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An Analysis of Inflation Expectations of the Turkish Private Manufacturing Industry

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Abstract

The main purpose of this paper is to make a detailed analysis of the quantified expected inflation series obtained from the Business Tendency Survey conducted by the Central Bank of the Republic of Turkey. Different representations of simple expectation formation mechanisms that appeared in the literature are discussed in the context of Turkey. In selecting the most appropriate mechanism, instead of an *ad hoc* and an arbitrary methodology, nested hypotheses and the sequential testing procedure are applied. A general first order extrapolative mechanism is found as a result of this procedure. But, the selected mechanism is far from being satisfactory. Therefore, a new augmented model, in which one lag of inflation, exchange rate, private sector capacity utilization rate, stock evaluations of the last three months and average cost expectations of the next three months are employed as explanatory variables, is proposed. Finally, taking into account problems regarding the tests of rationality, efficiency and orthogonality tests are carried out. As a result of these tests, rationality assumption cannot be rejected very powerfully. However, this is not stemmed from the accuracy of the expectations, but from the structure of the economy that precludes accurate short-term forecasting.

JEL Classification Numbers: C19, E31, D84
Keywords: Quantification; Sequential Testing Procedure; Formation of Inflation Expectations; Rationality.

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1. Introduction

Although, expectations have begun to play a key role in a wide variety of economic models beginning from the early 1930s, it was not modeled explicitly until the 1950s. Adaptive expectations hypothesis (AEH), introduced by Cagan (1956) was the first attempt to form an endogenous expectations formation mechanism. Here, expectations formation mechanism is defined as the specification of a rule by which individuals revise their expectations in the light of new information. In the 1960s and 1970s, AEH played a prominent role in macroeconomics. Then, after the papers of Lucas (1972) and Sargent (1973), rational expectations hypothesis (REH) influenced every branch of macroeconomics deeply and today it is nearly the standard approach to the expectations formation. Since policy implications of macroeconomic models depend on to a large extent assumptions about the expectations formation, it is important to test for the validity of these two hypotheses.

In the literature, quantified expected inflation series have been used extensively[1] following Carlson and Parkin's (1975) seminal work in testing which hypothesis describes the real data best. Following this conventional methodology, this paper aims at a detailed discussion about the validity of simple expectations formation mechanisms and REH utilizing quantified inflation series obtained from the Business Tendency Survey (BTS) conducted by the Central Bank of the Republic of Turkey (CBRT). In the post 2000 period, Turkish economy has experienced two major policy changes. Therefore, the paper also discusses some limitations resulting from these policy changes in testing validity of simple expectations formation mechanisms and REH.

The remainder of this paper is organized as follows: In Section 2, data is introduced and methodological problems resulting from conversion of qualitative responses into quantitative measures of inflation expectations are considered. In Section 3, simple models of expectations formation are tested using sequential testing procedure, and then a more satisfactory model that is not just related with past history of inflation or inflation expectations is proposed. In Section 4, basic postulates of rational expectationss hypothesis are discussed and some tests of REH are carried out. The last section summarizes the results.

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[1] For a brief literature review, see Grand and Thomas 1999.

2. Data

Beginning from the last month of 1987, the BTS has been conducted monthly by the CBRT. In BTS, various questions related with orders, stocks, costs, production, selling prices, inflation and interest rates are designed to allow respondents to evaluate past a few months (generally three), and to express their expectations over the next three months. Questions are generally of qualitative type, and respondents are asked to answer in one of "rise", "the same" or "fall" form. Besides qualitative questions, there are five questions asking for an ordering of several factors, and four asking for a quantitative value of credit interest rates and inflation expectations. The sample is chosen on the basis of Istanbul Chamber of Industry's ranking of the biggest 1000 firms. Since respondents are from private sector covering all the major manufacturing sub-sectors, in the study the inflation expectations is referred, hereafter, to the inflation expectations of private manufacturing industry.

The BTS consists of three questions on inflation expectations, one for the next three month's inflation expectations in standard qualitative form and the other two for quantitative estimates of the year-end and the next twelve months' inflation expectations respectively. Although, working with direct inflation expectations is very advantageous, as we shall see, we are limited with insufficient number of observations in using these three series, since the first one was added to the survey in May 1997, and the others were in January 1999. Therefore, we are only left with the question asking average selling price expectations of each respondent's product basket over the next three months[2] as an estimate of his inflation expectation.

Sampling frequency (monthly) of the question is different from the forecast horizon (three months), therefore using monthly data causes serial correlation in the error terms. Formally, let ${}_{t-3}w_t$ be the forecast error made at the end of $(t-3)$ for the end of next three months (t). Under the null hypothesis that the survey respondents' forecasts are unbiased and efficient, ${}_{t-3}w_t$ can be decomposed into unobserved monthly components:

$$ {}_{t-3}w_t = {}_{t-3}w_t^m + {}_{t-3}w_{t-1}^m + {}_{t-3}w_{t-2}^m \qquad (1) $$

where ${}_{t-3}w_{t-i}^m$ is the unobserved forecast error made at the end of the month $(t-3)$ for the month $(t-i)$, $(i=0,1,2)$. Under the null hypothesis stated above, only

[2] Original form of the question is: (Trend of the next 3 months) Average price for the new orders received from the domestic market (excluding seasonal variations).

${}_{t-3}w^{m}_{t-2}$ is likely to be a white noise process, and the remaining two terms in (1) cause serial correlation.

In order to solve the overlapping intervals problem, we have ignored overlapping months from the sample, similar to Bryan and Gavin (1986), so that consistency has maintained between the sample frequency and the forecast horizon.[3]

Although selected quantification method may have important effects on the results concerning expectations formation mechanisms and rationality, we have not expanded this discussion here since it has already been discussed in detail in Oral (2002), Ogunc et al. (2004), and Uygur (1989). At this stage, we use the Carlson and Parkin's (CP) methodology in order to obtain a time series of the expected inflation rates (P_t^e). In this methodology, it is assumed that firms do not expect any change in their product prices if their actual price changes lie within a certain interval ($-\delta$, δ), which is called as indifference interval. Then, the conversion is based on the subjective probability approach that can be summarized in the following equations.

$$P_t^e = \hat{\delta}\left(\frac{a_t + b_t}{b_t - a_t}\right) \tag{2}$$

where $\Phi(a_t) = 1 - A_t$, $\Phi(b_t) = B_t$ and $\hat{\delta} = \sum_{t=1}^{T} P_t \Big/ \sum_{t=1}^{T}\left(\frac{a_t + b_t}{b_t - a_t}\right)$

The percentage of the firms that expect a rise and a fall in their prices for the next three months is denoted by A_t and B_t respectively.[4] $\Phi(\cdot)$ refers to the cumulative distribution function for the selected form of distribution of expected inflation across the population. Finally, a_t and b_t can be derived from the inverse cumulative distribution function of the selected distribution. We have used three different statistical distributions: Uniform, Normal and Logistic. Though all distributions have given good results, the uniform distribution has yielded the best

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[3] Hansen (1982) proposes another procedure to avoid the problem in cases for which the forecast horizon is longer than the sample frequency. The methodology involves using OLS but making appropriate modifications in the estimation of the asymptotic covariance matrix. Though this methodology is superior in terms of gaining degree of freedom, we have preferred to drop the overlapping months from the sample, which is intuitively simpler.

[4] In this formula, it is assumed that the upper and lower boundaries of the indifference interval have the same absolute value. For the asymmetric indifference interval case, the formula can be rewritten as $P_t^e = \hat{\delta}_m\left(\frac{a_t}{a_t - b_t}\right) + \hat{\delta}_p\left(\frac{-b_t}{a_t - b_t}\right)$

result in the sense that contemporaneous correlation with the actual inflation rates is the highest. Therefore, in the rest of the study quantified expectations series obtained by this method is employed.

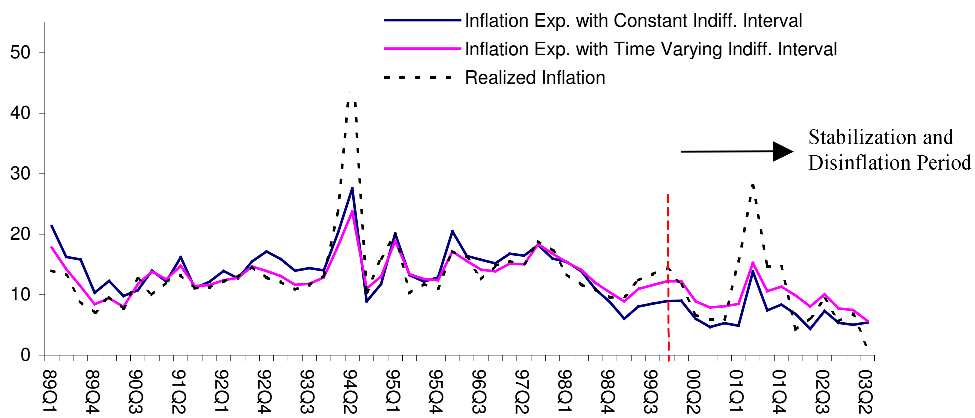
Additionally, we have relaxed the CP's restrictive assumption that indifference interval is symmetric and constant over the whole period, so that the upper and lower boundaries of the indifference interval are allowed to vary over time ($\delta_{m,t}, \delta_{p,t}$). Asymmetric and time varying estimate of the indifference interval is achieved via adaptive Kalman filter (see Appendix B.1).[5] As a result, two expectations series are derived, one from the original CP methodology with constant and symmetric indifference interval ($P_t^{e(c)}$) and the other from the extension of it that permits time varying and asymmetric indifference intervals ($P_t^{e(v)}$) (see Table A.1 in the Appendix A.1). In the rest of the study, in order to see how sensitive the results concerning expectations formation and rationality are to the selected quantification method, we employed both $P_t^{e(c)}$ and $P_t^{e(v)}$ series, but we have only reported test results obtained from $P_t^{e(c)}$ unless results did not indicate a significant difference.

We have omitted a few observations from beginning period of the survey in order to prevent any bias that may come from misunderstanding of the question or the forecast horizon by the respondents, late coming and similar issues. We have also excluded the period after the disinflation program of the year 2000. In order to explain the reasoning behind this decision, we need to make an early discussion of the logic behind the simple expectations formation mechanisms and REH. Firstly, when we consider the definition of expectations formation mechanism given in the introduction, it is clear that agents need more or less a stable economic environment in order to be able to form a specification of a rule by which they can revise their expectations in the light of the new information. However, the period we have excluded contains two-sub periods that represent different major policy changes. The first sub-period excluded is characterized by crawling peg exchange rate regime ends at February 2001, and the second sub-period -after February 2001- covers the floating exchange rate and implicit inflation-targeting regime. Although, econometrically it is hard to describe expectations formation mechanisms of these two sub-periods due to limited number of observations, we expect that the rule agents used in their expectations formation differentiates significantly. Therefore,

[5] See Seitz (1988), Smith and McAleer (1995) and Nardo (2003), for the use of asymmetric and time varying estimate of the indifference intervals.

taking the period 1989:Q4-2003:Q2 as a whole will probably lead to get a quite blur picture of the expectations formation. This may also be problematic in terms of rationality tests. In the test of rationality, unless you have a good mathematical representation of the true inflation generating process, which means that agents could learn the structure of the model properly, the power of your rationality test is low. It should be emphasized also that the REH assumes that agents converge to the true model by time with no systematic errors. But for the reasons mentioned above, it is difficult to give a good mathematical representation of the inflation generating process for the post 2000 period, so a probable test of the rationality may not be very meaningful for this period. As a result, we have worked with the period 1989:Q4-1999:Q4. In this period, both $P_t^{e(c)}$ and $P_t^{e(v)}$ are stationary at one percent of significance level according to ADF test results (Appendix C.1).

Fig. 1. Inflation Expectations and Realized Inflation



When we look at the expected and realized inflation rates (Figure I), they move generally together. However, as seen from the graph, $P_t^{e(c)}$ series are mostly over the realized values. A possible explanation can be the following. A significant underestimation of inflation in the second quarter of 1994[6] may result in higher estimations in other periods since the scaling parameter is determined with the assumption of equal change in inflation expectations and actual inflation over the sample period. Less likely, the respondents may be generally pessimistic about short-term inflation expectations.

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[6] In the second quarter of the 1994, Turkey experienced a deep financial crisis after which year-end wholesale price index rose by 149 percent, and GNP declined by 6 percent.

3. Sequential Testing of General Models of Expectations Formation

Simple models of expectations formation can be broadly classified as "extrapolative" and "adaptive" expectations. The first one is based on the idea that variations in expected inflation rate are simply explained by the past rates of inflation. On the other hand, under the latter, expectations are assumed to follow an error-learning process, which means that they adjust in proportion to the recorded errors. Although, these models are not very realistic in the sense that they do not take into account any variables other than past history of inflation and inflation expectations, they still need to be investigated in order to see whether people think in a simple manner as assumed by the models. Therefore, in this part of the paper we will concentrate on various representations of simple expectations formation processes, and try to see how well they perform empirically.

In the literature different *ad hoc* criteria, such as goodness of fit, economic sensibility or generality of the model are taken into the consideration in deciding on which model is better among the alternatives. However, as Mills (1981) states "*ad hoc* and arbitrary methodology for model selection and hypothesis testing is inadequate for obtaining the most appropriate mechanism generating the derived inflation series". Following his suggestion, we applied the sequential testing procedure that is originally proposed by Mizon (1977).

This procedure starts with a number of different models of extrapolative and adaptive mechanisms as shown in Table A.2 (see Appendix A.1). In the table, from F(1) to F(8) and F(9) to F(18) are different extrapolative and adaptive mechanisms, ordered from simple to general, which can be nested in F(8) and F(16) respectively. In the table, the most general expectations formation mechanism is F(19) within which, all the other can be nested. Since there is no unique ordering from F(1) to F(19), a complete list of nests is given in Table A.3 (see Appendix A.1). The procedure starts with the most general mechanism (unrestricted) of each nest. It is tested against the second most general (restricted) one by putting necessary restrictions that equate two mechanisms to each other. If the restrictions are accepted jointly, it means that the most general mechanism can be reduced into the second general one without loosing much information. Then this procedure continues until restrictions put on a more general one are rejected, and the mechanism that cannot be reduced into a less general one is selected from each nest. As a test statistics the usual large sample likelihood ratio (LR) test, $T\ln(SSR_{rest.}/SSR_{unrest.})$, is used. This test statistics is asymptotically distributed as χ^2 with r degrees of freedom where r is the number of restrictions imposed. Level of significance for each test is 0.025, and this implies that overall significance level for each sequence is below 0.10, since there are at most three tests in each sequence.

Results of the sequential testing procedure can be found in Table A.3. Among the extrapolative nests (F8) is selected from Nest1 (N1), N2, and N3, and (F4) from N4 and N5. On the other hand, (F16) is selected in all adaptive nests except for N8 and N9. Among these nests, (F12) and (F11) are selected mechanisms. Therefore, we are left with five mechanisms, namely (F4) and (F8) from the extrapolative nests, (F11), (F12) and (F16) from the adaptive nests. However, (F8) can be reduced into (F4) in N4 and N5, therefore we choose (F4) among the extrapolative mechanisms. Similarly, (F16) can be reduced into (F12) and (F12) can be reduced into (F11) in N9. As a result, two non-nested mechanisms, (F4) and (F11), remained. Estimation results of these mechanisms are:

$$P_{t+1}^{e(c)} = 0.20 - 0.25P_t - 0.26P_{t-1} + 0.74\hat{w}_{t-1} \quad \text{(F4)} \qquad (3)$$

(7.01) (-2.69) (-2.91) (5.76)

R_{adj}^2=0.23, SBC=-3.58, WH=0.27, LM(1)=0.57, LM(2)=0.47, LM(3)=0.65, LM(4)=0.76, ARCH LM(1)=0.08 ARCH LM(2)=0.12, ARCH LM(3)=0.21, ARCH LM(4)=0.36

$$P_{t+1}^{e(c)} = 0.08 + 0.65P_t^e - 0.21P_t \quad \text{(F11)} \qquad (4)$$

(3.41) (2.85) (-1.51)

R_{adj}^2=0.15, SBC=-3.54, WH=0.15, LM(1)=0.88, LM(2)=0.84, LM(3)=0.55, LM(4)=0.68, ARCH LM(1)=0.13, ARCH LM(2)=0.25, ARCH LM(3)=0.21, ARCH LM(4)=0.33

Note: t-statistics in parenthesis and p-values for the diagnostic tests.

At this point it should be noted that coefficient of the realized inflation in (F11) is insignificant. If we drop this variable from the equation, then coefficient of the expected inflation will be 0.39. Now, since (F4) and (F11) are non-nested, an additional decision criterion is needed. Here, we have used both J-test proposed by Davidson and MacKinnon (1993) and SBC values. According to J-test, we reject both specifications, against the alternatives, suggesting that another mechanism is needed. According to SBC values, we have chosen (F4), general first order extrapolative mechanism, as a result of the sequential testing procedure.

This result might be justified in a number of ways. Firstly, in this kind of qualitative surveys respondent never knows his prediction error, since he just says a direction for inflation, but not a value that can enable him to compare his prediction with a realized value later. This partly explains why AEH failed here. Secondly, in an environment that is highly volatile, it may be more practical to say just past inflation rates as inflation expectations, instead of computing prediction error, and trying to correct himself in the next period.

When we look at (F4), all the coefficients are significant, but those of the lagged inflation rates enter the equation with an unexpected sign, which is difficult to explain. Constant term is highly significant and indicating inflation expectations start with 20 percent, and then adjusted downward in proportion to the first and second lagged values of inflation. Note that there is also an adjustment of 74 percent for the error in predicting the previous quarterly change.

The well-known criticism that these simple expectations formation mechanisms do not take into account any information other than past history of inflation can be restated here. In order to overcome this shortcoming, we move on to an augmented model that tries to explain inflation expectations at a more satisfactorily level by employing some other economic variables.

Our augmented model of expectations formation is based on a few quite simple principles. Firstly, we do not think that it is very realistic to include variables that computationally burdening or costly available to the respondents. Secondly, we have returned to the original question and then tried to determine which factors can influence the respondent's perception about next three months' selling prices. The possible candidates are demand and cost conditions plus an uncertainty parameter. Thirdly, and more importantly, based on the estimation results, it is observed that in shaping their expectations, people do not go far away in the time span. Therefore, in defining the lag structure, we have preferred the most recent available variables, which probably affect the respondents at the date of survey filling. Finally, here we have tried to investigate which factors might contribute to explain the inflation expectations, but not necessarily the inflation itself; therefore the proposed augmented model may or may not be successful in explaining the actual inflation.

During the sequential testing procedure we had observed that the mechanisms containing prediction errors do not explain expectations satisfactorily, so that we did not insist on an adaptive component, but we kept an extrapolative component in a slightly different manner. As an extrapolative component, last month's inflation rate that we are sure all the respondents are aware of is taken. Since our data points are December, March, June and September, we pick up the inflation rates of November, February, May and August in every year. Exchange rates are also included in the model in order to capture its influence on costs through imported raw materials, and also it may be used as a policy variable that measures uncertainty. Real Sector Confidence Index[7] is also used as an alternative policy variable, but it did not perform well, probably due to some opposite movements with inflation. As a demand variable private capacity utilization rate and respondents' evaluation of last three months' stocks of produced goods are taken. Finally, as a forward-looking component average cost expectations of respondents over the next three months is included in the model. Estimation result is:

$$P_{t+1}^{e(c)} = -0.12 + 0.72PMINF + 0.61DLR + 0.29PCUR - 0.22BTS20 + 0.37BTS21 \quad (5)$$

(-2.04) (4.20) (7.86) (5.43) (-3.44) (5.41)

R_{adj}^2 =0.83, SBC=-4.97, WH=0.78, LM(1)=0.42, LM(2)=0.18, LM(3)=0.31, LM(4)=0.47, ARCH LM(1)=0.65, ARCH LM(2)=0.77, ARCH LM(3)=0.73, ARCH LM(4)=0.47

Note: t-statistics in parenthesis and p-values for the diagnostic tests

PMINF: Private manufacturing sector inflation rate in the months November, February, May and August. (SIS)

DLR: Percentage changes in average dollar exchange rates of December, March, June and September in regards to previous month's average dollar exchange rates. (CBRT)

PCUR: Logarithmic private sector capacity utilization rate divided by 100, quarterly. (SIS)

BTS20: Respondents' evaluations of produced goods stocks of the last three months -diffusion index- divided by 100, in the months November, February, May and August, taken from 20th question of the BTS. (CBRT)

BTS21: Respondents' average cost expectations over the next three months -diffusion index- divided by 100, in the months November, February, May and August, taken from 21st question of the BTS. (CBRT)

All the variables are significant with expected signs, and diagnostics of the regression are fairly good. Expectations are very sensitive to the last month's inflation rate and exchange rate changes as expected. Also, production capacity and

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[7] It is constructed by making use of the responses given to the selected questions of the BTS.

stock levels of the last three months are important determinants of price expectations of the next three months. An increase in production capacity or a decrease in stock levels in the last three months are perceived as a sign of increase in demand, so they enter the regression with positive and negative signs respectively.

The role of public sector in the formation of expectations has been tested by considering public manufacturing sector prices[8], total expenditures and some budget deficit definitions but found to be insignificant. Some cost variables such as energy prices, wage payments and interest rates have also been found to be insignificant[9], therefore not presented in the equation. Among them insignificance of wage payments may be attributed to some factors such as small share of wage payments in total costs, lack of union activities during the period[10] or to the flexibility of wage rates during economic crises[11].

The policy implications of these results, if correct, are mixed. Firstly, as the proposed model shows, the respondents do not take into account the past history of the variables; instead they give more importance to the recent data. It is encouraging in the sense that inflation expectations may respond policy changes rather quickly. But the model also points out that the dollar exchange rate is a highly significant component of the expectations formation, and the volatility in this item may disturb the expectations. This result is not an unexpected one so long as dollar exchange rate preserves its importance both through the imported raw materials and as a store of value in the studied sample period. Also note that to reduce firms' inflation expectations, it is necessary to reduce the actual rate of inflation and to give more weight to the factors that affect the firms' average cost expectations since the behavior of these variables apparently have a significant effect on expectations.

As mentioned in the first section, Turkish economy underwent a major structural change after the stabilization and disinflation program. As a last exercise we have tried to see whether this structural change can be traced from the estimated time

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[8] This sector is mainly composed of administered prices and it is thought that monitoring the behavior of this sector may carry important information for expectations since public manufacturing goods are direct inputs to private manufacturing sector and revenue that is generated by increasing these prices is intensively used as a source of financing the budget deficits.

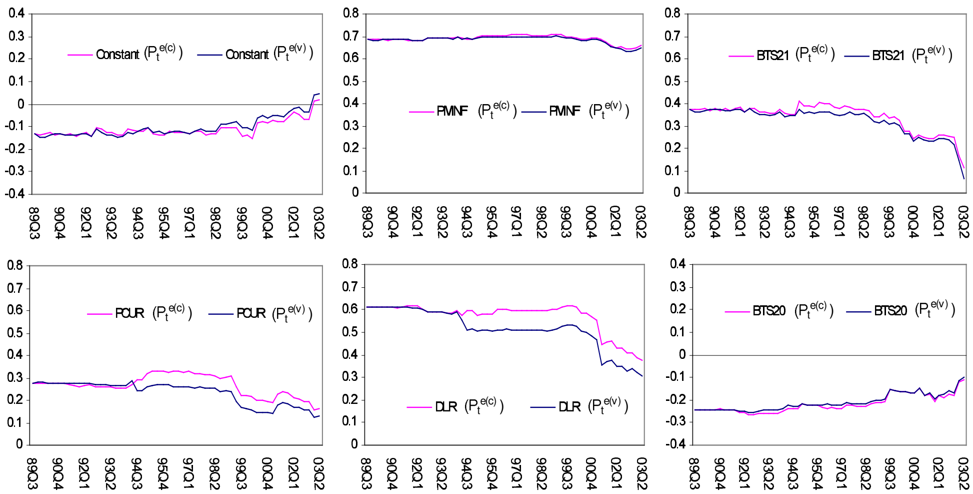
[9] Wages and energy prices are also found to be insignificant in Uygur (1989).

[10] Lim and Papi (1997).

[11] Yeldan (2001).

varying coefficients of augmented model via the adaptive Kalman Filter algorithm (see Appendix B.2) and the results are presented in Figure 2. Time varying coefficients suggest that realized inflation rates preserve its significant role on expectations after the stabilization program, whereas respondents give less weight, in absolute value, to changes in dollar exchange rate, cost expectations, stock evaluations and capacity utilization rates.

Fig. 2. Time Varying Parameter Results of the Augmented Model



4. Tests of Rationality

Rationality hypothesis in Muthian sense has three implications (Muth, 1961). Firstly, economic system generally does not waste scarce information set. Secondly, the way expectations are formed depend specifically on the structure of the relevant system describing the economy, and lastly, a public prediction will have no substantial effect on the operation of the economic system. Based on these three assertions REH can be defined as the true mathematical expectation implied by the model, conditional on the information set assumed to be available when expectations are formed. Here, the true mathematical expectation stands for the expectation that can be derived by writing the correct structural model of the economy. Furthermore, the information set is assumed to have three components: "knowledge of the structure of the model; knowledge of government policies in operation; and knowledge of the past values of economic variables" (Begg, 1982, p.72).

REH defined as above has some statistical properties that utilized in empirical testing. These are (Evans and Gulemani, 1984):

1. Unbiasedness: Under REH, expectations should not systematically over or under estimate the realized inflation rates. Formally,

$$P_t = P_t^e + u_t \tag{6}$$

where u_t is uncorrelated with P_t^e and $u_{t-i} (i = 1, 2, ...)$. Regressing the equation

$$P_t = \alpha + \beta P_t^e + u_t \tag{7}$$

and testing H_0: $(\alpha, \beta) = (0, 1)$ is the conventional test of unbiasedness.

2. No serial correlation: Let e_t denote forecast error made in time t, if there is a pattern of systematic forecast error, then e_t's are serially correlated. This hypothesis can be tested by making use of the following regression

$$e_t = \sum_{i=1}^{k} \beta_i e_{t-i} + u_t \tag{8}$$

and testing $H_0 : \beta_i = 0\ (i = 1, ..., k)$ for a selected k.

3. Efficiency: REH assumes people use, at least, the information regarding the past history of inflation. To be precise the forecast error should not be improved by utilizing P_{t-i}, $(i = 1, 2, ...)$. This can be tested by estimating

$$e_t = \sum_{i=1}^{k} \beta_i P_{t-i} + u_t \tag{9}$$

and testing the null hypothesis $H_0 : \beta_i = 0$, $(i = 1, ..., k)$ for a selected k.

4. Orthogonality: Let I_{t-1} consists of all the costlessly available information that helps to explain inflation at the end of period $t-1$. If the forecast error could be improved by exploiting I_{t-1}, then the forecasts are not rational. Therefore, a test of orthogonality looks for a lack of serial correlation between e_t and a sub-sample of I_{t-1}. Let S_t be a vector of information variables from I_t, and β is a vector of coefficients, then regressing

$$e_t = S_{t-1}^{'} \beta + u_t \tag{10}$$

and testing H_0: $\beta = 0$ is the test of orthogonality.

In the tests of rationality, we have to bear in mind that P_t^e series is not the direct measure, it is derived from the qualitative surveys and is likely to subject to some measurement error. In order to illustrate what kind of errors we are faced with, consider the following representation[12]:

$$P_t^e = \varphi_1 + \varphi_2 P_t^* + \varepsilon_t \tag{11}$$

here P_t^* stands for the true measure of inflation expectations which is in fact not available, and ε_t represents the random component of the measurement errors, whereas the parameters φ_1 and φ_2 correspond to the systematic components. It is assumed that the random component has a zero mean and constant variance. If the scaling problem is serious, then we should have φ_1 and φ_2 values that are significantly different from zero and one respectively.

The unbiasedness and no serial correlation tests can be applied only when the expectations are measured without systematic or random errors. However, as Pesaran (1985, p.950) stated "the conversion of qualitative responses into quantitative measurements, no matter how ingeniously carried out, will not be free from error" owing to incorrect scaling (systematic error) and general uncertainty (random error), so there is no point to apply these tests. Expectation measures obtained according to CP's methodology prevents the test of the unbiasedness itself because of its manner of construction. The scaling parameter, which is changeable according to the sample size and the distribution chosen, may bring about diverse results for the unbiasedness tests. Also, Pesaran emphasized that existence of the random measurement errors brings in the moving-average errors, which in turn precludes a precise test of no serial correlation. However, these do not preclude examining the series in terms of rationality with the remaining tests provided that the measurement error is white noise. As a result, we can apply only the efficiency and the orthogonality tests.

If we turn back to the efficiency test defined in equation (9) and as well consider the true expectation measure, specifically the measurement error problem, then we have the following regression for the efficiency test:

$$e_t = P_t - P_t^* = c_0 + \sum_{i=1}^{k} \beta_i P_{t-i} + u_t \tag{12}$$

However, in the existence of the measurement error, our inflation expectation measure differentiates from the true one by $P_t^* = \varphi_2^{-1}(P_t^e - \varphi_1 - \varepsilon_t)$ hypothetically. Hence we are faced with the following regression:

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[12] See Pesaran (1985) for the further details concerning the measurement error problem.

$$P_t - \varphi_2^{-1} P_t^e = c_0^{'} + \sum_{i=1}^{k} \beta_i P_{t-i} + \delta_t \tag{13}$$

where $c_0^{'} = c_0 - (\varphi_1 / \varphi_2)$ and $\delta_t = u_t - (\varepsilon_t / \varphi_2)$. In this case, according to the degree of the measurement error, it is likely to expect $c_0^{'}$ to be different from zero, and δ_t to be serially correlated, and these do not necessarily cause to reject REH. In the applications, however, it is seen that there is no need to consider various specifications for the autocorrelation. Moreover, as in the Pesaran's work, three different values of φ_2 (0.9, 1.0 and 1.1) are assumed since it is not possible to estimate this parameter precisely. We also apply the same logic to the orthogonality test later.

Table 1 gives empirical results of the efficiency test for four different lag structures. It shows that REH cannot be rejected as a result of efficiency test, namely forecast errors could not be improved by past data of realized inflation rates which means that the basic condition for the rationality, fully utilization of the most costlessly available information that is past inflation rates, has been satisfied.

Table 1
Results of the Efficiency Test

Sample: 1989:04-1999:04

	$\varphi_2 = 0.9$		$\varphi_2 = 1$		$\varphi_2 = 1.1$	
	Chi-square	P-value	Chi-square	P-value	Chi-square	P-value
P_{t-1}	1.743	0.194	1.942	0.164	2.108	0.147
P_{t-1}, P_{t-2}	1.973	0.373	2.118	0.347	2.234	0.327
$P_{t-1}, P_{t-2}, P_{t-3}$	2.312	0.510	2.276	0.517	2.267	0.519
$P_{t-1}, P_{t-2}, P_{t-3}, P_{t-4}$	3.758	0.440	3.682	0.451	3.611	0.461

Now, we turn to the most comprehensive test of rationality, that is the orthogonality test. Here, crucial point is selection of independent variables and the number of lags that these variables enter into the equation. We begin with a large number of variables; say information set I that is potentially related with inflation. Possible candidates are lags of inflation rates (q, m), nominal wages (q), exchange rates (q, m), energy prices (q, m), public sector manufacturing prices (q, m), money supply (q) and deposit interest rates (q), where (q) indicates quarterly data, and (q, m) both quarterly and monthly data.

In the literature, usually, quarterly data with appropriate lag numbers have taken into consideration as independent variable whenever dependent variable is quarterly. If we use the conventional procedure and take one lag of each quarterly variable in the information set I, except money supply and deposit interest rates where two lags are allowed in order to capture publication delays, then rationality assumption is rejected (not shown). However, this method may be misleading for two reasons. Firstly, we do not know a priori that information set should consist of only quarterly variables. There may be some variables with non-quarterly frequency that perform better in explaining inflation. Especially, if the pass-through from changes in cost items to inflation is immediate, then the effect of the contemporaneous changes in these items may weight more on inflation expectations. If this is the case, orthogonality test should be carried out with more recent information set, specifically monthly data may also be allowed. Secondly, in rationality tests independent variables are regressed on the forecast error, therefore there is a possibility of identifying some variables in explaining the forecast error significantly but fail to explain realized inflation rates. This problem may arise from some variables that are spuriously correlated with inflation expectations but actually are not predictors of inflation (Madsen, 1996).

In order to overcome these shortcomings of the orthogonality test, we have first tried to determine which variables in the information set I are successful in explaining the inflation. Once we form such information set, we expect that a rational respondent should be aware of these variables and form his/her inflation expectation accordingly. It is found that dollar exchange rate (DLR), one lag of inflation (PMINF) and private sector capacity utilization rate (PCUR) that used in augmented expectations formation mechanism are significant and satisfactorily explain the inflation process. Estimation result is:

$$P_t = 0.11 + 1.19PMINF + 0.64DLR + 0.18PCUR + 0.22D94Q2 \quad (14)$$

(4.41) (4.25) (4.26) (2.55) (6.19)

R^2_{adj} =0.85, SBC=-4.23, WH=0.35, LM(1)=0.74, LM(2)=0.72, LM(3)=0.88, LM(4)=0.94, ARCH LM(1)=0.57, ARCH LM(2)=0.86, ARCH LM(3)=0.93, ARCH LM(4)=0.59

Note: t-statistics in parenthesis and p-values for the diagnostic tests

Description and justification of independent variables used in equation (14) has already been discussed in Section III, except the dummy variable $D94Q2$ that put into the equation in order to capture effect of the financial crises occurred in the second quarter of 1994. Now, we are sure that PMINF, DLR and PCUR explain the inflationary process satisfactorily and available to the respondents when they form their expectations. At this stage it is more sensible to investigate whether these variables are fully exploited or not. However, it should be kept in mind that the results of the orthogonality tests are conditional on the variables appeared in the inflation equation.

Table 2 shows results of the orthogonality test under three different values of φ_2. Null hypothesis that the forecast error cannot be improved by a better utilization of PMINF, DLR and PCUR is rejected at different levels of significance depending on value φ_2 takes.[13] If we examine each variable separately, it is seen that the forecast error could be improved only by PCUR.

Table 2
Result of the Orthogonality Test
Sample: 1989:04-1999:04

$\varphi_2 = 0.9$		$\varphi_2 = 1$		$\varphi_2 = 1.1$	
Chi-square	P-value	Chi-square	P-value	Chi-square	P-value
9.428	0.024	7.795	0.050	6.698	0.082

From the efficiency and orthogonality tests we can conclude that although respondents fully utilize past data on inflation rates, the forecast errors could be improved partially with better understanding of PCUR-inflation relation, and in this sense inflation expectations are not rational though for φ_2=1.1 we have not rejected rationality very powerfully.

Since rejection of rationality stemmed from just underutilization of one variable, and it is not very powerful for each value of φ_2, we have begun to suspect whether underutilization of the relevant information, PCUR, common in the whole period or it is peculiar to some very specific time period. If we examine Figure 1 closely, it is seen that in 1999, $P_t^{e(c)}$ measure decreases more sharply as compared to the realizations, which results in large forecast errors. The variable PCUR may owe its significance to co-movements with the forecast error in this period. In order to test this argument and to see whether our results regarding the rationality robust to time period selected or not, we have excluded the last year that inflation expectations fall very sharply, and then reapplied efficiency and orthogonality tests. The results are presented in Table 3.

[13] Actually, this result is valid for the $P_t^{e(c)}$ series. When $P_t^{e(v)}$ is used, test results conclude that expectations are significantly rational for all values of φ_2.

Table 3
Results of the Revisited Efficiency and Orthogonality Tests
Sample: 1989:04-1998:04

Efficiency Test	$\varphi_2 = 0.9$		$\varphi_2 = 1$		$\varphi_2 = 1.1$	
	Chi-square	P-value	Chi-square	P-value	Chi-square	P-value
P_{t-1}	3.037	0.081	2.982	0.084	2.896	0.089
P_{t-1}, P_{t-2}	3.927	0.140	3.637	0.162	3.357	0.187
$P_{t-1}, P_{t-2}, P_{t-3}$	3.871	0.276	3.542	0.315	3.258	0.354
$P_{t-1}, P_{t-2}, P_{t-3}, P_{t-4}$	4.905	0.297	4.531	0.339	4.197	0.380
Orthogonality Test	2.665	0.446	2.849	0.415	3.875	0.275

Results of efficiency and orthogonality tests indicate that we cannot reject the rationality for the period 1989:4-1998:4, indicating respondents utilize available information set I efficiently. The sample period selected has a crucial effect on the outcome, and it suggests that PCUR is not neglected in the whole period. Underutilization of the information regarding PCUR in just a few periods should not create a systematic bias in terms of the rationality hypothesis.

However, these results should be taken with some care for a number of reasons. As mentioned above, the rationality assumption demands a more or less stable economic environment in order to allow economic agents to learn true inflation generating mechanism. But, the period we have studied on witnessed a major domestic and two external (East Asian and Russian Crises) financial crises that make it difficult to assume respondents had enough time to learn the true generating mechanism. If this argument is accepted, it is expected to create a bias in the direction of rejecting rationality and, as we have not rejected the rationality it may be seen irrelevant here. But, it may also imply the reverse. If the lack of economic stability prevents construction of a strong econometric model of inflation, then it may also weaken the test, since in such a situation it is enough to give expectations as good as the econometric model to pass the rationality tests. Namely, when the economy could not be expressed in a structurally consistent way that enables forecasters to give accurate inflation expectations at time t-1 for t, it gets more difficult to blame them of not incorporating some relevant information in their inflation expectations that would lead to rejection of the rationality. The same thing may also arise when pass-through is too speedy from changes in demand or cost conditions to inflation or price adjustments. Since, in this study we have taken private manufacturing sector inflation rates as realized inflation series, changes in demand and especially in cost conditions that are strictly related with changes in exchange rates and pricing policy of public sector, are probably reflected to manufacturing prices within the same month or one month later. If this is the case, both expectations and econometric estimates formed with all available information at time t-1 carry out an uncertain part due to changes in cost conditions in three months between t-1 and t. This also may explain why energy prices that heavily controlled by the public sector did not enter into the equations (5) and (14).

5. Conclusion

In this paper, we have attempted to analyze inflation expectations of private manufacturing sector. Firstly, overlapping nature of the data resulting from the inconsistency between frequency of data and forecast horizon is discussed and, this problem is solved by picking up non-overlapping data points. Then, by utilizing sequential testing procedure, it is studied to what extent the simple models of expectations formation explains the expectation measures obtained from the BTS. Resultant mechanism is a general first order extrapolative. But it is found that simple expectations formation hypotheses considered in the sequential testing procedure are too simple to describe the formation procedure of producers' price formation sufficiently. Inadequacy of the simple models led us to propose a new model of expectations formation that incorporates economic variables other than past history of the inflation and expectations. In this model, last month's inflation rate, changes in average dollar exchange rates of the last month, quarterly private sector capacity utilization rate and respondents' evaluation of produced goods stocks of the last three months and average cost expectations of the next three months have been found to be significant.

In the last part, rationality has been discussed rather comprehensively. From that discussion, it can be stated the conventional procedure that use the same frequency for both dependent and independent variables may not be appropriate in our case and it is important to assure significance of independent variables used in orthogonality test as explanatory variables of inflation. From the tests, results on rationality seem heavily depending on the time period selected, but for the period 1989:04-1998:04 expectations are rational in the sense that there is no underutilization of relevant available information. However, results suggest that failing to reject the rationality may not come from the accuracy of the expectations, but of structure of the economy that preclude accurate short term forecasting for time t with available information set at t-1.

APPENDIX:

Table A.1
The Actual and Expected Quarterly Inflation Series

	Realized Inflation	Inflation Exp. (Constant Indiff. Interval)	Inflation Exp. (Time Varying Indiff. Interval)		Realized Inflation	Inflation Exp. (Constant Indiff. Interval)	Inflation Exp. (Time Varying Indiff. Interval)
89:Q1	13.95	21.32	17.74	Q2	16.13	16.41	15.57
Q2	13.24	16.23	14.21	Q3	12.51	15.77	14.13
Q3	8.90	15.83	11.37	Q4	14.76	15.17	13.86
Q4	7.04	10.29	8.38	97:Q1	15.52	16.77	15.12
90:Q1	9.65	12.27	9.44	Q2	15.10	16.44	15.04
Q2	7.66	9.80	7.99	Q3	18.88	18.18	18.33
Q3	12.59	10.74	11.72	Q4	17.28	15.96	16.77
Q4	9.93	13.98	13.78	98:Q1	13.36	15.41	15.32
91:Q1	12.11	12.14	12.54	Q2	11.65	13.84	14.08
Q2	13.25	16.21	14.76	Q3	10.82	10.88	11.97
Q3	11.05	11.08	11.40	Q4	9.52	8.78	10.34
Q4	11.15	12.14	11.56	99:Q1	9.67	6.01	8.87
92:Q1	12.24	13.88	12.35	Q2	12.37	8.03	10.97
Q2	12.94	12.69	12.82	Q3	13.38	8.51	11.56
Q3	14.63	15.48	14.64	Q4	14.31	8.96	12.22
Q4	12.81	17.15	13.89	00:Q1	11.71	9.01	12.19
93:Q1	12.09	15.86	13.06	Q2	6.69	6.02	8.89
Q2	10.83	13.94	11.65	Q3	5.85	4.66	7.88
Q3	11.59	14.39	11.78	Q4	5.93	5.28	8.11
Q4	13.17	14.01	12.85	01:Q1	15.52	4.88	8.44
94:Q1	23.43	20.16	18.01	Q2	28.08	13.82	15.25
Q2	49.21	27.53	23.72	Q3	14.71	7.43	10.57
Q3	10.29	8.89	10.98	Q4	14.62	8.37	11.34
Q4	16.04	11.76	12.99	02:Q1	4.19	6.78	9.85
95:Q1	19.98	20.12	18.87	Q2	6.21	4.33	8.05
Q2	10.27	13.24	13.40	Q3	9.26	7.29	10.07
Q3	11.81	12.15	12.60	Q4	5.61	5.37	7.71
Q4	10.97	12.87	12.36	03:Q1	6.83	5.00	7.43
96:Q1	17.21	20.45	17.15	Q2	1.21	5.42	5.68

Table A.2
Expectations Formation Mechanisms[14]
Extrapolative

Simple first order:

(F1): $P^e_{t+1} = P_t + \theta(P_t - P_{t-1}) + w_t$, (F2): (F1) with $w_t = \rho w_{t-1} + u_t$

General first order:

(F3): $P^e_{t+1} = \beta_1 P_t + \beta_2 P_{t-1} + w_t$, (F4): (F3) with $w_t = \rho w_{t-1} + u_t$

Simple second order:

(F5): $P^e_{t+1} = P_t + \theta_1(P_t - P_{t-1}) + \theta_2(P_{t-1} - P_{t-2}) + w_t$, (F6): F(5) with $w_t = \rho w_{t-1} + u_t$

General second order:

(F7): $P^e_{t+1} = \beta_1 P_t + \beta_2 P_{t-1} + \beta_3 P_{t-2} + w_t$, (F8): (F7) with $w_t = \rho w_{t-1} + u_t$

Adaptive

Simple first order:

(F9): $P^e_{t+1} = P^e_t + \lambda(P_t - P^e_t) + w_t$, (F10): (F9) with $w_t = \rho w_{t-1} + u_t$

General first order:

(F11): $P^e_{t+1} = \alpha_1 P^e_t + \beta_1 P_t + w_t$, (F12): (F11) with $w_t = \rho w_{t-1} + u_t$

Simple second order:

(F13): $P^e_{t+1} = P^e_t + \lambda_1(P_t - P^e_t) + \lambda_2(P_{t-1} - P^e_{t-1}) + w_t$, (F14): (F13) with $w_t = \rho w_{t-1} + u_t$

General second order:

(F15): $P^e_{t+1} = \alpha_1 P^e_t + \alpha_2 P^e_{t-1} + \beta_1 P_t + \beta_2 P_{t-1} + w_t$, (F16): (F15) with $w_t = \rho w_{t-1} + u_t$

Restricted second order:

(F17): $P^e_{t+1} = P_t + \pi_1(P_t - P_{t-1}) + \pi_2(P_t - P^e_t) + \pi_3(P_{t-1} - P^e_{t-1}) + w_t$, (F18): F(17) with $w_t = \rho w_{t-1} + u_t$

Maintained

(F19): $P^e_{t+1} = \gamma_1 P^e_t + \gamma_2 P^e_{t-1} + \gamma_3 P^e_{t-2} + \delta_1 P_t + \delta_2 P_{t-1} + \delta_3 P_{t-2} + \delta_4 P_{t-3} + w_t$

Note: P^e_{t+1} is the expectation formed at t for t+1. Constant term is omitted in the table for simplicity.

[14] Mills (1981,p.157), Table 1.

Table A.3
Sequential Testing Results of the Ordered Nests

		→						Model selected
Extrapolative Nests:								
N1	Model	**(F19)**	**(F8)**	**(F6)**	**(F5)**	**(F1)**		
	Test Stat.	Maintained	1.01 (3)	29.39 (1)	-	-		**(F8)**
N2	Model	**(F19)**	**(F8)**	**(F7)**	**(F5)**	**(F1)**		
	Test Stat.	Maintained	1.01 (3)	10.77 (1)	-	-		**(F8)**
N3	Model	**(F19)**	**(F8)**	**(F7)**	**(F3)**	**(F1)**		
	Test Stat.	Maintained	1.01 (3)	10.77 (1)	-	-		**(F8)**
N4	Model	**(F19)**	**(F8)**	**(F4)**	**(F3)**	**(F1)**		
	Test Stat.	Maintained	1.01 (3)	0.59 (1)	12.98 (1)	-		**(F4)**
N5	Model	**(F19)**	**(F8)**	**(F4)**	**(F2)**	**(F1)**		
	Test Stat.	Maintained	1.01 (3)	0.59 (1)	55.48 (1)	-		**(F4)**
Adaptive Nests:								
N6	Model	**(F19)**	**(F16)**	**(F14)**	**(F13)**	**(F9)**		
	Test Stat.	Maintained	1.32 (2)	14.38 (2)	-	-		**(F16)**
N7	Model	**(F19)**	**(F16)**	**(F14)**	**(F10)**	**(F9)**		
	Test Stat.	Maintained	1.32 (2)	14.38 (2)	-	-		**(F16)**
N8	Model	**(F19)**	**(F16)**	**(F12)**	**(F10)**	**(F9)**		
	Test Stat.	Maintained	1.32 (2)	5.49 (2)	9.39 (1)	-		**(F12)**
N9	Model	**(F19)**	**(F16)**	**(F12)**	**(F11)**	**(F9)**		
	Test Stat.	Maintained	1.32 (2)	5.49 (2)	0.01 (1)	12.36 (1)		**(F11)**
N10	Model	**(F19)**	**(F16)**	**(F15)**	**(F12)**	**(F10)**	**(F9)**	
	Test Stat.	Maintained	1.32 (2)	5.37 (1)	-	-	-	**(F16)**
N11	Model	**(F19)**	**(F16)**	**(F15)**	**(F13)**	**(F9)**		
	Test Stat.	Maintained	1.32 (2)	5.37 (1)	-	-		**(F16)**
N12	Model	**(F19)**	**(F16)**	**(F15)**	**(F11)**	**(F9)**		
	Test Stat.	Maintained	1.32 (2)	5.37 (1)	-	-		**(F16)**
N13	Model	**(F19)**	**(F16)**	**(F18)**	**(F17)**	**(F9)**		
	Test Stat.	Maintained	1.32 (2)	17.44 (1)	-	-		**(F16)**
N14	Model	**(F19)**	**(F16)**	**(F15)**	**(F17)**	**(F9)**		
	Test Stat.	Maintained	1.32 (2)	5.37 (1)	-	-		**(F16)**
N15	Model	**(F19)**	**(F16)**	**(F18)**	**(F14)**	**(F10)**	**(F9)**	
	Test Stat.	Maintained	1.32 (2)	17.44 (1)	-	-	-	**(F16)**
N16	Model	**(F19)**	**(F16)**	**(F18)**	**(F14)**	**(F13)**	**(F9)**	
	Test Stat.	Maintained	1.32 (2)	17.44 (1)	-	-	-	**(F16)**
N17	Model	**(F19)**	**(F16)**	**(F18)**	**(F17)**	**(F13)**	**(F9)**	
	Test Stat.	Maintained	1.32 (2)	17.44 (1)	-	-	-	**(F16)**
N18	Model	**(F19)**	**(F16)**	**(F15)**	**(F17)**	**(F13)**	**(F9)**	
	Test Stat.	Maintained	1.32 (2)	5.37 (1)	-	-	-	**(F16)**

$\chi^2_{1,0.025} = 5.02, \chi^2_{2,0.025} = 7.38, \chi^2_{3,0.025} = 9.35$

Note: Number of restrictions in parenthesis.

B.1. State Space Representation for Time Varying Indifference Intervals

The vector of observed variable (inflation) is denoted as **y**, while the vector of unobserved state variables (time varying indifference interval bounds) is denoted by β. Then the measurement equation where the evolution of the observed variables is described as a function of the unobserved state variables and transition equation are:

$$y_t = H_t \beta_t + v_t \tag{B.1.1}$$

$$\beta_t = \Phi_t \beta_{t-1} + G_t w_t \tag{B.1.2}$$

where the **v** and **w** denotes vectors of normally distributed iid shocks, which are assumed to be uncorrelated with each other and also with the initial state vector β_0.

For $\beta_t = (\delta_{mt}, \delta_{pt})'$ we can write the state space representation as:

$$[P_t] = \begin{bmatrix} \frac{a_t}{a_t - b_t} & \frac{-b_t}{a_t - b_t} \end{bmatrix} \begin{bmatrix} \delta_{m,t} \\ \delta_{p,t} \end{bmatrix} + v_t \tag{B.1.3}$$

$$\begin{bmatrix} \delta_{m,t} \\ \delta_{p,t} \end{bmatrix} = \begin{bmatrix} \rho_1 & 0 \\ 0 & \rho_2 \end{bmatrix} \begin{bmatrix} \delta_{m,t-1} \\ \delta_{p,t-1} \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \varepsilon^m \\ \varepsilon^p \end{bmatrix} \tag{B.1.4}$$

By using the adaptive Kalman filter[15], our aim is to obtain the adaptive estimate of v_t and in this way to include the transitory shocks into the model by allowing them vary over time.

In the literature, Φ_t is assumed to be identity, which means threshold parameters, deviates from its previous value according to the white noise shocks. However, as stated by Nardo (2003), there are no economic or psychological reasons to suppose that individuals have an indifference interval following a random walk. For that reason, in this model time varying lower and upper threshold parameters are assumed to be shaped with respect to different values of the ρ_1 and ρ_2 parameters.

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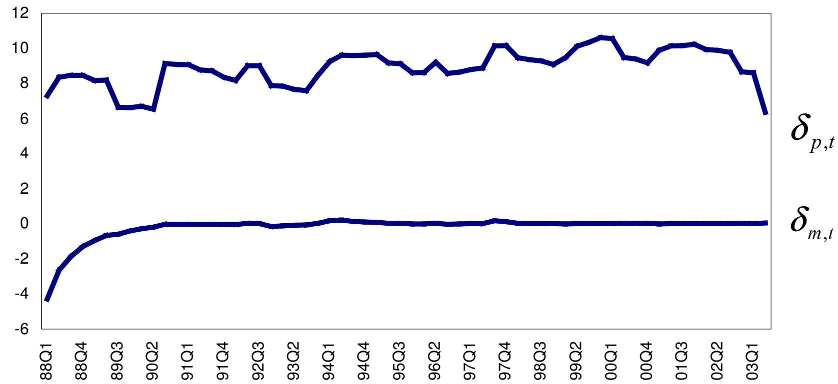
[15] See Harvey (1990) and Ozbek (2000) for the technical details of Kalman filter and its adaptive version.

Fig. B.1. Estimated Lower and Upper Threshold Parameters



As it can be seen from the Figure, lower threshold parameter takes values close to zero or with zero included. This can be interpreted as, for participants there is no need to have a fall in their prices to declare "down" option for their price expectations instead no change case is enough for them. This result can be perceived as meaningful especially considering that inflation was in high levels along the sample period. On the other hand, it is seen that upper bound has a changeable structure but its average is close to the values obtained from the constant indifference interval case under different distribution assumptions.

B.2. State Space Representation for Augmented Model of Expectations Formation

Assuming parameter vector evolves according to a random walk process, and following (5), (B.1.1) and (B.1.2), the state space representation can be written as:

$$\left[P^e_{t+1}\right] = \left[1 \quad PCUR_t \quad PMINF_t \quad DLR_t \quad BTS21_t \quad BTS20_t\right] \begin{bmatrix} \theta_{1,t} \\ \theta_{2,t} \\ \theta_{3,t} \\ \theta_{4,t} \\ \theta_{5,t} \\ \theta_{6,t} \end{bmatrix} + e_t \qquad \text{(B.2.1)}$$

$$\begin{bmatrix}\theta_{1,t}\\ \theta_{2,t}\\ \theta_{3,t}\\ \theta_{4,t}\\ \theta_{5,t}\\ \theta_{6,t}\end{bmatrix}=\begin{bmatrix}1&0&0&0&0&0\\0&1&0&0&0&0\\0&0&1&0&0&0\\0&0&0&1&0&0\\0&0&0&0&1&0\\0&0&0&0&0&1\end{bmatrix}\begin{bmatrix}\theta_{1,t-1}\\ \theta_{2,t-1}\\ \theta_{3,t-1}\\ \theta_{4,t-1}\\ \theta_{5,t-1}\\ \theta_{6,t-1}\end{bmatrix}+\begin{bmatrix}\varepsilon_t^{\theta_1}\\ \varepsilon_t^{\theta_2}\\ \varepsilon_t^{\theta_3}\\ \varepsilon_t^{\theta_4}\\ \varepsilon_t^{\theta_5}\\ \varepsilon_t^{\theta_6}\end{bmatrix} \tag{B.2.2}$$

where P_{t+1}^{e} is the observed expectations on the system and θ_t is the state vector of six parameters. The observation error e_t and the state disturbance ε_t^{θ} are mutually uncorrelated, normally distributed, random vectors of zero mean with covariance matrices R_t and Q_t respectively. By using the initial guess of the parameter vector and its covariance matrix and then applying the adaptive Kalman filter, time varying estimates of the parameters in the model are obtained and reported in the Figure III in the text.

C.1. Augmented Dickey-Fuller Unit Root Results (1989Q4-1999Q4)

	Augmented Dickey-Fuller test statistic		
Variables	t-statistic	Prob.*	LM(4)**
$P_t^{e(c)}$	-4.061	0.003	1.26 (0.30)
$P_t^{e(v)}$	-3.901	0.005	1.32 (0.28)
PMINF	-3.902	0.005	0.49 (0.74)
DLR	-7.824	0.000	0.24 (0.91)
PCUR	-3.420	0.016	0.40 (0.81)
BTS20	-2.814	0.065	0.15 (0.96)
BTS21	-3.327	0.020	1.19 (0.33)

		With Constant
Test critical values:	1% level	-3.600987
	5% level	-2.935001
	10% level	-2.605836

* The critical values for the ADF test are based on MacKinnon (1996).

** LM(4) represents Breusch-Godfrey serial correlation LM test F statistic for 4 lags. The figure in parenthesis is its p-value.

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