korean Expected Inflation Rates



Note: The shaded area is the target range of price stability (1998-2004 and after 2007: CPI inflation rate basis, 2004-2007: core inflation rate basis). A dotted line in the shade area is the center line of the target of price stability. The survey data is the one-year ahead expected inflation rate.

the consensus survey looks like the most accurate survey compared with other survey. We compare the forecast accuracy by using Sum of Squared Error (SSE) and Mean Squared Error (MSE). The SSE and MSE are defined as followings:

$$SSE = \sum_{t=1}^{N} (\pi_t^e - \pi_t)^2,$$

$$MSE = \frac{1}{N} \sum_{t=1}^{N} (\pi_t^e - \pi_t)^2$$

where π_t denotes actual inflation at time t, and π_t^e is expected inflation forecast at time $t - 12$ for period t, and we calculate SSE and MSE for all survey data.

Table 1: Forecast Error

	BOK public	BOK professional	Consensus
Average	3.54	3.14	3.05
SSE	148.52	79.63	139.59
MSE	1.33	1.35	1.25

Note: The time series of BOK survey data is from 2002:M2 through 2011:M5 and the BOK professional survey data is used from 2006:Q3 to 2011:Q2, and the consensus survey data is used from 2002:M2 to 2011:M5. We use CPI inflation rate (2010=100) from 2003:M2 to 2012:M5. The MSE means Mean Squared Error and SSE is Sum of Squared Error.

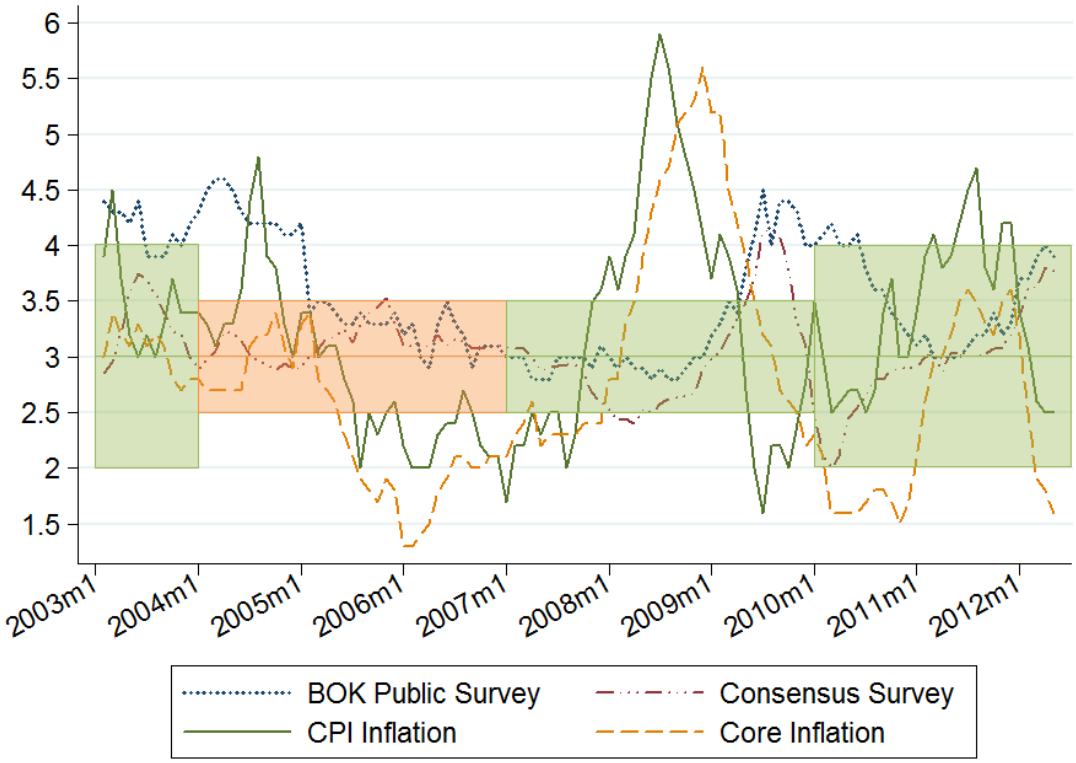
Table 1 shows that the public survey is higher than other survey data on average and the Consensus survey has the lowest MSE value and so this survey is more accurate than other survey. In case of the BOK professional survey, the available time series is short, and so comparing predictive accuracy with other survey is not useful.

In Figure 3, we plot the Consensus survey and the public survey as the expected inflation, and CPI inflation rate and Core inflation rate as the actual inflation rate. The core inflation is the headline (CPI) inflation rate excluding agricultural products except for the grains and the petroleum. As we explained at Figure 1, we find that the public survey index tends to accompany with the actual inflation at the time of expectation formation, not at the time of prediction target (next 1 year).

We noted that from 2004 to 2007 the underlying inflation rate is used as bench mark indicator because an underlying inflation rate is lower and less volatile (stable) than CPI inflation rate in history, and therefore, inflation targeting system based on the underlying inflation rate as a benchmark indicator seems to improve the efficiency and accountability of monetary policy. But, the benchmark indicator of Korean inflation target was changed to CPI inflation rate after 2007. This is because CPI inflation rate is more familiar with real life of general public, and so it has higher popularity and satisfy universality for the international standards.

In Figure 3, overall the survey of inflation expectations both households and professionals appears to move more similarly with CPI inflation rate than Core inflation rate. That is, the CPI inflation rate as the benchmark indicator of inflation target may be much better. On the other hand, the core inflation rate is usually less than CPI inflation rate, but after fourth quarter 2008, the core inflation rate is higher than CPI

Figure 3: Expected Inflation Rates and Actual Inflation Rate



Note: The shaded area is the target range of price stability (1998-2004 and after 2007: CPI inflation rate basis, 2004-2007: core inflation rate basis). A dotted line in the shade area is the center line of the target of price stability. The survey data is the one-year ahead expected inflation rate.

inflation rate. This can be explained by the fact[33] that the price of the international raw materials fall back but the pass-through impacts of higher exchange rate became more serious.

3.3 Summary statistics

Table 2 reports the summary statistics of Korean inflation rates. The mean and median of the BOK public survey is higher than other survey data, and the mean and median of the Consensus survey data is the lowest. The mean and median of Core

[33]The first-round effects of a supply shocks include both direct impact which means the direct impact on the price of the energy component of general consumer prices, and pass-through impact which means the effect of higher energy prices into the price of non-energy goods and services.

Table 2: Summary Statistics of Korean Inflation Rates

Statistics	CPI Inflation	Core Inflation	BOK Public	BOK Professional	Consensus
Mean	3.20	2.78	3.54	3.14	3.05
Median	3.10	2.70	3.40	3.15	3.05
Std.	0.89	0.95	0.54	0.32	0.39
Variance	0.80	0.91	0.29	0.10	0.15

Note: The time series of BOK survey data is from 2002:M2 through 2011:M5 and the BOK professional survey data is used from 2006:Q3 to 2011:Q2, and the consensus survey data is used from 2002:M2 to 2011:M5. We use CPI inflation rate (2010=100) and Core inflation rate from 2003:M2 to 2012:M5.

inflation rate is smaller than those of CPI inflation rate. These facts were able to catch at figure 2 and figure 3. In case of the variance of the survey data, the BOK public survey provide more volatile predictions with respect to the other professional survey data and the variance of the Consensus survey is the lowest. It may implies that the professionals shows more persistent inflation forecasts.

On the other hand, the core inflation rate is more volatile than CPI inflation rate. This fact is an abnormal phenomenon. Actually, many countries have used the CPI for many purposes and also commonly used CPI when measuring inflation. This index is more volatile on month to month basis than core inflation, and so core inflation rate is intended to be an indicator and predictor of underlying long-term inflation. However, even though the sample size is somewhat short (2003:M2-2012:M5), this phenomenon is very abnormal in Korea. We think this phenomenon can be explained by the way of measuring the underlying inflation. The Korea now use only "exclusion" measure as underlying inflation rate while the major advanced countries use both "exclusion" and a variety of measures simultaneously. We want to say that if we use both "exclusion" measure that is measured by CPI inflation rate excluding changes in food and energy prices and other approaches for measuring underlying inflation rate (statistical measures, theory-based measures) that I mentioned, this phenomenon can be solved. Furthermore, the central bank should come up with new measure of Core inflation rate appropriate to the Korean situations.

3.4 Persistence Test

We use variance ratio (VR) test originally proposed by Lo and MacKinlay (1988, 1989)[34], which is widely used to test for the random walks hypothesis in the finance and economics literatures. Under homoscedasticity the VR would be exactly equal to one, and it still approaches one under heteroscedasticity in Lo and MacKinlay (1988). If the series of the inflation expectations cannot be explained by the random walk hypothesis, then we can reject the the rational expectations hypothesis. On the other hand, the VR tests show that rejections of the random walk hypothesis due to not only heteroscedasticity but also autocorrelation while the Box-Pierce tests show rejections of the random walk only due to heteroscedasticity. Therefore, the VR test results can support the overshooting or undershooting hypothesis (Liu and He, 1991).[35]

In case of the series of the survey not follows randomness, we can define two types of deviations of inefficient market: mean reversion (long-term case) and persistence. The information shocks have a prolonged effect in the price series, then the persistence that past information contain useful information for prediction so that long memory violates the random walk hypothesis makes the agent react to current information vis-a-vis prior information slowly. On the other hand, if the information shock have a temporary effects on the prices and it disappears quickly, we can define the series is said to be mean reversion (long-term case). Sometimes mean reversion is attributed by the agents' overreaction to the information shocks.

As to Lo and MacKinlay, if a series follows the random walk process, the variance of its q-differences would be equal to q-times the variance of its first difference. Therefore, this nonparametric tests, the variance ratio test is following simple equation:

$$VR(q) = \frac{Var(Y_t - Y_{t-q})}{qVar(Y_t - Y_{t-1})} = \frac{Var(\Delta Y_t + \ldots + \Delta Y_{t-q+1})}{qVar(\Delta Y_t)}$$

[34]Lo and MacKinlay (1988) shows that the variance-ratio test is more reliable than either the Dickey-Fuller t test (Dickey and Fuller, 1979, 1981) for detecting the unit root component and Box-Pierce Q test (Box and Pierce, 1970). However Lo and MacKinlay (1988) said that Dickey-Fuller t test and Box-Pierce Q test are not direct competitors of the VR test because they have been designed with different null hypotheses in mind.

[35]On the other hand, according to Bessembinder (2003), and Chordia, Roll, and Subrahmanyam (2008), and Kaul and Sapp (2009), the VR is defined as the accuracy that all of the information which have an effect on price making are reflected. Thus, the efficient market hypothesis says that any efficient price series have to follow random walk. We follow the logic of the definition.

The test statistic under the homoskedasticity, Z(q), which follows the standard normal distribution asymptotically ($T \to \infty$), is then:

$$Z(q) = \frac{VR(q) - 1}{\phi(q)^{1/2}} \sim N(0, 1)$$

where the asymptotic variance, $\phi(q)$, is given by

$$\phi(q) = \frac{2(2q-1)(q-1)}{3qT}$$

where T is the sample size.

In this studies, we apply the VR to test the random walk hypothesis for the inflation expectations. Furthermore, we can capitalize on this different behavior to formulate tests for the hypothesis, and check how much persistence is in the actual and expected inflation. We use 1-month as our base observation interval, and test the random walk hypothesis for each of the intervals $q = 3, 6, 9, 12, 15, 18, 21, 24$ months. The test is given by

$$VR_q = \frac{Var(\pi_t^{(e)} - \pi_{t-q}^{(e)})}{qVar(\pi_t^{(e)} - \pi_{t-1}^{(e)})}$$

where π_t is the CPI inflation, and π_t^e is the expected inflation, public survey, professional survey, and consensus professional survey. And the null hypothesis is $H_0 : \ VR = 1$. The results are reported in Table 3.

Table 3 reports the results of the VR tests under the maintained hypothesis of homoskedasticity for the CPI inflation, public survey, professional survey, and the Consensus survey. We find that all survey data and CPI inflation rate reject the random walk hypothesis. Almost all VR are more than 1 ($VR > 1$). In addition, the VR for CPI inflation shows low level of persistence while the Consensus survey shows the high level of persistence. The CPI inflation and the public survey provide only weak rejections, while the Consensus survey and the professional survey provide more strong rejection. On the other hand, when $q = 15, 18$ all the survey significantly reject the random walk hypothesis even though the significant levels are different (the professional survey are exceptional). It may be interesting to note that the professional

Table 3: The Variance Ratio Test

q	CPI inflation	BOK Public	BOK Professional	Consensus
3	1.326 (0.041)**	0.905 (0.554)	1.189 (0.466)	2.103 (0.000)***
6	1.441 (0.102)	1.171 (0.525)	1.652 (0.149)	2.866 (0.000)***
9	1.641 (0.070)*	1.486 (0.169)	2.286 (0.035)**	2.745 (0.000)***
12	1.795 (0.052)*	1.620 (0.130)	5.114 (0.000)***	2.232 (0.003)***
15	1.939 (0.056)*	1.970 (0.048)**	4.222(0.000)***	2.255 (0.011)**
18	2.005 (0.070)*	2.071 (0.053)*	.	2.210(0.029)**
21	1.511 (0.359)	1.586 (0.292)	.	1.663 (0.234)
24	1.789 (0.222)	2.099 (0.089)*	.	2.058 (0.102)

Note: The time series of the public survey data is from 2002:M2 through 2011:M5 and the professional survey data is used from 2006:Q3 to 2011:Q2, and the consensus survey data is used from 2002:M2 to 2011:M5. We use CPI inflation rate (2010=100) from 2003:M2 to 2012:M5. For each value are reported in the row and the parenthesis shows p-value for the test statistics. The number of observation of VR(q) for CPI inflation, Public survey, Professional survey, Consensus survey is 88, 88, 35, and 88, respectively. $***/**/*$ denotes significant at 1/5/10 percent level, respectively.

survey, which conducted by BOK, shows the most persistent forecasts and it followed by the consensus professional survey, the public survey, and CPI inflation. We wonder this finding because it implies that the professionals update their forecast less frequently than the public agents, and they don't use up-to-date information. Moreover, the information that the professionals use, are not immediately reflected on their forecasts. This is not consistent with the general idea that the professionals are usually regarded as nearly rational agents.

4 Heterogeneity in Inflation Expectations

A number of previous literatures have focused on the measures of central tendency, and assessed the influence of consumers socioeconomic backgrounds on their inflation forecasts or the degree of heterogeneity in households' inflation forecasts. However Pfajfar and Santoro (2010) said that this may not be an appropriate method when the data on households' inflation expectations formation shows asymmetric and (or) multi-modal densities. This is because the measure of central tendency have limits in extracting the idiosyncratic information in the cross-section of forecasts and analyzing the distribution of households' inflation expectations. Moreover, Madeira and Zafar

(2012) said that using only median or mean (the measures of central tendency) expectations and ignoring the heterogeneity and persistence of idiosyncratic beliefs may neglect important information.

In order to measure the heterogeneity in inflation expectations, various measures have been proposed. In case of the EU countries, Lacy (2006) proposed the Lacy measure (see, e.g, Maag (2010, chaptet 2.4.2); Badarinza and Buchmann (2009)) by using the European Commission (EC)'s qualitative survey data. On the other hand, Mankiw, Reis, and Wolfers (2004) attest to the fact that disagreement is substantial by using the survey data (both households and professional forecaster) on inflation expectations. Mankiw, Reis, and Wolfers (2004) focus on the median and interquartile range as the relevant indicators of central tendency and disagreement, respectively. Madeira and Zafar (2012) measure the dispersion in agents' beliefs about future inflation, and report the interquartile range (a measure of disagreement) of the distribution of households' inflation expectations. Van der Klaauw and Bryan (2008) compute an individual uncertainty (interquartile range) as the relevant indicators of disagreement. In these studies, disagreement is usually measured by the variance or interquartile range (Mankiw, Reis, and Wolfers, 2004) of the distribution of respondents' inflation forecasts.

In this study, we measure the heterogeneity in inflation expectations by measuring the variance (dispersion) or interquartile range (Mankiw, Reis, and Wolfers, 2004) of the distribution of respondents' inflation forecasts. We use the cross-sectional data in the public survey on the expected inflation from 2006:M7 to 2011:M5. Unlike the general analysis of Korean inflation rate section, in this studies we regard the response "expect price to down or stay the same" as '0' and include this response in the category "expect price to go up by -0.5-1.5 percent". Only the category "do not know" is excluded. Actually, the BOK has excluded this response '0' in the publicly available data. However, we consider this response has important information because excluding the response is to disregard the information of the households' forecasts that expect price to down or stay the same.

To study how inflation expectations indeed empirically affect the behavior of individual economic agents, we focus on the cross-section of public forecasts and employ the percentile time series models (Pfajfar and Santoro, 2010). The purpose of this approach is accounting for the evolution of the cross-section of inflation forecasts over

time. In order to analyze the cross-section of Korean households' heterogeneity in inflation expectations, we compute percentiles of the empirical distribution in each period, and then retrieve monthly time series for each percentiles. Therefore, we can obtain the information in the cross-sectional forecasts of different agent-types in the empirical density, and show that households' forecasting mechanisms are different across the regions of the distribution.

4.1 Descriptive Studies

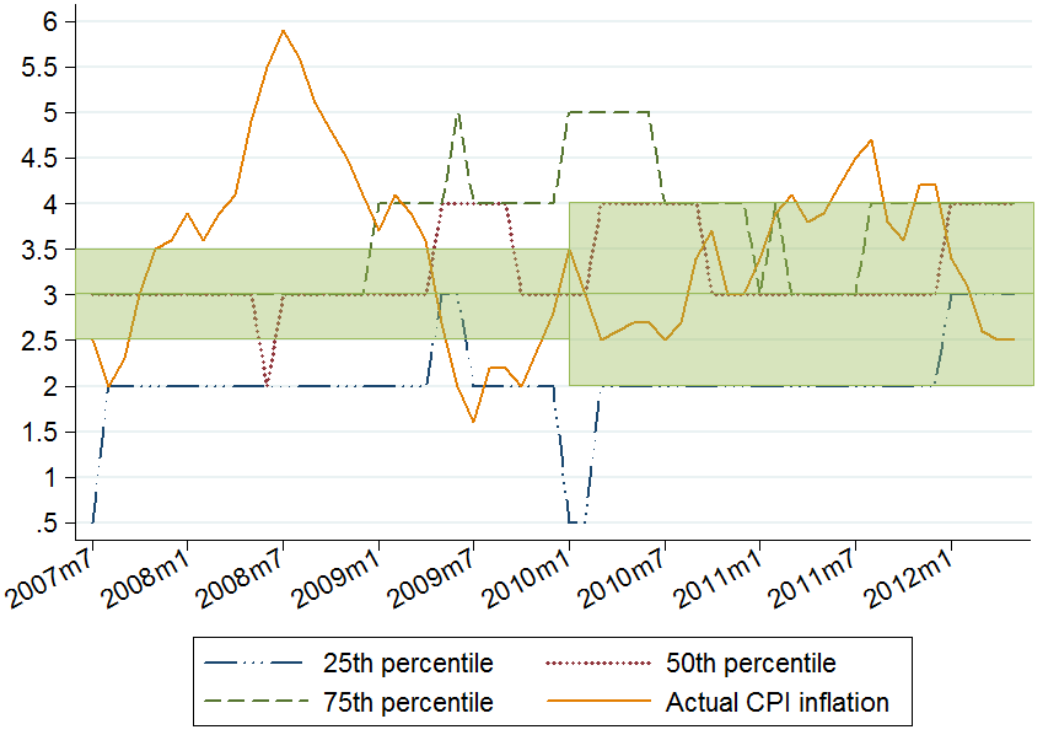
In this section, we use the cross-sectional data in the public survey on the expected inflation from 2006:M7 to 2011:M5 and consider monthly time series for each percentiles retrieved from the distribution of households' forecasts by using percentile times-series model (Pfajfar and Santoro, 2010).

Figure 4 displays the 25th, 50th, 75th percentiles and actual inflation rate. All of the region of the distribution of households' forecast looks to show a delay in reacting to the inflation shocks. This finding is in line with the general analysis in the Figure 1. In addition, interquartile ranges (IQR), which is a measure of statistical dispersion, shows higher dispersion during high inflation periods and lower dispersion during low inflation periods with a marked delay in reacting to the new information or inflation shocks. To be specific, during 2010 the cross-sectional dispersion is the highest and during 2007-2008 households inflation expectations shows lower cross-sectional dispersions. This finding is in line with the inflation expectations.[36] We interpret that higher dispersion of households inflation forecasts means higher level of heterogeneity. In this notion, we can say that the heterogeneity (disagreement) in inflation expectations is time variant.

We find that the 25th percentile appears to be remarkably stable overall periods compared to the other percentiles, while the 75th percentile shows more volatile forecasts. That is, different regions of the distribution of households' inflation expectations show different degrees of volatility. We interpret this finding as that the region on the left hand side of the distribution of households' forecasts, the 25th percentile, less reacts to the new information or economic shocks than the other percentiles, and so the percentile presents somewhat static forecasts. The right hand side of the distribution of

[36] In previous literatures, the higher dispersion in inflation expectations is positively correlated with the inflation expectations as well, the inflation rate, and conditional on current inflation. In addition, this is positively related to higher variance of measured inflation, and so on.

Figure 4: Cross-sectional Dispersion of Public Survey and Actual Inflation



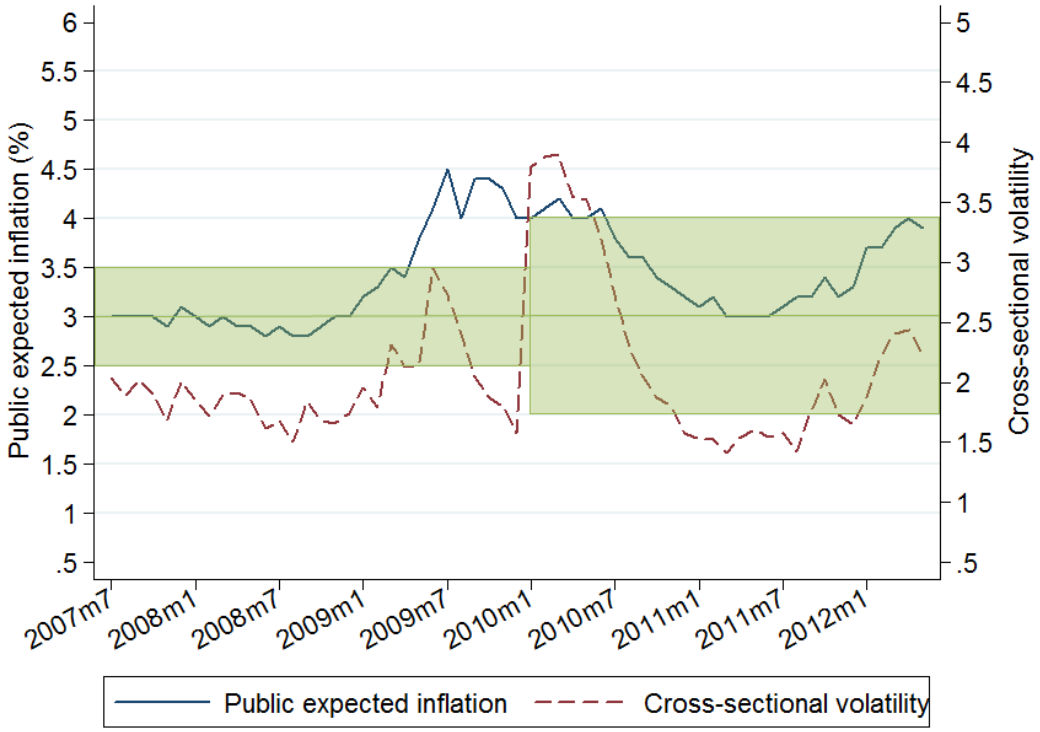
Note: The shaded area is the target range of price stability (CPI inflation rate basis). A dotted line in the shade area is the center line of the target of price stability. Each percentiles is the forecasts of 25th, 50th, 75th percentiles of Korean households, respectively.

households' forecasts, the 75th percentile, produces highly volatile forecasts compared to the other percentiles. This means that the households in the region on the right hand side of the distribution of households' forecasts might update their forecasts more frequently.

On the other hand, the 50th percentile, which is the median of the distribution of households' inflation expectations, shows well-anchored inflation expectations at the inflation target range compared with other percentiles. In case of the 25th percentile tend to usually forecast the future inflation below the inflation target range, and there are periods that households expect price to down for quite some time. This implies that a substantial number of households expect deflation.

When we not take into account for the delay in reacting to the new information or

Figure 5: Cross-sectional Volatility and Expected Inflation of Public Survey



Note: The shaded area is the target range of price stability (CPI inflation rate basis). A dotted line in the shade area is the center line of the target of price stability. The volatility is calculated from the cross-sectional data in BOK public survey on inflation expectations.

inflation shocks, we can interpret the relationship between the cross-sectional dispersion of inflation expectations and the actual inflation rate somewhat differently. To be specific, when the actual inflation rate is high, the degree of the heterogeneity in inflation expectations looks lower, while low level (or stable) of actual inflation rate appears to be associated with higher heterogeneity. That is, the actual inflation rate may be negatively correlated with the degree of heterogeneity in inflation expectations.

Figure 5 displays the cross-sectional volatility (dispersion) and expected inflation rate of the public survey. Not surprisingly, we find that higher inflation expectations is usually associated with higher cross-sectional volatility and lower expectations on inflation is associated with low cross-sectional volatility. That is, the degree of heterogeneity in inflation expectations is positively correlated with the level of inflation

Table 4: Summary Statistics of the Percentiles

Percentile	Mean	Median	Std.D	Variance
1	0.50	0.50	0.00	0.00
3	0.50	0.50	0.00	0.00
5	0.50	0.50	0.00	0.00
10	0.55	0.50	0.27	0.07
20	1.69	2.00	0.79	0.63
35	2.66	3.00	0.51	0.26
47	3.14	3.00	0.51	0.26
48	3.19	3.00	0.51	0.26
49	3.24	3.00	0.50	0.25
50	3.27	3.00	0.49	0.24
51	3.29	3.00	0.46	0.21
52	3.31	3.00	0.46	0.22
53	3.31	3.00	0.46	0.22
65	3.46	3.00	0.54	0.29
80	3.97	4.00	0.64	0.41
90	4.36	4.00	0.63	0.40
95	5.14	5.00	0.81	0.66
97	5.53	5.00	0.81	0.66
99	6.57	6.75	0.53	0.28

expectations.

4.2 Summary Statistics

Table 4 reports the summary statistics of the percentiles of Korean households' inflation forecasts. Not surprisingly, as the percentiles are higher, the mean and median of the percentiles are also higher. In addition, the center region of the distribution of the households' forecasts display lower volatility on average. On the other hand, among the region on the left hand side of the distribution of households' forecasts, 1-9th percentiles shows 0 variance. It means that their forecasts are never changed.

4.3 Persistence Test

In this studies, like the persistence test in the section 3, we apply the variance ratio (VR) test to test the random walk hypothesis for the percentiles of Korean households'

inflation forecasts. We check whether the inflation expectations shows the persistence or mean reversion. We use 1-month as our base observation interval, and test the random walk hypothesis for each of the intervals $q = 3, 6, 9, 12, 15, 18, 21, 24$ months. The test is given by

$$VR_q = \frac{Var(\pi_t^e - \pi_{t-q}^e)}{qVar(\pi_t^e - \pi_{t-1}^e)}$$

where π_t is the CPI inflation, and π_t^e is the public expected inflation. And the null hypothesis is $H_0 : \ VR = 1$. The results for the percentiles are reported in Table 5

Table 5 reports the results of the VR tests under the maintained hypothesis of homoskedasticity for the percentiles. From 1-9 percentiles, the they shows 0 variance the VR test is impossible. We find that almost of all percentile ranges of the distribution of households' inflation forecasts not reject the random walk hypothesis. That is, most households' inflation forecasts follows random walk hypothesis and they use all of available information and then this information is immediately reflected on their forecasts. Only 10-19th percentile forecast rejects the null (five rejections out of the eight cases examined) and its VR are significantly less than 1. On the other hand, 47th percentile forecast show weak rejections (two rejections out of the eight cases examined).

5 Tests of Rationality

The rational expectations hypothesis (originally proposed by Muth (1961) and developed by Thomas J. Sargent and Robert E. Lucas) has widely used by researchers in modeling expectations. Rational expectations hypothesis (hereafter REH) states that although the future is not perfectly predictable, agents' forecasts of the future value of economically relevant variables not yields systematic bias, that is, all errors are random. In order to satisfy the REH, agents' expectations should not be systematically biased (unbiasedness) and use all relevant information in forming expectations (efficiency). In this section, we grasp how much the survey-based inflation expectations has limited rationality, and check whether the survey-based inflation expectations is efficient or not in Korea.

Table 5: The Variance Ratio Test for the Percentiles

Pct.	$q = 2$	$q = 4$	$q = 6$	$q = 8$	$q = 10$	$q = 12$	$q = 14$	$q = 16$
1	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.	.
10	0.538	0.315	0.166	0.149	0.09	0.105	0.078	0.154
	(0.003)***	(0.021)**	(0.029)**	(0.069)*	(0.088)*	(0.152)	(0.144)	(0.277)
20	0.966	0.957	0.874	1.006	0.969	1.15	0.789	1.546
	(0.834)	(0.884)	(0.742)	(0.990)	(0.954)	(0.810)	(0.738)	(0.483)
35	0.802	0.567	0.465	0.48	0.491	0.64	0.42	0.836
	(0.201)	(0.144)	(0.161)	(0.266)	(0.341)	(0.564)	(0.358)	(0.834)
47	0.53	0.449	0.385	0.396	0.33	0.429	0.353	0.724
	(0.002)***	(0.063)*	(0.107)	(0.197)	(0.210)	(0.361)	(0.305)	(0.723)
48	0.834	0.887	0.733	0.72	0.558	0.722	0.593	1.305
	(0.281)	(0.703)	(0.484)	(0.549)	(0.407)	(0.657)	(0.519)	(0.695)
49	1.071	1.244	1.116	0.929	0.709	1.013	0.893	1.954
	(0.647)	(0.410)	(0.761)	(0.880)	(0.586)	(0.984)	(0.866)	(0.220)
50	1.071	1.244	1.116	0.929	0.709	0.928	0.831	1.706
	(0.648)	(0.410)	(0.761)	(0.880)	(0.586)	(0.909)	(0.789)	(0.364)
51	1.071	1.244	1.084	0.904	0.69	0.825	0.758	1.69
	(0.647)	(0.410)	(0.826)	(0.838)	(0.561)	(0.780)	(0.701)	(0.375)
52	1071	1.224	0.995	0.904	0.762	0.91	0.82	1.814
	(0.647)	(0.410)	(0.990)	(0.838)	(0.656)	(0.885)	(0.776)	(0.296)
53	1071	1.224	0.995	0.904	0.762	0.91	0.82	1.814
	(0.647)	(0.410)	(0.990)	(0.838)	(0.656)	(0.885)	(0.776)	(0.296)
65	0.764	0.706	0.647	0.702	0.803	0.95	0.807	1.648
	(0.126)	(0.321)	(0.354)	(0.524)	(0.712)	(0.936)	(0.760)	(0.405)
80	1.007	0.817	0.654	0.69	0.798	0.987	0.721	1.316
	(0.962)	(0.536)	(0.365)	(0.507)	(0.705)	(0.984)	(0.658)	(0.685)
95	0.832	0.684	0.608	0.476	0.57	0.714	0.51	0.914
	(0.275)	(0.285)	(0.304)	(0.263)	(0.420)	(0.647)	(0.437)	(0.912)
97	0.918	0.887	0.993	0.663	0.506	0.602	0.548	1.217
	(0.595)	(0.703)	(0.552)	(0.471)	(0.355)	(0.524)	(0.474)	(0.781)
99	1.076	0.788	0.662	0.597	0.632	0.84	0.543	0.926
	(0.624)	(0.474)	(0.376)	(0.388)	(0.491)	(0.798)	(0.469)	(0.925)

Note: The cross-sectional data of public survey is from 2006:M7 through 2011:M5. For each value are reported in the row and the parenthesis shows p-value for the test statistics. The number of observation of VR(q) is 43. $***/**/*$ denotes significant at 1/5/10 percent level, respectively.

5.1 Motivation of Rationality Tests

Under the rational expectations hypothesis, expectations are identical to the best forecasts of the future economic structure that uses all available information. Moreover, rational expectations hypothesis assumes to have instantaneous and costless accesses to all of the latest economic information or data, and thus all economic agents have identical beliefs and information sets, and therefore forecasts. As a result, people do not make systematic errors in forecasting future economy, and deviations from prefect foresight occur only randomly. Therefore, rational expectations do not differ systematically or predictably from equilibrium results. In an economic model, it assumes that the expected value of an economic variable is equal to the expected value predicted by the model.

However, the rational expectations hypothesis have a problem in relating to aggregate behavior. As we mentioned in section 1 and 2 by ample empirical evidences on inflation and other economic variables, the assumptions of rational expectations are not valid, that is, individual behaviors do not lead to aggregate behavior in real world. In addition, even if all individual economic agents have rational expectations, the representative households may not satisfy the rationality assumptions. Therefore, assuming the rational expectations hypothesis is controversial issue in several economic fields.

Mincer and Zarnowitz (1969) propose methods of evaluating economic forecasts. They classify the forecasts (sets of numerical point predictions) by source (individual or group agents), subject (time series for aggregate economic variables), and span (time from issue to target data). They said that in order for the forecast to be unbiased, the mean value of predictions and the realizations should be equal. If the predictions are uncorrelated with forecast error (the slope of regression equals unity), then the predictions are said to be efficient. They use the MSE[37] as a summary measure. Thus mean component and the slop component are zero for an unbiased and efficient forecast, respectively, and hence, if the predictions are unbiased and efficient, the MSE reduces to the residual variance.

In the foreign exchange market, Baillie, Lippens, and McMahon (1983) test the null hypothesis that the forward exchange rate is an unbiased estimate of the corresponding

[37]MSE includes the variance of the residuals from the regression and reflects the bias and inefficieny of the forecaster, respectively.

future spot exchange rate by using a nonlinear Wald test and found that the rational expectations hypothesis is rejected for all six currencies they considered. They derive the null hypothesis (the forward rate is an unbiased predictor of the future spot rate) under the assumption of rational expectation and risk neutrality. Thus, under the null, the expected rate of return to speculation will be zero. An empirical test of Baillie, Lippens, and McMahon (1983) shows that the joint hypothesis was rejected and this can be interpreted as rejecting rational expectations, or nonzero and time-varying risk premium, or both assumptions are unappropriate.

Chen and Yeh (2002) consider two famous hypotheses in economics and finance, the efficient market hypothesis (EMH)[38] and the rational expectations hypothesis (REH). By applying various econometric tests, they show that the EMH and the REH can be satisfied with some portions of the artificial time series. They said that if all of traders, the collective behavior (macro-behavior), satisfy EMH (or REH), then the behavior of individual traders can be expected to be a feature of the collective behavior, that is, these would be an emergent property. The result of their econometric tests shows that the aggregate results (macro-behavior) are very different from individual behavior (micro-behavior). They think that identifying the EMH and the REH as emergent properties may not seem rigorous, but this way is quite normal in the light of the long-lasting debate on these two hypotheses. This is a first attempt to formally interpret the REH and EMH as an emergent propertie in the artificial stock markets.

Malkiel (2003) define the efficient financial markets as that the investors cannot earn above-average returns without taking above-average risks in the market. He said that the the collective judgment of investors will sometimes make mistakes in the stock market. That is, some investors are obviously not rational. Moreover, the stock market cannot be perfectly efficient, and it result in the pricing irrationalities and even predictable patterns in stock returns. Malkiel (2003) argues that market pricing has not always be perfect and markets have made egregious mistakes (during recent "Internet bubble"). On the other hand, Dockery and Kavussanos (1996) consider the Athens stock market, and examine the behavior of stock prices to assess the market

[38]The EMH is associated with the idea of a "random walk," which means that all subsequent price changes represent random departures from previous prices in a price series. The random walk hypothesis is that there is no delay in all of new information flow, and information is immediately reflected in stock prices. Therefore, it results in that the change in stock prices at next period (tomorrow) cannot be reflected by the current price change, and only will reflect the next period's information, which are unpredictable and random.

efficiency by using well known empirical tests for unit roots in the price series. Their results of Wald test show that random walk hypothesis are overwhelmingly rejected for stock prices, and confirm that the Athens stock market is inefficient and it resulted in the systemical movement of the share prices.

Forsells and Kenny (2002) use the European Commissions Consumer Survey, and assess consumers inflation expectations in the euro area. In order to test the rationality of inflation expectations[39], they first take a test for the bias in the survey of consumers' inflation expectations, that is, they check whether the consumer perfectly forecast the future inflation. Second, they consider the speed of adjustment of current forecast to past forecast errors. This dynamic perspective test assesses the extent to which consumers update their forecasts based on their previous forecast error and the flow of new information to be in line with the fully rational expectations. Finally, they also test the efficiency of consumers' inflation expectations. Under the rational expectations, consumers' expectational errors should not be explained by the information sets that are available at the time when the expectations are formed, including a broad set of macroeconomic indicators such as demand, cost pressure, and monetary and financial conditions. Their results show that the consumers provide an unbiased predictor of one-year ahead time horizon, and revise their expectations in the light of new information. But, their inflation expectations is not fully rational when take into consideration that consumers' forecast errors are not orthogonal with respect to a wide range of macroeconomic information.

Keane and Runkle (1990) also conduct the unbiasedness test and efficiency test, but their results not reject the rationality of individuals' inflation forecasts. This result is unlike most previous studies. They said this result is because "(1) using individual forecasts avoids aggregation bias, (2) comparison of forecasts to initial data avoids bias due to data revision, (3) the professional forecasters have economic incentives to state their expectations accurately, (4) a new covariance matrix estimator consistent when forecast errors are correlated across individuals is used."

Mankiw, Reis, and Wolfers (2004) think that the rational expectations imply statistically efficient forecasting, and it does not yield predictable errors. They conduct simple tests for the rationality in inflation expectations. First test is a test for bias,

[39]Under the rational expectations hypothesis, agents form their expectations based on all the relevant information and their inflation forecasts do not show the systematic errors, but also are unbiased.

regressing the forecast error on a constant. They also test whether there is information in the inflation forecasts can be used to predict forecasting errors, by regressing the forecast error on a constant and inflation expectations. If this regression does not yield predictive power, the inflation expectations will satisfies the rationality. Third test is to ask whether current forecast errors can be forecasted based on the previous forecast errors (persistence test of forecasting errors), by regressing forecast errors at current year on the previous years' forecast errors. Final test is to test whether all of publicly available (macroeconomic) information are fully exploited in forecasting inflation, by regressing forecast errors on recent macroeconomic data, such as Treasury-bill rate, the unemployment rate. Their results of forecast rationality suggest that these survey data (Michigan survey, Livingston survey, and Survey of Professional Forecaster) not fully satisfy some of implications of rationality. Specifically, all survey data show biased inflation forecasts, but the bias is typically small. In addition, inflation forecasts is inefficient in the consumer (Michigan) survey, not professional survey. All survey data show persistent forecasting errors and that the inflation expectations not fully take into account recent macroeconomic information. They conclude that the inflation expectations are consistent with neither the naïveté of adaptive expectations nor the sophistication of rational expectations for all survey data.

5.2 Methodology

As we stated above, in order to satisfy the rational expectations hypothesis forecasting procedure should not yield predictive (systematic) errors. Specifically, in order to check whether the inflation expectations satisfy the rationality, inflation expectations should be unbiased, and have no bias in forecast errors, and fully exploit all of available information. We test rationality in inflation expectations through three simple tests, unbiasedness test of inflation expectations, bias test of expectational errors, and efficiency test of inflation expectations, from following simple regressions.[40]

Unbiasedness tests of inflation expectations.

Let π_t denote actual inflation rate (CPI inflation) at time t, and $\pi_{t|t-12}$ is the inflation forecasts at time $t-12$ for period t. In general, the unbiasedness of inflation

[40]see, for an application, Mankiw, Reis, and Wolfers (2004) and Pfajfar and Santoro (2010)

expectations follows the Mincer and Zarnowitz (1969). A formal test for unbiasedness in the expectations can be carried out using the following equation:

$$\pi_t = \alpha + \beta\ \pi_{t|t-12} + \epsilon_t \tag{1}$$

where ϵ_t is a serially uncorrelated error term. The unbiased inflation forecasts imply accepting the joint null hypothesis, $H_0 :\ \alpha = 0\ and\ \beta = 1$ in a statistical sense.

Bias test of expectational errors.

A test for bias is to check whether inflation expectations centered on the right value. This test is easily conducted by regressing expectational errors on a constant term:

$$\pi_t - \pi_{t|t-12} = \alpha + \epsilon_t \tag{2}$$

where ϵ_t is a serially uncorrelated error term, and if the null hypothesis, $H_0 :\ \alpha = 0$, is not rejected, the expectational errors is not biased. That is, agents not expect to overestimate or underestimate future inflation rate.

Efficiency test of inflation expectations.

Efficiency test of inflation expectations checks whether the available information is fully exploited in forecasting inflation. In the test, we regress the forecast errors on the previous inflation expectations:

$$\pi_t - \pi_{t|t-12} = \alpha + (\beta - 1)\pi_{t|t-12} + \epsilon_t \tag{3}$$

where the null hypothesis is $H_0 :\ \alpha = 0\ and\ \beta = 1$ are jointly satisfied. If we reject the null hypothesis, then the agents not use all of available information when forecast.

5.3 Rationality Tests of General Case

Rational expectations hypothesis states that although the future is not perfectly predictable, agents' forecasts of the future value of economically relevant variables not yields systematic bias, that is all errors are random. In order to satisfy the REH, agents'

inflation expectations should not be systematically biased (unbiasedness) and use all relevant information in forming inflation expectations (efficiency). We test rational expectations hypothesis by using above simple regression model. Under the rationality condition, followings regressions should not have predictive power. In this section, we use the inflation forecasts at time $t-12$ for period t, $\pi_{t|t-12}$, as the public survey and consensus survey. The time series of the public expected inflation and the consensus survey are from 2002:M2 through 2011:M5 and CPI inflation rate (2010=100) is used from 2003:M2 to 2012:M5.

5.3.1 Test of unbiasedness of inflation expectations

The rational expectations on inflation should not yield systematical bias in connection with actual inflation of the future, that means that on average, they do not expect to overestimate or underestimate future inflation rate (next 1 year inflation rate). In general, the unbiasedness of inflation expectations follows the Mincer and Zarnowitz (1969) and is valid when accepts the null hypothesis of rationality. Eq.(1) tests unbiasedness of inflation expectations.

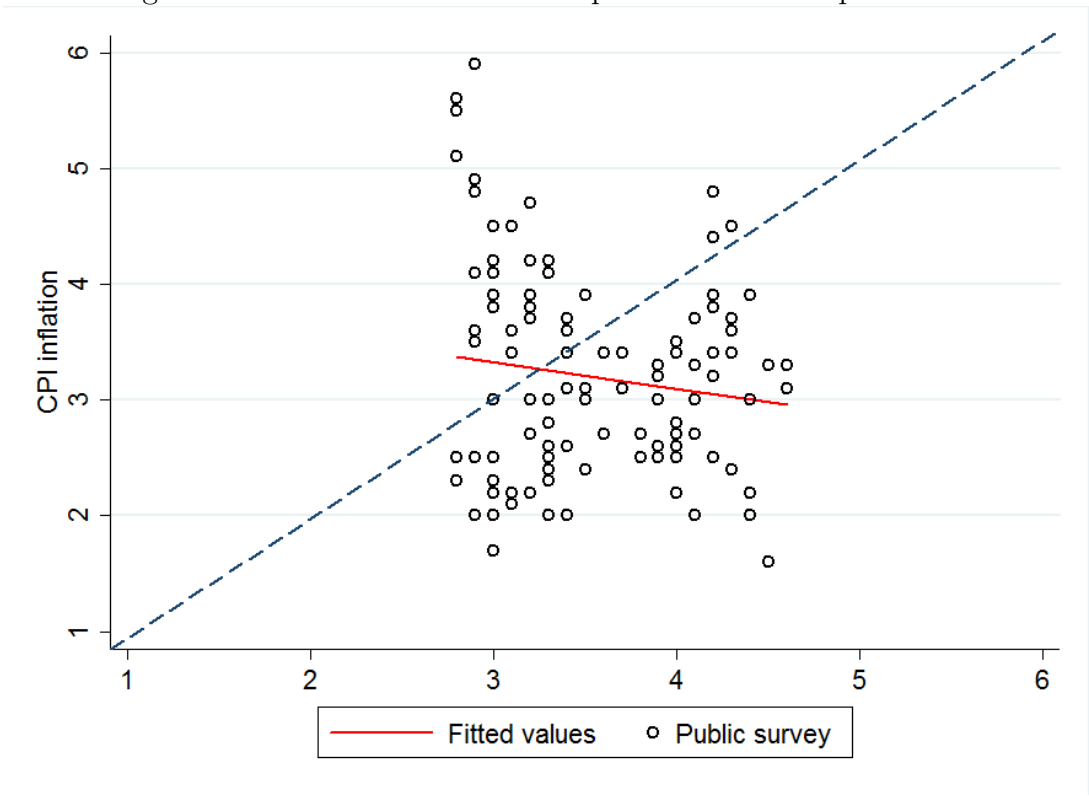
Table 6: Unbiasedness test of inflation expectations (Mincer and Zarnowitz, 1969)

	$\hat{\alpha}$	Std.err	t-stat	$\hat{\beta}$	Std.err	t-stat	F-stat
Public survey	4.014	0.556	7.22	-0.229	0.156	-7.904	39.06***
Consensus survey	6.066	0.614	9.89	-0.938	0.199	-9.72	49.13***

Note: The Newey-West HAC standard error (Newey and West, 1987) is similar with the standard error of the least square estimation and deduces the same conclusion. $***/**/*$ denotes significant at 1/5/10 percent level, respectively.

The results of simple regression based Eq.(1) show whether the expected inflation of public and consensus professionals are unbiased. These findings reported on F-test in Table 6 show that two survey data reject the rational expectations hypothesis (unbiasedness), and so we cannot assume that the inflation expectations are unbiased in both survey data. In addition, both survey data show that the constant term, $\hat{\alpha}$, is higher than 0 and expected inflation term $\hat{\beta}$ is negative. On the other hand, the expected inflation term, $\hat{\beta}$, are significantly very different with the null hypothesis, $H_0: \ \alpha = 0 \ and \ \beta = 1$. This finding is anomaly, and we interpret this as the view

Figure 6: Unbiasedness test of the public inflation expectations



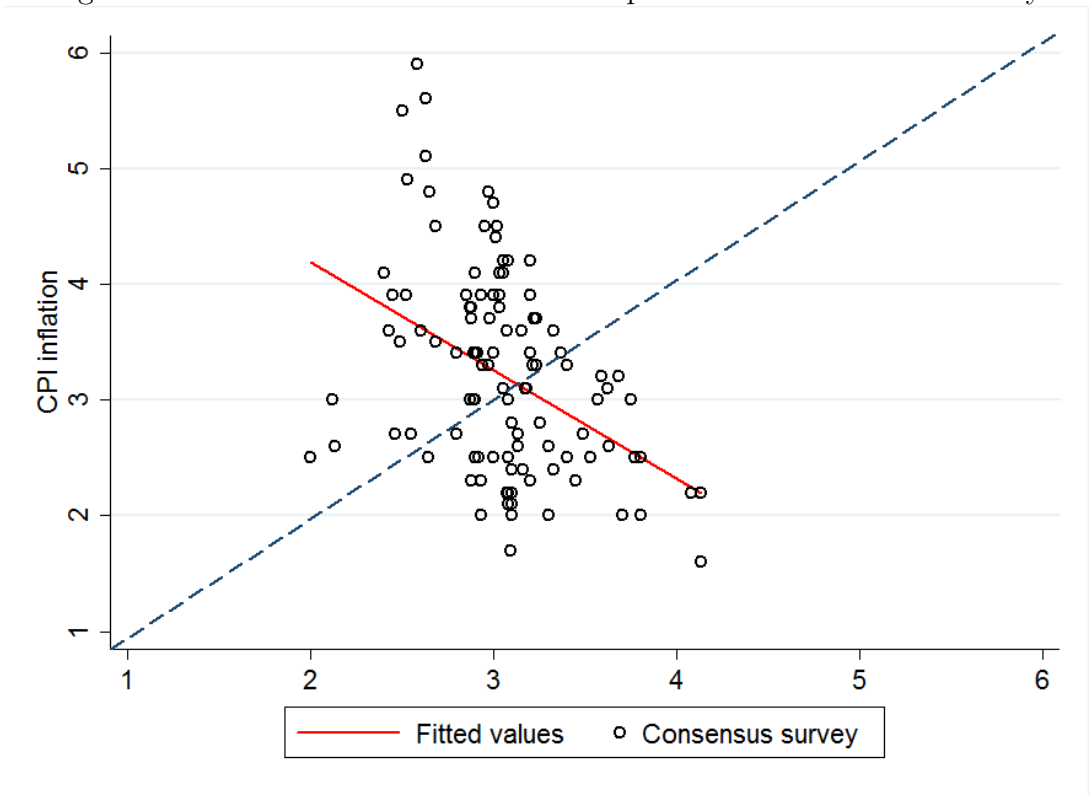
Note: The time series of the public expected inflation is from 2002:M2 through 2011:M5 and CPI inflation rate (2010=100) is used from 2003:M2 to 2012:M5. A dotted line is the regression line in case of satisfying the unbiasedness.

that expected inflation in next year is negatively correlated with the actual inflation in next year. Figure 6 and Figure 7 also shows that the public predictions of inflation rate are biased. Around the dotted line, which means the regression line in case of satisfying the unbiasedness, the actual data diverse. In addition, we also can find that the expected inflation of the public survey is higher than that of the consensus survey.

5.3.2 Test of bias of expectational errors

To determine whether the bias of expectational errors are statistically significant, we implement the t-test on the constant term α. This simple equation is equivalent to the equation of unbiasedness test of Mincer and Zarnowitz (1969) with the restriction

Figure 7: Unbiasedness test of inflation expectations of consensus survey



Note: The time series of the consensus survey on expected inflation is from 2002:M2 through 2011:M5 and CPI inflation rate (2010=100) is used from 2003:M2 to 2012:M5. A dotted line is the regression line in case of satisfying the unbiasedness.

that $\beta = 1$. Eq.(2) checks whether inflation expectations are centered around the right value.

The public survey in Table 7 shows that coefficient of $\hat{\alpha}$ is -0.332, negative value. That means that the public tend to overestimate the future inflation level on average and the p-value for the null is 0.002, and thus the bias of expectational errors is statistically significant at the 1% level. In this test, actually the expectational errors of the expected inflation have a serial correlation, but we don't need to interpret this fact as lack of rationality because there are overlapping nature of the data between the current term expectational errors and the prior term expectational errors by the definition of expectational errors. On the other hand, the consensus survey shows the positive constant term, but it is not significant. Therefore, we cannot reject the null hypothesis, $H_0 : \ \alpha = 0$, and thus there is no serial correlation in the expectational

Table 7: Test of bias of expectational errors

	$\hat{\alpha}$	Std.err	t-stat
Public survey	-0.332	0.1047	-3.17^{***}
Consensus survey	0.151	0.1050	1.44(0.153)

Note: The Newey-West HAC standard error (Newey and West, 1987) is similar with the standard error of the least square estimation and deduces the same conclusion. The parentheses is a p-value, and $***/**/*$ denotes significant at 1/5/10 percent level, respectively.

errors.

5.3.3 Test of efficiency of inflation expectations

The efficiency of expected inflation means that all of the information that are available at the time of expectations formation should be already fully exploited on forming inflation expectations, and thus the expectational errors must not be explained by the information that are available at the time of expectations formation. Eq.(3) can test whether the available information is fully exploited.

Table 8: Test of efficiency of inflation expectations

	$\hat{\alpha}$	Std.err	t-stat	$\widehat{\beta-1}$	Std.err	t-stat	F-stat
Public survey	4.014	0.556	7.22	-1.229	0.156	-14.334	1163.91^{***}
Consensus survey	6.066	0.614	9.89	-1.938	0.199	-2.956	812.02^{***}

Note: The Newey-West HAC standard error (Newey and West, 1987) is similar with the standard error of the least square estimation and deduces the same conclusion. $***/**/*$ denotes significant at 1/5/10 percent level, respectively.

Table 8 reports the result of simple regression Eq.(3). The result suggests that the inflation expectations not satisfy the efficiency conditions of information in the public and consensus survey data. That means that both the public agent and consensus professionals do not use all of information that are available at the time of expectation formation, and thus current expectational errors are affected by the prior expectations on inflation. In addition, the $\hat{\beta-1}$ is negative in both survey data, and so we can say that there is negative correlation between the information of previous inflation

expectations and the current expectational errors. Consequently, we can say that this results imply that the Korean expected inflation index based on the survey is not efficient.

In sum, the public survey fails to satisfy all of the implications of rationality. There exists bias and the expectations is not efficient, and the the expectational errors show a serial correlation. And, the public tends to over-predict the future inflation rate. On the other hand, the consensus survey satisfy the bias test of expectational error, but their forecasts are inefficient and biased. Thus, the consensus survey is said to have limited rationality.

5.4 Rationality Tests of Percentile Case

In this section, we focus on the cross-section of public forecasts and employ the percentile time series models (Pfajfar and Santoro, 2010), and thus compute monthly time series for each percentiles. We use the cross-sectional data in the public survey on the expected inflation from 2006:M7 to 2011:M5. Likewise the rationality test in the general case, in order to satisfy the REH, agents' inflation expectations should not be systematically biased (unbiasedness) and use all relevant information in forming inflation expectations (efficiency). Under the rationality condition, followings regressions should not have predictive power. We estimate following simple regression equations for all percentiles, and we use the inflation forecasts at time $t-12$ for period t, $\pi_{t|t-12}$, as the cross-sectional data of the public survey.

5.4.1 Test of unbiasedness of inflation expectations across the percentiles

We follows the Mincer and Zarnowitz (1969) for the unbiasedness test across the percentiles as well, and in order to satisfy the unbiasedness conditions, households' inflation expectations should not yield systematical bias. In the Eq.(4), unbiasedness condition is valid when accepts the null hypothesis of rationality.

$$\pi_t = \alpha + \beta\ \pi^k_{t|t-12} + \epsilon_t \tag{4}$$

Table 9: Unbiasedness test for the percentiles (Mincer and Zarnowitz, 1969)

Percentile	$\hat{\alpha}$	Std.err	t-stat	$\hat{\beta}$	Std.err	t-stat	F-stat
1	3.453	0.127	27.25	omitted	(collinearity)	.	742.36***
3	3.453	0.127	27.25	omitted	(collinearity)	.	742.36***
5	3.453	0.127	27.25	omitted	(collinearity)	.	742.36***
10	3.225	0.287	11.23	0.412	0.468	-1.26	261.97***
20	3.919	0.296	13.25	-0.275	0.158	-8.05	131.99***
35	5.542	0.621	8.93	-0.785	0.229	-7.79	53.45***
47	7.094	0.643	11.04	-1.161	0.202	-10.68	61.85***
48	7.434	0.621	11.96	-1.249	0.193	-11.68	71.97***
49	7.474	0.644	11.62	-1.242	0.196	-11.41	67.55***
50	7.485	0.693	10.80	-1.233	0.210	-10.66	58.39***
51	7.472	0.767	9.74	-1.222	0.231	-9.61	47.44***
52	7.481	0.754	9.93	-1.219	0.226	-9.82	49.27***
53	7.481	0.754	9.93	-1.219	0.226	-9.82	49.27***
65	7.113	0.684	10.39	-1.059	0.196	-10.52	55.38***
80	7.180	0.632	11.36	-0.940	0.157	-12.32	89.06***
95	6.593	0.709	9.29	-0.611	0.136	-11.82	188.28***
97	6.270	0.803	7.81	-0.509	0.144	-10.51	217.06***
99	7.204	1.513	4.76	-0.571	0.230	-6.84	353.54***

Note: The Newey-West HAC standard error (Newey and West, 1987) is similar with the standard error of the least square estimation and deduces the same conclusion. $***/**/*$ denotes significant at 1/5/10 percent level, respectively.

where π_t denotes actual inflation at time t, and $\pi^k_{t|t-12}$ is k th percentile from the distribution of the public inflation forecasts at time $t-12$ for period t, while ϵ_t is a serially uncorrelated error term. The null hypothesis is that $H_0: \ \alpha = 0 \ and \ \beta = 1$ are jointly satisfied.

Table 9 reports that the result of the regression based on equation (4). This result shows that all of the percentiles of households' forecasts on future inflation rate are biased. That is, we reject the null of unbiasedness condition for all percentiles. In addition, like unbiasedness test for the general analysis case, the constant term $\hat{\alpha}$ is higher than 0 and expected inflation term $\hat{\beta}$ is negative except for only 10th percentile. We interpret this as the view that expected inflation in next year is negatively correlated with the actual inflation in next year for almost percentiles. Especially, the expected term β of 46th-65th percentiles and 81st-86th percentiles is less than -1. These find-

ings are also anomaly. On the other hand, 1st-9th percentiles shows collinearity, thus expected inflation terms are omitted.

5.4.2 Test of bias of expectational errors across the percentiles

The second test for the rationality is the test of bias of expectational errors which checks whether the forecast errors are statistically significant. We implement the t-test on the constant term α for the percentiles.

$$\pi_t - \pi^k_{t|t-12} = \alpha + \epsilon_t \tag{5}$$

where where π_t denotes actual inflation at time t, and $\pi^k_{t|t-12}$ is k th percentile from the distribution of the public inflation forecasts at time $t-12$ for period t, and the null hypothesis is $H_0: \ \alpha = 0$.

Table 10 shows that only the 48th-75th percentile range is not biased. That is, the bias of expectational error is statistically significant except for the 48th-75th percentile range. To be specific, the bias of expectational error of the 1st-45th and 80th-99th percentile range is significant at 1 percent level of significance, and the rest of percentile range is significant at 1(5)percent level of significance. We find that the 1st-47th percentile ranges tend to underestimate the future inflation level, while 76th-99th percentile rages tend to overestimate the future inflation level.

5.4.3 Test of efficiency of inflation expectation across the percentiles

In order to satisfy the efficiency of expected inflation, the expectational errors cannot be explained by the information that are available at the time of expectation formation. Equation (6) can test whether the available information is fully exploited for the percentiles.

$$\pi_t - \pi^k_{t|t-12} = \alpha + (\beta - 1)\pi^k_{t|t-12} + \epsilon_t \tag{6}$$

Table 10: Test of bias of expectational errors for the percentiles

Percentile	$\hat{\alpha}$	Std.err	t-stat
1	2.953	0.127	23.30^{***}
3	2.953	0.127	23.30^{***}
5	2.953	0.127	23.30^{***}
10	2.902	0.128	22.74^{***}
20	1.758	0.181	9.73^{***}
35	0.792	0.166	4.77^{***}
47	0.317	0.175	1.81^{*}
48	0.266	0.177	1.50
49	0.215	0.176	1.22
50	0.181	0.173	1.05
51	0.164	0.168	0.98
52	0.147	0.169	0.87
53	0.147	0.169	0.87
65	-0.005	0.177	-0.03
80	-0.514	0.190	-2.70^{***}
95	-1.692	0.202	-8.36^{***}
97	-2.081	0.197	-10.59^{***}
99	-3.119	0.162	-19.20^{***}

Note: The Newey-West HAC standard error (Newey and West, 1987) is similar with the standard error of the least square estimation and deduces the same conclusion. $***/**/*$ denotes significant at 1/5/10 percent level, respectively.

where where π_t denotes actual inflation at time t, and $\pi^k_{t|t-12}$ is k th percentile from the distribution of the public inflation forecasts at time $t-12$ for period t. The null hypothesis is $H_0: \ \alpha = 0 \ and \ \beta = 1$ are jointly satisfied.

The regression based on Eq.(6) is reported in Table 11. We reject the null hypothesis for all percentiles. This implies households do not fully exploit all of the information in forming inflation expectations. In addition, the constant term $\hat{\alpha}$ is higher than 0, but expected inflation term $\hat{\beta}$ is negative. Especially the expected term $\hat{\beta}$ of almost all percentiles are less than -1. This finding is also anomaly.

In sum, most percentiles of the distribution of households' inflation expectations are not rational. All of the percentiles make biased inflation forecasts and their forecasts are inefficient. That is, all percentiles do not use all of information when forecast. Only 45th-75th percentiles show that their expectational errors is unbiased. Therefore, we

Table 11: Test of efficiency for the percentiles

Percentile	$\hat{\alpha}$	Std.err	t-stat	$\widehat{\beta-1}$	Std.err	t-stat	F-stat
1	2.953	0.127	23.30	omitted	(collinearity)	.	542.91***
3	2.953	0.127	23.30	omitted	(collinearity)	.	542.91***
5	2.953	0.127	23.30	omitted	(collinearity)	.	542.91***
10	3.225	0.287	11.23	-0.588	0.468	-3.395	177.19***
20	3.919	0.296	13.25	-1.275	0.158	-14.370	103.37***
35	5.542	0.621	8.93	-1.785	0.229	-12.153	202.82***
47	7.094	0.643	11.04	-2.161	0.202	-15.167	505.46***
48	7.434	0.621	11.96	-2.249	0.193	-16.871	595.98***
49	7.474	0.644	11.62	-2.242	0.196	-16.504	611.75***
50	7.485	0.693	10.80	-2.233	0.210	-15.428	588.60***
51	7.472	0.767	9.74	-2.222	0.231	-13.929	542.24***
52	7.481	0.754	9.93	-2.219	0.226	-14.253	562.60***
53	7.481	0.754	9.93	-2.219	0.226	-14.253	562.60***
65	7.113	0.684	10.39	-2.059	0.196	-15.637	677.73***
80	7.180	0.632	11.36	-1.940	0.157	-18.676	1172.63***
95	6.593	0.709	9.29	-1.611	0.136	-19.161	2117.28***
97	6.270	0.803	7.81	-1.509	0.144	-17.475	2318.91***
99	7.204	1.513	4.76	-1.571	0.230	-11.201	3249.01***

Note: The Newey-West HAC standard error (Newey and West, 1987) is similar with the standard error of the least square estimation and deduces the same conclusion. $***/**/*$ denotes significant at 1/5/10 percent level, respectively.

can say that only 45th-75th percentiles have limited rationality.

6 Concluding Remarks and Future Research

This paper considers the Korean inflation expectations, and applies the percentile time series model (Pfajfar and Santoro, 2010) in order to assess the heterogeneity in Korean households' inflation expectations. We focus on the weighted mean value using the median of survey response intervals as the central tendency, and the interquartile ranges as a measure of the degree of the heterogeneity (disagreement; cross-sectional dispersion). We use three survey data, the public survey and professional survey conducted by the Bank of Korea, and Consensus professional survey conducted by Consensus Economics.

We find that all survey data on inflation expectations show similar movement with actual (CPI) inflation rate with somewhat different volatility and persistence. And all survey on inflation rate fail to perfectly account for the inflationary pressure and shows a consistent delay in reacting to the inflation shock or new information during overall period. In addition, the consensus survey shows the more accurate predictions compared with the public survey and the professional survey. On the other hand, we find that the core inflation rate is more volatile than the CPI inflation rate. This finding is abnormal phenomenon. We suggest that when if we use both "exclusion" measure and other approaches of measuring underlying inflation rate, this phenomenon can be solved. And the professional survey show the most persistent inflation expectations, followed by the consensus professional survey. This is not consistent with the general idea that the professionals are usually regarded as nearly rational agents and update their information set and revise their forecasts more frequently than those of the general public. As to rationality test, the households show the biased forecasts and their process of the expectations formation is not efficient. The results of the rationality tests also show the abnormal phenomenon that the constant term is higher than 0, but expected inflation term is negative. On the other hand, the consensus survey satisfy the bias test of expectational errors, but their forecasts are inefficient and biased. Therefore, we can conclude that the households' inflation expectations is not rational, while the consensus survey shows limitedly rational expectations.

In order to check how much heterogeneity in inflation expectations exists, we explore the time series of percentiles by using the public cross-sectional data. We find all of the region of the distribution of households' forecast show a delay in reacting to the inflation shocks. This finding is in line with the general analysis case. Not surprisingly, higher inflation expectations are usually associated with higher volatility and lower expectations on inflation are associated with low volatility. In addition, almost of all the percentile ranges of distribution of households inflation forecasts follow the random walk hypothesis. In the rationality tests of percentile time series analysis, we also find the anomaly that the constant term is higher than 0, but expected inflation term is negative. Only the 48th-75th percentile range is not biased, that is not shows systematical forecast errors and the 1st-64th percentile range underestimates the future inflation level, and the 76th-99th percentile rage overestimates the future inflation level. We also find that households don't fully exploit all of the information on forming

inflation expectations.

In this studies, we notice several abnormal phenomena. First is the core inflation rate is more volatile than CPI inflation rate (headline inflation rate). Second is the expected inflation term negatively affects the actual inflation and forecast error in unbiasedness test and efficiency test of rationality test. We suggest that this results imply that the Korean expected inflation index based on the survey is not efficient. Therefore, we need more in-depth studies about the mismeasurement of expected inflation rate, examining the way to improve the survey index, and the process of the inflation expectations formation. For example, one is to adjust the response intervals in the survey. The current response intervals have an lower bound (-0.5%) and upper bound (8.0%), and asymmetric response distribution. In addition, the Korea exclude the responses both "do not know" and the "expect price to down or stay the same" in the survey data. This may not desirable because excluding the response is to disregard the households' forecasts that expect price to down or stay the same.

Furthermore, the monetary policy maker is considered to more pay attention to the stability of inflation expectations. We find that actual inflation rates and the expected inflation rate have been off the target range several times. Thus, we think that the central bank has a serious credibility problem. We consider this credibility problem is due to insufficiency of the necessary conditions for inflation targeting. Thus, the central bank should communicate with the public more frequently and make the public understand of an operation of the inflation targeting to strengthen the credibility of monetary policy. We propose that communicating with various different demographic groups by different ways may help to well anchor inflation expectations around the inflation target. In addition, now the Korea conduct short-term (next a year) and long-term (next 5 year) inflation expectations survey. However, In Korea there is no household's long-term expected inflation survey, and only the professional's long-term (5-year ahead) expected inflation survey started after 2011Q1. It is very important to maintain stable mid-to long-term expected inflation for price stability, and hence we need to further study mid-to long-term expected inflation which is not dealt in this paper due to the data constraints

In conclusion, we find that the short-run (survey-based) Korean inflation expectations is not rational, but also not efficient. In addition, the households' expected inflation shows some degrees of the time-varying heterogeneity. For the future research,

we first investigate the heterogeneity in the process of the inflation expectations formation, which can not be explained by the rational expectations model. We will use the 'sticky information model' (Mankiw and Reis, 2002; Carroll, 2003) or 'Adaptive learning model' (Evans and Honkapohja, 2001), and thus analyze the origin of heterogeneity in the process of inflation expectations formation. Second, we are interested in proposing a better measure of expected inflation survey. For this study, we need more in-depth studies about the mismeasurement of expected inflation, and also examine the way to improve the survey index of expected inflation taking into account for the heterogeneity in inflation expectations, and the performance of inflation targeting framework. Finally, we want to propose a better inflation forecasting model. The Korea only use the survey-based expected inflation rate, as the expected inflation measure. In addition, we believe that the long-term inflation forecasts is as important as the short-term inflation forecasts in the mid-term inflation targeting system. Therefore, we will study for proposing a long-term (and also short-term) inflation forecasting model, and furthermore, suggest a better inflation forecasting model that has higher predictive power. We sure that our study will make a significant contribution to the Korean inflation targeting framework, but also possibly have important macroeconomic implications of monetary policy.

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