

Inflation Expectations in the Czech Interbank Market

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Abstract

Monthly data on the inflation expectations of financial analysts in the Czech Republic exhibit a tendency for permanent bias and ineffectiveness which violates the rational expectations hypothesis assumed in macroeconomic models. This paper asks whether the surveyed data have any explanatory power; in other words, whether the surveyed expectations correspond to the truly (unobservable) market expectations, and hence should be reflected in macro models of the Czech economy instead of the rational expectations hypothesis. Using methodology based on a simple Fisher rule, it is found that the difference between the surveyed and market expectations is not statistically significant.

1 Introduction

The Czech National Bank surveys the inflation expectations of major institutions operating on the Czech financial market. In this paper we analyze the role of these expectations in the formation of prices at the Czech interbank money market. The question of interest is: *To what extent do the surveyed expectations correspond to the true market expectations which cannot be observed?* Put differently, have the surveyed expectations got any explanatory power for the nominal interest rate?

Fig.1 and 2 provide motivation for asking that question. A simple plot of the surveyed expectations and the actual inflation rate in Fig.1 reveals that the expectations can hardly be accepted given what economic theory assumes by the rational expectations hypothesis (REH).¹ We observe a tendency for expectations' permanent overshooting. The two series do not follow a common trend, either. In general, there might be a doubt about the seriousness of the forecasts. What is remarkable, though, is that in Fig.2 we observe a strong correlation between the money-market price (PRIBOR - Prague Interbank Offer Rate) and the surveyed expectations.

An economist and policy-maker should be interested in whether the surveyed data have any relevant predictive power, i.e., whether the expectations reported by the financial analysts are truly processed into market activities. First, if they are not, then the Czech National Bank ought to reconsider the motivation for conducting the survey. But even though it seems that

the expectations do not have any predictive power for highly aggregated data like the actual inflation rate, given Fig.2, they are likely to project in the money market activity. This suggests the second possibility that the survey data does have predictive power, and that economists and policy-makers should reflect them in their models and decisions. As Orphanides & Williams (2002) and Evans & Honkapohja (2002) find, optimal monetary policy differs dramatically when the REH holds and when it does not.

[Figure 1]

[Figure 2]

Forming expectations is an essential part of any optimal decision making of any individual. Macroeconomic theory builds on the rational expectation hypothesis (REH). As can be found in any textbook, agents or group of agents use all available information and utilize it, given the costs of the process, as well as they can in their decisions. Certainly, because agents are heterogenous (they face different information utilization costs, they have different information sets available, etc.), that is expectations about the future differ. For the REH it is important, however, that the expectations are on average (of all individuals) unbiased and efficient, i.e., on the aggregate level the expectations correspond to reality with minor and random differences only.

Recently Mankiw & Wolfers (2003) provided empirical evidence (for the

American economy) that inflation expectations differ for different groups of agents (households, firms, academics, professional forecasters, etc.), which they explain by a sticky information model. According to their model, the disagreement in expectations varies with the state of the economy. There is empirical evidence, however, that financial analysts provide the most efficient inflation forecasts from all studied groups. If we assume that it applies also for the Czech economy, it calls into a question why the forecasts in Fig.1 are not efficient and why they still have predictive power.

In this paper we deal with the expectations of a single group of people, financial analysts. As such, one would think that what we observe in Fig. 1 is irrelevant for judging the applicability of the REH. This paper builds, however, on the fact that the interbank money market is dominant in the Czech financial system. The price on the market (PRIBOR) serves as a benchmark for other markets, like the credit or swap market. If the financial analysts' expectations play a role in the determination of PRIBOR, then they should also be relevant for judging the applicability of REH in macroeconomic models of the Czech economy.

Technically, there are four main reasons for choosing the interbank money market. First, market-makers and financial analysts reporting inflation expectations come from the same institutions. Second, the interbank money market price serves as a benchmark for similar prices in the economy, as argued above. Third, the interbank money market is the most liquid market

in the Czech financial system. One would be willing to think of the market as an effective market. Thus, it is already close to accepting the REH.² The fourth reason, which is connected to the methodology and will later be made clear, is that due to the type of market-makers (major banks in the Czech Republic) the market exhibits constant or zero risk. This minimizes the problem of a risk premium, and increases the probability that the simple Fisher rule, as assumed, is a valid model for the market price.

Given the question of interest above, the null hypothesis is formulated as the surveyed expectations are equal to the true market ones. As a common part of any standard macroeconomic model, the Fisher rule is the cornerstone of the methodology employed here. Fama & Gibbons (1982), Mishkin (1990*b*), and Mishkin (1990*a*) are the motivation for this approach. Testing the null hypothesis, we find that there is no statistical difference between the true market expectations and the surveyed ones.

A careful reader will have already noticed that this paper views the money market from the macroeconomic perspective, and that it will be abstracted from the real mechanism of how the market functions, i.e., how the market price is actually formed. Certainly, the market-makers take into account different information than inflation forecasts (expectations) of financial analysts, even though they come from the same institution. One does not know, however, whether the expectations are unintentionally transmitted in to the price via the different information that the market-makers

utilize. In the section devoted to interpretation of results, a possible explanation for such a transmission is provided.

The further text is structured as follows. Methodology is formulated in the next section. Estimation results and their interpretation follow in section 3, and the fourth section concludes.

2 The Methodology

2.1 The Testing Procedure

The methodology developed in this section is structured so that the stated question of interest " *To what extent do the surveyed expectations correspond to the true market expectations which cannot be observed?*" is addressed. To this purpose the null hypothesis is formulated as " *The market expectations coincide with the surveyed expectations*". Formally expressed,

$$H_0 : \pi_{t,m}^e = \Pi_{t,m}^e,$$

where $\pi_{t,m}^e$ denotes the surveyed inflation expectations formed at time t for the $t + m$ period, and $\Pi_{t,m}^e$ are the true market expectations for the same period of time.

Testing H_0 , similar to Fama & Gibbons (1982), Mishkin (1990*b*), and Mishkin (1990*a*), the Fisher rule is assumed as the true pricing rule for the money market, i.e.,

$$i_t^m = \Pi_{t,m}^e - r_t^m. \tag{1}$$

where i_t^m is the nominal interest rate valid from t to $t + m$, $\Pi_{t,m}^e$ as is defined above, and r_t^m is the ex ante real interest rate. As discussed in the introduction, the Fisher rule is assumed in its basic form without a risk premium which is implicitly assumed to be equal to zero.

In a standard way, let us assume that the inflation expectations are based on information Ω available at time t . Furthermore, following assumptions common to the economic literature, let us assume that the market inflation expectation at time t is equal to the actual inflation rate π_{t+m} which might be noised by error ε_{t+m} . Formally written

$$\Pi_{t,m}^e = E(\pi_{t+m}|\Omega_t) = \pi_{t+m} + \varepsilon_{t+m}. \quad (2)$$

Under the REH ε_t is i.i.d. with zero mean and finite variance. If the mean is non-zero, then the expectations are biased. If the expectation error follows a stationary process with zero mean, the expectations are so-called weakly rational. It is important to note that autocorrelation in such a case causes only inefficiency of expectations but does not affect their consistency. For test convenience, no particular form of the market expectations will be prescribed, hence they can be both rational, inefficient, and/or biased.

For our purposes, it is not important to know the exact process unanticipated inflation follows. The objective is to find the relation of the surveyed expectations to the market ones, i.e., whether those two are the same or if there is a difference. Thus, to test the hypothesis H_0 , it is convenient and sufficient to keep the error in expectations in a nearly unspecified form.

Substituting (2) in (1) yields

$$i_t^m = \pi_{t+m} + \varepsilon_t - r_t^m, \quad (3)$$

which can be further rewritten in a more suitable form for the test

$$i_t = \phi_0 + \phi_1 \pi_{t+1} + v_t, \quad (4)$$

where (putting $m = 1$), $\phi_0 = E(\phi_1 \varepsilon_t - r_t)$, and $v_t = \phi_1 \varepsilon_t - r_t - \phi_0 = \phi_1(\Pi_{t+1}^e - \pi_{t+1}) - r_t - \phi_0$. As indicated, $E(\varepsilon_t)$ can be different from zero.³

Because it is unsure that the market expectation error has a zero mean, any *a priori* unbiasedness condition on the expectations is imposed. Without loss of generality, the parameter ϕ_1 is included. As Mishkin (1990*b*) shows, the parameter ϕ_1 does not need to be necessarily equal to 1. Its value depends on the correlation between the inflation expectations and the real interest rate. In this light, $\phi_1 = 1$ counts just for a special case.

Note that for v_t in formulation (4), one is not able to separate the real interest rate from the expectation error. It is impossible to distinguish what part of variation of v_t accounts for the unanticipated inflation and what for the real interest rate. In other words, one is not even able to extract the error in the market inflation expectations from v_t , and to learn the expectations' exact form. That is why the null hypothesis is formulated as above, i.e., there is a correspondence between the surveyed expectations (which are observed) and the market expectations (which are unobservable).

Let us decompose expression (4) for the market expectations and survey

expectations separately:

$$v_t = \phi_1(\Pi_{t+1}^e - \pi_{t+1}) - r_t - \phi_0, \quad (5)$$

and

$$\tilde{v}_t = \psi_1(\pi_{t+1}^e - \pi_{t+1}) - \tilde{r}_t - \psi_0, \quad (6)$$

where ψ_0 and ψ_1 have the same interpretation as ϕ_0 and ϕ_1 , respectively. In the parameters' values lie the core idea of the test. Obviously, if the null hypothesis holds, i.e. $\Pi^e = \pi^e$, the two expressions must coincide ($\phi_0 = \psi_0$ and $\phi_1 = \psi_1$).

Now substituting \tilde{v}_t instead of v_t in (4) and rearranging it, we obtain

$$i_t = (\phi_0 - \psi_0) + (\phi_1 - \psi_1)\pi_{t+1} + \psi_1\pi_{t+1}^e + r_t. \quad (7)$$

After further simplification, a final testing expression is received

$$i_t = a_r + a\pi_{t+1} + b\pi_{t+1}^e + \epsilon_t. \quad (8)$$

If the following requirements hold, then one may conclude that $\Pi^e = \pi^e$, or at least they are very close to each other: (i) if $\phi_0 = \psi_0$ and $\phi_1 = \psi_1$, then it must be $a_r = a = 0$, (ii) b must be statistically significant and positive (ideally close to 1) so that the Fisher rule is the correct model.

When performing the test, one ought to be aware of the three major weaknesses the test suffers from. The first concerns the *character of residuals* in (8). By definition they can (i), in the best case, follow a stationary process or (ii), in the worse case, they can contain a unit root. In the former case,

the test is still usable. One just has to correct for the autocorrelation effect on the parameters' standard error estimates. The parameters' unbiasedness and consistency property remain unaffected.

In the worst case, when residuals contain a unit root, the test fails in that the test results in a spurious regression. This occurrence is not unlikely because if we are aware of the real interest rate being a function of marginal productivity, then for an economy in transition the real interest rate can easily be a non-stationary process.⁴ Given this possibility, an essential part of the methodology is to test the residuals for stationarity. In this paper the augmented Dickey-Fuller (ADF) test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test are employed.

The second major weakness of the test is the *problem of multicollinearity*. The occurrence of multicollinearity is very likely. It follows from the logic of expectations formation. In such a case, the unbiasedness property of the parameter's estimates is not affected but the efficiency suffers. The multicollinearity tends to bias the standard errors upward. The closer the expectations are to the REH, the more severe the problem is. However, we believe that the problem is not significant in the case of the Czech data. The correlation between inflation and inflation expectations is about 0.55, which is still acceptable. The regression results in the next section also look reasonable and do not indicate the presence of multicollinearity.

The third considerable weakness the methodology may suffer from is the

*problem of joint hypothesis.*⁵ The problem is that the methodology crucially relies on the assumption that the Fisher rule holds. Thus if it happens the null hypothesis is rejected, one cannot be certain whether it is because the market expectations are truly different from the surveyed ones or because the Fisher rule is invalid. Indeed, this is common to all tests of this type.⁶ However, the problem is weakened here. As said in the introductory section, the focus on the problem of inflation expectations is from the macroeconomic perspective, and there the Fisher rule is a standard way to capture the interest rate behavior. In addition, the results in the next section strongly suggest that the Fisher rule holds.

In summary, to test H_0 , we run the OLS regression of (8) and test whether the parameter a_r and a are statistically significant. If the parameters are insignificant and the parameter b is significant than H_0 is accepted. If H_0 cannot be rejected, the surveyed inflation expectations are likely to coincide with the market expectations. Accounting for the test weaknesses, an essential part of the test has to be (i) the test of residuals stationarity and (ii) a check of the multicollinearity magnitude.

2.2 The Data

The test developed above is performed on the monthly data of the Czech interbank money market. The source of the data is the Czech National Bank (CNB) and the Czech Statistical Office. The monthly data of nominal one-

year interbank interest rate (PRIBOR 1Y, monthly average values), year-to-year inflation rate (computed from the CPI), and of year-to-year expected change in the CPI are employed. The expectations are formed by financial market analysts; details of their survey can be found at <http://www.cnb.cz>. The CNB's expectations survey began in the year 1999, which is why the data range is from 1999:05 to 2003:12. The data set is freely accessible at <http://home.cerge-ei.cz/fukac/papers>.

3 The Results

The results on estimation of equation (8) are reported in Table 1 and graphically presented in Fig.3. As follows from Table 1, the null hypothesis that the market expectations are equal to the surveyed expectations cannot be rejected at the standard level of significance. The parameters a_r and a are not significantly different from zero, and the parameter b is found significant. The critical values for the test are obtained by Monte Carlo simulations. The reason is discussed below. The goodness of fit is 82%. Thus the joint hypothesis problem is not binding here.

[Table 1]

One certainly notices the very low Durbin-Watson (DW) statistics which may indicate the presence of unit root in the residual term, in the ex ante real interest rate. As discussed in section 2.1, the real interest rate depends

on such magnitudes like productivity. In a transition economy, productivity may follow a stochastic trend which affects the path of the real interest rate. In order to avoid spurious regression results, we must make sure that residuals are stationary. To do so, the augmented Dickey-Fuller test and the Kwiatkowski-Phillips-Schmidt-Shin test are applied. The results are summarized in Appendix A. From there it follows that the residuals can be considered stationary.

[Figure 3]

If the unit root is not present and the regression is not spurious, there is a different problem with interpreting the results, though not as crucial as the former one. It can be easily shown that strong positive serial correlation, which the DW test identifies, underestimates the parameters' standard errors. As a consequence, it cannot be decided about the rejection or acceptance of the null hypothesis using the standard t-test. The problem is solved here by simulating a new set of critical values that reflect positive autocorrelation. The procedure for obtaining the critical values is outlined in Appendix B. The new critical values are those already reported in Table 1.

As discussed in section 2.1, multicollinearity is another phenomenon we have to check for. The t-statistics and \bar{R}^2 are of reasonable magnitudes and do not indicate the presence of multicollinearity. As suggested by Pindyck & Rubinfeld (1998), regressing the inflation rate and inflation expectations

on the nominal interest rate separately may also serve as an indicator. If the regression results significantly alter from the joint regression, multicollinearity matters. We do not report on these results here but it was found that the results did not change in a significant way from the ones in Table 1. The parameter a was still close to zero although slightly significant at the 5% (the t-statistic was not corrected for autocorrelation effect, however), and the parameter b was still significant and close to unity. The goodness of fit did not change, either. Having this information suggests that multicollinearity is not a problem in this particular case.

Knowing that the estimation results are reliable, i.e., the model is significant, that we corrected for autocorrelation, and that there is no multicollinearity problem, the results are somewhat surprising. One would expect the market expectations to be much more precise than the surveyed ones. In other words, the parameter a would be of a larger value than 0.15. Instead, it is found that the REH, as understood by macroeconomic theory, does not hold for the Czech economy. Moreover, it can be observed in Fig.3 that the predictability of i_t using π_{t+1}^e is even improving, which further supports the notion that the REH does not hold. In the last year and a half, which is the period of a significant expectations overshooting, the predictability of nominal interest rate was the strongest.

The surveyed expectations are formed by financial analysts and, in theory, the market expectations should be formed by market dealers who form

the market price, i_t . More than likely, the dealers do not pay any attention to the analysts' expectations, or rather they do not have any inflation expectations at all. Their particular objective, as of professionals, is to maximize profit. As a result of their actions, a market price arise. It is surprising that the price is inefficient from the macroeconomic point of view, i.e., it is based on inefficient inflation expectations. If we admit the idea that the market-makers do not pay attention to inflation forecasts, how are the inefficient inflation forecast, that we see in Fig.1, transmitted into the market price?

The character of the Czech interbank money market and the credit market can offer one possible explanation. The credit market is the main channel used to transmit the capital to the economy. Banks (lenders) are the market price setters, and borrowers are price-takers. The price on the credit market is derived from the price on the interbank money market which, in contrast to the credit market, may be considered a competitive one.

For banks as the lenders of capital, it is profitable to overshoot their inflation forecasts (expectations). If we believe that bankers take into account nominal depreciation of money when forming a credit price, overshooting these expectations increases their ex post real revenues. Given that the borrowers are price-takers, the overshooting is accepted. Let us assume that a bank on the Czech credit market sets the one-year nominal interest rate on a credit so that it is composed of an individual PRIBOR 1Y estimate plus a risk premium and a profit margin. The individual bank's PRIBOR

1Y estimate is composed of a required minimum ex ante real return plus an expected nominal depreciation (expected inflation). Having a price on the credit market, the lenders face a possible lack or excess of loanable funds (deposits from clients). To utilize them, they are motivated to enter the interbank money market and trade them. Under the assumption that the pricing rule is the same for all banks in the credit market, there will be only a moderate correction in the market PRIBOR in order to make the market clear. The new market PRIBOR is recursively reflected in the price on the credit market.

In this story, the money-market dealers do not necessarily need to know the inflation expectations the market price includes or even how the credit price is formed. They are only "endowed" with an excess or deficit of money which they trade. The deficits or excesses of loanable funds are determined by the credit market, which is exogenous to the interbank money market.

4 Conclusion

In this paper we find that inefficient surveyed inflation expectations have predictive power on the interest rate and that they do not differ from the market expectations in a significant way. This has crucial consequences for modelling the Czech economy and particularly for optimal monetary policy. As Orphanides & Williams (2002) and Evans & Honkapohja (2002) find, optimal monetary policy differs for an economy where the REH is valid, and

for an economy where the expectations do not meet the REH requirements. What is found optimal in the REH world is not optimal in the bounded rationality world, and vice versa. Macroeconomists and policy-makers ought to be aware of this fact.

Nonetheless, the research has brought up more questions than answers. The findings call for a study on why the Czech interbank money market, anticipates inefficient expectations, and yet why there is no arbitrage incentive for an improvement. Given that the market has a unique position in the financial system, in general, it is not possible that the results found here would hold in the long run. Hence, although we make some headway towards explaining how the inefficient inflation forecasts are transmitted into the market price, a serious attempt to find the final answer should still be made. Having a better understanding of how the market functions, we are in a better position to improve our economic models and to suggest optimal policies.

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Notes

¹When speaking about rationality, it is meant that the REH is satisfied. When using the term irrationality or irrational, the inefficiency of expectations, in the sense of the REH again, is meant, understanding that that the violation of REH does not necessarily bring about irrational behavior.

²Podpiera (2003) finds that the Czech interbank money market is not efficient. It takes a few days for the market to absorb new information, though from the perspective of this analysis which is performed on monthly data, the market can be thought of as efficient.

³In the opposite case, the parameter ϕ_0 only catches the average ex ante real interest rate.

⁴The source of unit root cannot be ε_t . Even if the expectations do not satisfy the REH, they have to have a constant mean at least.

⁵The author thanks to Jan Kmenta for bringing this to his attention.

⁶We refer to Campbell, Lo & MacKinlay (1997), section 1.5.2.

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Appendix A

The regression residuals from (8) are tested for a unit root here. Testing for a unit root is crucial for the regression results. Because residuals are partially estimates of real interest rate, and there might be an economic reason to believe that a unit root is present. If it is so, then the results are spurious and non-usable.⁷ To test for the unit root, the augmented Dickey-Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test are employed. Each of them test for a unit root but from different directions. The null hypothesis of the ADF test is that *a time series is not stationary* while the null of KPSS test is that *a series is stationary*. Applying both tests provides a more complex picture than using only one of them.

The results for the ADF test are summarized in Table 2. Following Enders (1995), the ADF test is based on testing $H_0 : \gamma = 0$ in

$$\Delta\hat{\epsilon}_t = \gamma\hat{\epsilon}_{t-1} + \sum_{i=2}^p \beta_i \Delta\hat{\epsilon}_{t-i+1} + v_t.$$

[Table 2]

The critical values in Table 2 are for the 5% level of significance. As seen, the null hypotheses of residuals being non-stationary is rejected ($\gamma \neq 0$).

The KPSS test results on level stationarity are reported in Table 3. The test statistics is computed for the lag truncation parameter, l , from 0 to 8. As argued by Kwiatkowski, Phillips, Schmidt & Shin (1992), for $l = 8$ the test has got the largest power. Including $l = 0$, the test accounts for

autocorrelation. More details can be found in Kwiatkowski et al. (1992).

The critical value for the test at the 5% significance level is 0.463.

[Table 3]

The results on KPSS test suggest that the regression residuals form (8) are stationary. Putting the result together with the ADF test, it may be concluded that the residuals do not contain a unit root and follow a stationary process. Consequently, the parameter estimates reported in the text are unbiased and consistent, although, inefficient.

Appendix B

In this appendix, the methodology for obtaining the critical values reported in the text is outlined. The methodology relies on Monte Carlo experiments. Mishkin (1990*b*) was the motivation for this approach.

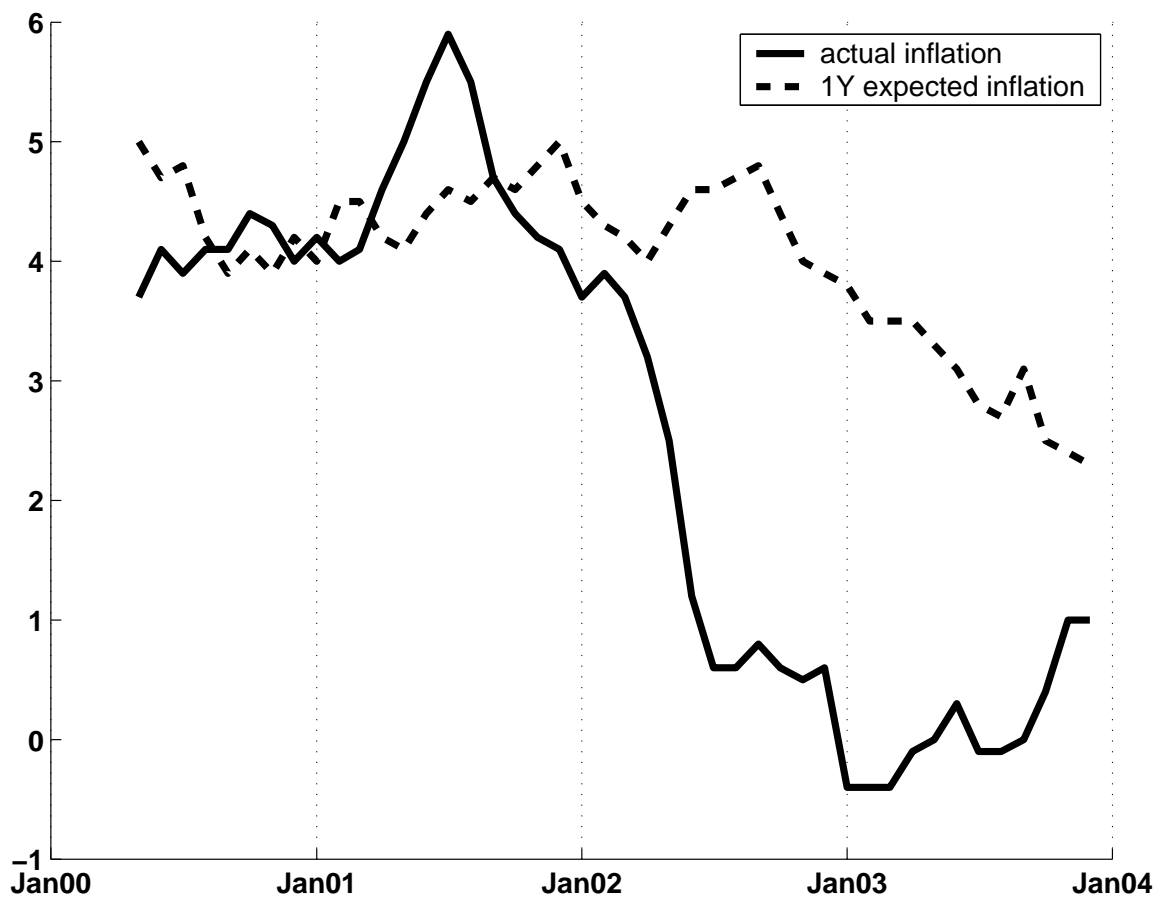
The methodology can be summarized in a few following steps:

1. Analyze the time series of model variables, i.e., PRIBOR 1Y, year-to-year inflation, and inflation expectations, on the unit root.
2. Apply the Box-Jenkins methodology on the data. The outcome ought to be an ARIMA(p,d,q) model with the best fit as possible.
3. Simulate the estimated models from the previous step.
4. Using the simulated time series, estimate equation (8), and save the results on the t-tests.
5. Repeat steps 3.) and 4.) 10,000 times.
6. From step 5.) construct a new distribution for critical values.

The simulated critical values are reported in Table 4.

[Table 4]

Figure 1: Comparison of inflation expectations and actual inflation



**Figure 2: Comparison of inflation expectations and
1Y PRIBOR**

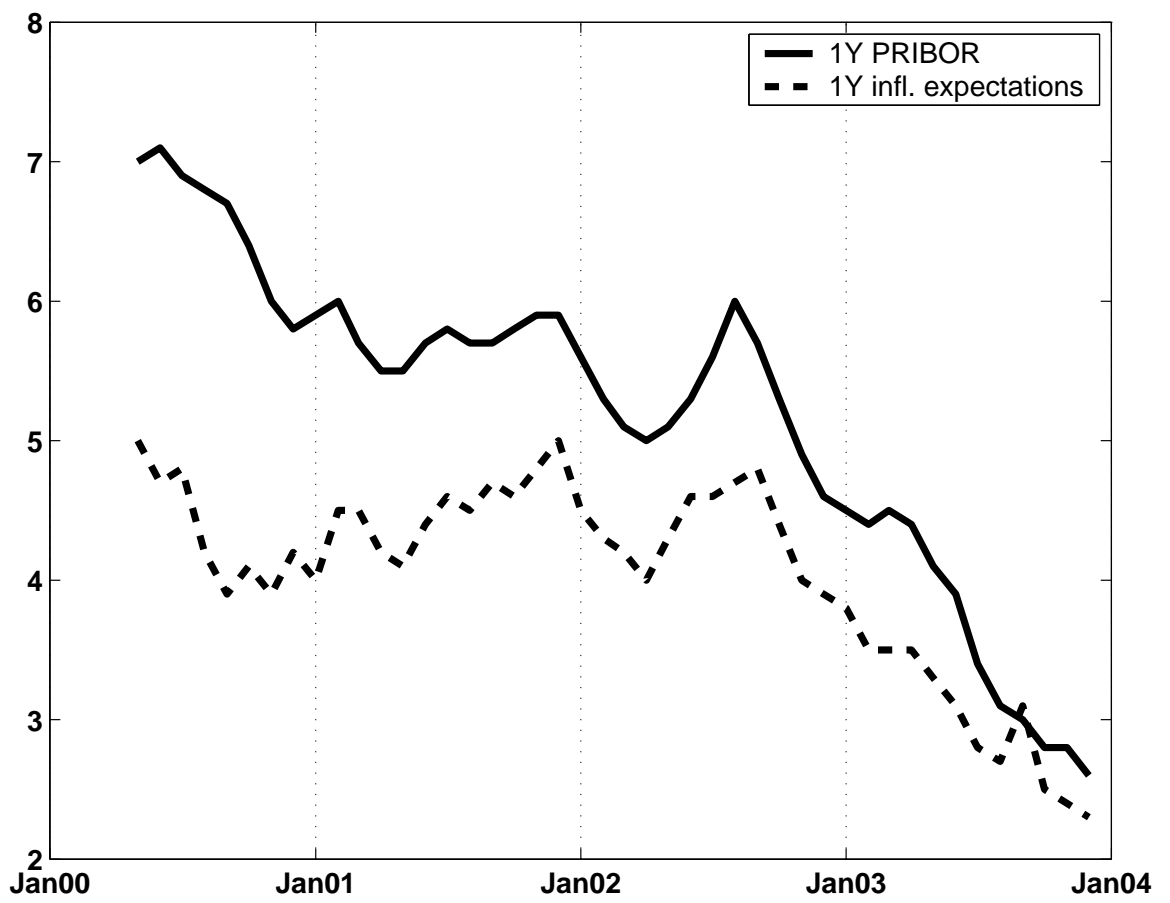
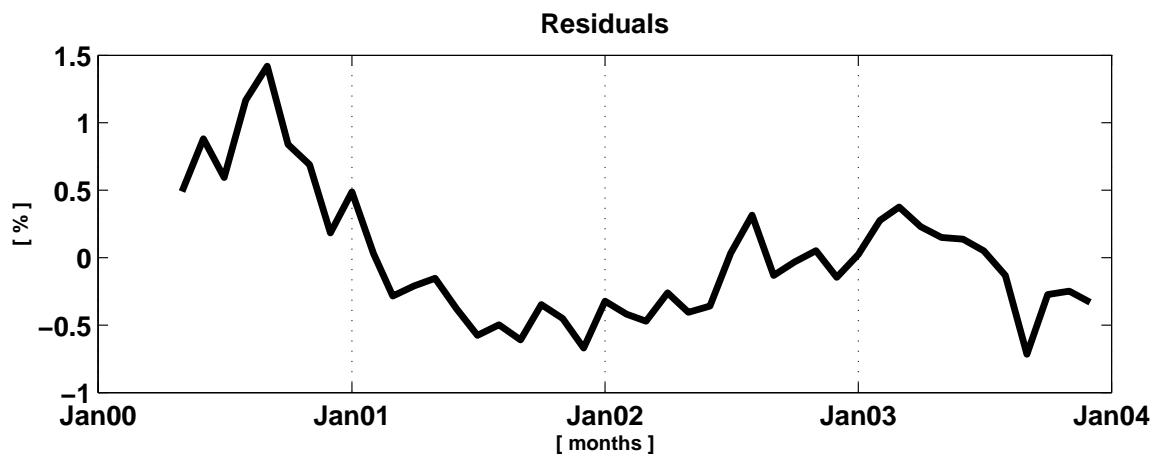
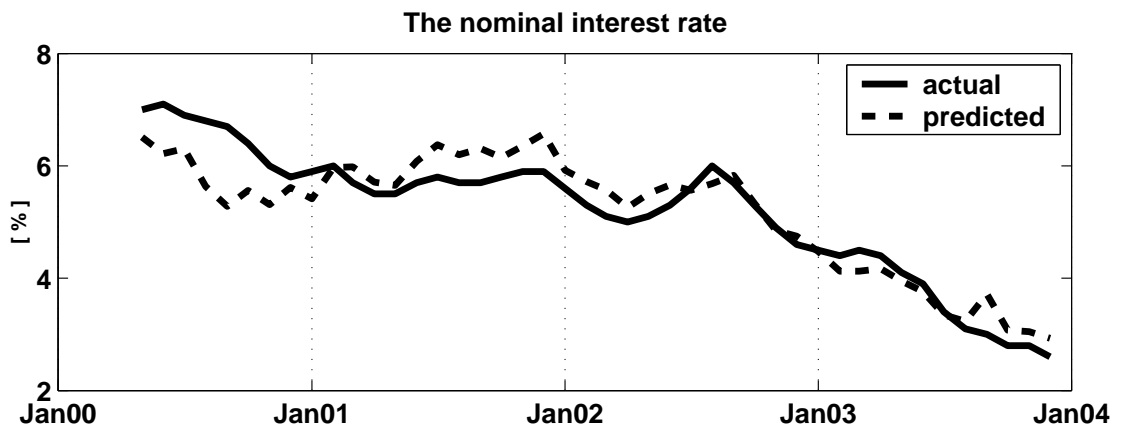


Figure 3: The regression results of equation (8)



Tables

Table 1: $i_t = a_r + a\pi_{t+1} + b\pi_{t+1}^e + \epsilon_t$

Parameter	Estimate	t-stat.	Critical value	DW	\bar{R}^2	No. of obs.
			5%			
a_r	0.0810	0.1688	4.5052			
a	0.1526	3.2986	4.3978	0.32	0.82	44
b	1.1726	8.8514	4.6014			

Table 2: Augmented Dickey-Fuller Test Results

Parameter	Estimate	t-test	t-crit.	F-test	Q-test
				(p-value)	(crit.val.)
γ	-0.3526	-7.8295	-1.95		
β_1	-0.0716	-0.8492	-1.69		
β_2	-0.0201	-0.2380	-1.69	2.98	18.28
β_3	0.2030	2.4783	-1.69	(0.02)	(25.70)
β_4	0.2160	2.4014	-1.69		
β_5	0.2355	2.6853	-1.69		

Table 3: Kwiatkowski-Phillips-Schmidt-Shin Test Results

l	0	1	2	3	4	5	6	7	8
$\hat{\epsilon}_t$	1.10	0.62	0.44	0.35	0.30	0.27	0.24	0.23	0.22

Table 4: The empirical critical values

Parameter	25%	10%	5%	1%
a_r	1.7339	3.6738	4.5052	7.2765
a	1.7232	3.4252	4.3978	6.8293
b	1.8041	3.4825	4.6014	6.8393