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Factors Determining the Exchange Rates in Inflation Targeting Monetary Policy: An Empirical Investigation the Turkish Case

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Abstract

This study aims to evaluate the forecasting performance of traditional and recently developed exchange rate models with the data obtained from Turkey. Within the performance framework it is also possible to discuss the fundamental factors that affect the exchange rates in an economic environment with floating exchange rate regime and inflation targeting monetary policy. All of the exchange rate models outlined in the study, except the sticky price monetary model and augmented Taylor rule model with the real exchange rate, reveal the presence of cointegration relationship among the explanatory variables specific to each model. This situation reflects that prices rapidly adjust to excess demand as pointed out by the monetary model with flexible prices. Unconfirmed cointegration relationship by the Taylor rule model augmented with the real exchange rate in the special case of Turkey could be accepted as a result of absence of a specific exchange rate target and interventions to foreign exchange markets oriented only to control the volatility. In the context of out of sample forecasting performance, monetary model with flexible prices including the conditions of uncovered interest rate and purchasing power parities is the best model outperforming the random walk model in terms of short and long term forecasting. Obtained results also show that there is a strong connection between exchange rates and economic fundamentals and that interest rates, at least in the short run, are highly substantial in explaining and predicting the exchange rate movements.

I. Introduction

During the last three decades there has been a significant increase in the research studies related to exchange rates. The reason for this increase is to clarify the variables underlying exchange rate behavior besides the collapse of Bretton Woods system in 1971. Aftermath of Bretton Woods, there has been a number of episodes and incidents strongly proving the role of exchange rates on the economic growth and development process. Rapid depreciation of the currencies of Latin American countries during 80s, exchange rate crises experienced by Italy, Britain and Spain during 90s, exchange rate crises known as Tequila Crisis lived in Mexico and Argentina in 1994 after the collapse of currency board in Argentina, Far East Asian and Russian crises are among the events that can be immediately listed. Turkey, naturally, were affected by these crises and experienced crises specific to herself in which the underlying factors include the balance of payments and exchange rate issues. Economic crises in 1980, 1994 and 2001 are the featured ones during this period. Turkey actualized sweeping changes in her exchange rate policy after each of the mentioned crises and the Turkish Lira devaluated in high rates reaching 120%. After the balance of payment crisis in 1980 Turkey abandoned the fixed exchange rate regime and started to apply the controlled floating regime, passed to crawling peg regime in 1994 and finally returned the floating exchange rate regime in 2001. Immediately after the radical change in exchange rate regime in 2001, Turkey has also adopted the inflation targeting regime in conducting monetary policy implicitly in 2002, explicitly in 2006.

After adopting the inflation targeting regime Turkey experienced periods in which Turkish lira strongly appreciated or depreciated. Because interest rate was used as primary instrument of monetary policy by the Central Bank of the Republic of Turkey (CBRT) and the Turkish Lira was leaved to fluctuate under monetary policy regime, using the exchange rate as a target was out of question. In spite of the fact that CBRT does not have a concrete target on exchange rate, it intervenes to the foreign exchange market from time to time in order to prevent the high volatility in exchange rates. However these interventions revived a trade-off widely discussed in recent years. Studies related to this topic present various evidence that central banks faced with a trade-off between monetary and exchange rate policies as a result of high exchange rate volatilities (Kamil, 2009). If the exchange rate displays a considerable deviation from its equilibrium value, the intensity of the trade-off further increases (Zampoli, 2006).

Together with the inflation targeting regime in Turkey during the last decade there is a widespread belief that the volatility of exchange rates has increased. Consequently it gains a deep importance to search the economic factors affecting exchange rates in terms of conducting and improving monetary policy. Some studies conducted recently in the economics literature obtain interesting results showing that controlling the international capital movements (Celements – Kamil, 2009) and intervening of central banks to the foreign exchange markets (Kamil, 2008) have no effect on the level of exchange rates, in contrast they increase the volatility. In particular, the fear of floating argument is among the frequently investigated topics.

Regarding above stated rationale, this study aims to analyze the relevance of different exchange rate models and to identify which one includes the fundamental determinants of exchange rates in an inflation targeting monetary policy framework in the period of 2002 – 2013 in Turkey. This study uses the monetary models when it comes to estimation phase because of the following reasons: Some of the exchange rate models (1) do not give place to monetary policy, (2) handle the problem with the microeconomic approach, (3) require a longer time period for estimation and could not be estimated due to unavailable data.

Analysis that will be performed in the study includes the traditional models such as sticky price monetary model, flexible price monetary model, Balassa – Samuleson model, uncovered interest rate parity model and also recently developed models such as Taylor rule model. Including different models, it is possible to test the hypothesis that traditional models and specifications based on endogenous monetary policy assumption have a more predictive power than random walk specification. Inclusion of endogenous models to the analysis makes also possible to study the proposed strong connection between exchange rates and interest rates.

The rest of the paper is organized as follows: In the first part entitled Short Empirical Review, latest empirical studies related with the out of sample forecasting performance of exchange rate models which were raised by the classic Meese – Rogoff (1983) study are shortly reviewed. In the second part, functional forms of the exchange rate models to be estimated in this study are specified and the expected results are discussed in the context of Turkish economy. In the third part named as Empirical Analysis, the data set, exchange rate developments during the investigation period are discussed and the results of cointegration analysis are evaluated. Finally, in the fourth part, out of sample forecasting results are interpreted and some economic policy inferences are made. In the Conclusion section, the main findings of the study are summarized and outstanding results and policy recommendations are discussed.

II. Empirical Review

The first research regarding the out of sample forecasting performance of exchange rate models was conducted by Meese – Rogoff (1983). According to this study, exchange rate models were inadequate in explaining the behavior of exchange rates during 70s and random walk model enabled the more consistent forecasts than the traditional models. After the mentioned first study in the economics literature, there were a couple of different studies toward investigating the same subject for different time periods, countries or regions. For instance, Sorno – Taylor (2002) analyses the different exchange rate determination models and summarizes the empiric studies performed from the early 1980s. One of the main conclusions of that study is that there isn't any powerful and reliable model other than the random walk in terms of in sample and out of sample forecasting performances. Although, compared to random walk model, some consistent estimation are obtained by incorporating dynamic equations to the out of sample forecasting techniques, it is remarkable that these techniques produce different results for different currencies and time periods.

One of the conspicuous study among researches regarding the inclusion of dynamic equations to the exchange rate models is the Engel – West (2006) study which focuses on asset market approach to the exchange rate determination. Incorporating the rational expectations to the traditional exchange rate models, according the results obtained by the mentioned study, do not produce more efficient outcomes than the random walk model alone.

Another study analyzing the forecasting power of traditional models is conducted by Cheung – Chinn – Pascual (2005). Unlike other studies that work includes productivity differentials in tradable sectors among countries in to the exchange rate model they used. The results of the research conducted show that none of the exchange rate models can explain the behavior of exchange rates alone, only some of the models show a better performance than others in specific periods. This also means that there isn't sufficient evidence for evaluating the forecast performance of those models.

Much of the studies recently conducted about out of sample forecasting focus on endogenous monetary policy models. For instance, the research conducted by Molodtsova – Papell (2009) analyses the predictability of exchange rates in OECD countries by issuing Taylor rule model and compares the results with purchasing power parity model and some other monetary models. According to study, in monthly basis, out of sample forecasting performance of endogenous models outperforms the traditional models.

As can be seen in the aforementioned short review, it is a fact that Taylor rule models came forward recently in the economics literature related to exchange determination. In order to evaluate the forecasting performance of Taylor rule model different forecasting techniques have been developed and used. For instance, Mark (2005) develops a model in which economic agents try to obtain required information without having any idea about the coefficients of the model. This study reaches the conclusion that the Taylor rule model is the best one to explain the behavior of the US Dollar/German Mark and presents evidence that it produces more realistic outcomes than the conventional exchange rate models.

It is possible to say that there are a few studies regarding the evaluation of out of sample forecasting performance of traditional exchange rate models and random walk model in the context of developing countries and most of them are about the Latin American countries. For instance, in the Rowland – Oliveros (2003) study, purchasing power parity integrated Balassa – Samuleson model is tested and it is concluded that the developed model produces more consistent estimates than random walk model when one considers the long estimation periods from 12 to 24 months.

In the study conducted for Colombia, different traditional forecasting methods are used and the results are compared with results of Meese – Rofoff (1983) study in which a simple random walk procedure is used (Rowland, 2003). Two of the traditional models produce more consistent out of sample estimates than the random walk model in the long run forecasting horizon. The basic reason for such result, according to the author, is that a relatively long investigation period (1970 – 2002) is covered in the study.

III. Exchange Rate Forecasting Models

In this part of the study we put forth the exchange rate models using the equations to be estimated. Consequently, we deal with the models with their functional forms to be used in the estimation phase keeping out the theoretical controversies. In this regard the models to be estimated can be listed as sticky price monetary model, flexible price monetary model, Balassa – Samuelson model, uncovered interest rate parity model and Taylor rule model.

III.1. Flexible Price Monetary Model

Sorno – Taylor (2002) defines the flexible price monetary model as a predominant model of 70s. As it can be understood from the name of the model, it assumes full flexibility in prices and the natural rate hypothesis in output level. Full price flexibility means that is there is an excess demand in the economy, for instance, prices fully adjust instantaneously. At the same time, because of the full capital mobility assumption, interest rate in the long run is exogenous. In the flexible price monetary model it is accepted that the purchasing power parity and uncovered interest rate parity conditions hold.

Including full price flexibility in domestic and foreign markets, we can write down the following equations in which variables with an asterisk represent the foreign values of the related variables:

$$m_t = p_t + \kappa y_t - \theta i_t \quad (1)$$
$$m_t^* = p_t^* + \kappa^* y_t^* - \theta^* i_t^* \quad (2)$$

where m and m^*, p and p^*, y and y^*, i and i^* represent the monetary aggregates, price levels, output levels and interest rates, respectively. Since the nature of the model requires purchasing power parity to hold, we will have

$$s_t = p_t - p_t^* \quad (3)$$

Here the exchange rate defined as the value of one unit of foreign currency in terms of domestic currency is shown by s. The final form of flexible price monetary model can be obtained by subtracting equation (2) from equation (1) and substituting into equation (3):

$$s_t = (m_t - m_t^*) - \kappa(y_t - y_t^*) + \theta(i_t - i_t^*) \quad (4)$$

As Moura – Lima – Mendoca (2008) points out, the final form obtained above can be written econometrically in the reduced form as:

$$s_t = \beta_0 + \beta_1(m_t - m_t^*) + \beta_2(y_t - y_t^*) + \beta_3(i_t - i_t^*) + \zeta_t \quad (5)$$

The variables in the above equation are defined as follows:

s_t	: log of nominal USD/TL exchange rate
m_t	: log of M1 monetary aggregate
m_t^*	: log of U.S. M1 monetary aggregate
y_t	: log of manufacturing production index
y_t^*	: log of U.S. manufacturing production index
i_t	: short term interest rate
i_t^*	: short term U.S. interest rate
ζ_t	: error term with the classical properties (IDD)

III. 2. Sticky Price Monetary Model

Developed by Rudiger Dornbusch, this model includes the overshooting of exchange rate above its long term equilibrium value. Like flexible price monetary model, output is also its natural level, but the price level adjusts gradually in case of an aggregate demand shock. The result of this type of specification is that stickiness of variables like price level is compensated by the variables like exchange rate and interest rate.

In fact, this model, as pointed out by Cheung – Chinn – Pascual (2005), is an expanded version of the purchasing power parity model. If one takes into account this determination, the sticky price monetary model has the capability to explain the phenomenon of "neutrality of money". In other words, a change in monetary aggregates creates an equal change in prices in the long run instead of increasing output. In the context of the behavior of exchange rates, if the prices are sticky in the short run, a decrease in monetary aggregates, for instance, reduces the real money balances at the beginning and increases interest rate in the short run (Sarno – Taylor, 2002). Although exchange rate appreciates, in the long run, as a result of decreasing real balances price level starts to decrease and then so does interest rate. In this case appreciating exchange rate in the short run depreciates in the long run. In fact this situation explains the existence of devaluation expectations in countries with high interest rates. In the light of these statements related to operating mechanism of sticky price monetary model, the specification to estimate will be as follows:

$$s_t = \beta_0 + \beta_1(m_t - m_t^*) + \beta_2(y_t - y_t^*) + \beta_3(i_t - i_t^*) + \beta_4(\pi_t - \pi_t^*) + \zeta_t \quad (6)$$

In addition to those previously defined π_t shows the annual inflation rate realized each month in home country, π_t^* is the annual inflation rate measured each month in the USA.

III.3. Balassa – Samuelson Model

This model is completely based on the portfolio balance model in which the exchange rate is determined by the supply and demand conditions in the market (Binici, 2007). Compared to two models previously discussed this specification presents three different points: (1) There is no place to purchasing power parity condition, (2) There is no requirement for uncovered interest rate parity condition and (3) Productivity differential between two countries which determines the direction of exchange rate is placed in the model. The form to estimate, for this reason, can be written as follows:

$$s_t = \beta_0 + \beta_1(m_t - m_t^*) + \beta_2(y_t - y_t^*) + \beta_3(i_t - i_t^*) + \beta_4(z_t - z_t^*) + \zeta_t \quad (7)$$

In addition to those previously defined, the variables in the model are described as:

z_t : log of the productivity in tradable and nontradable sectors
z_t^* : log of the productivity in tradable and nontradable sectors in the USA

The problem here is the availability of these productivity indices. For instance, there is no detailed data related to grouped productivity indices for Turkey. The methodology suggested by Moura – Lima – Mendonca (2008) is used and reciprocal of price indices in each sector is proportioned to obtain the time series. In order to avoid possible bias the same methodology is applied for two countries.

III.4. Uncovered Interest Rate Parity Model

The simplest definition of this concept could be stated as that the differential between two countries' interest rates determines the expected rate of change in exchange rate (Molodtsova – Papell, 2009). If uncovered interest rate parity condition holds, investors cannot obtain a return greater than the market's return. Following Moura – Lima – Mendonca (2008), two different interest rate parity conditions will be included in this study. In the first specification, it is accepted that the exchange rate is a function of interest rate differential only. In the second one, fundamentals related with the risk factor are included in the specification. As a result, equations to estimate in empirical part of this study can be written as follows:

$$s_t = \beta_0 + \beta_1(i_t - i_t^*) + \zeta_t \quad (8)$$

$$s_t = \beta_0 + \beta_1(i_t - i_t^*) + \beta_2(embi(+))_t + \zeta_t \quad (9)$$

In the last equation embi(+) refers the risk factor measured by the logarithm of EMBI(+) index while the other variables stand for previous definitions.

III.5. Taylor Rule Model

In the studies aiming to analyze the exchange rate forecasting models, the fundamental equations of Taylor rule model are specified and discussed in detail (see, for instance, Rogoff, 2002; Obstfeld, 2004; Macdonald, 2000; Clarida – Gali – Gertler, 1998). In this part of the study we try to put forth the empirical forms in the estimation of the model and to obtain the final forms of the equations. As known, if central banks determine the interest rate in accordance with Taylor's two-country model, a relationship arises between exchange rate and fundamental economic variables. If we show the realized inflation rate in terms of deviation from the target with π_t, the output gap (or deviation from long term equilibrium value to have same meaning) with y_t, as stated by Engel – West (2006) and Deverux – Engel (2007), we can write the monetary policy rules in home and foreign country as:

$$i_t^* = \gamma_s E_t \pi_{t+1}^* + \gamma_s y_t^* \quad (10)$$

$$i_t = \gamma_q(s_t - \bar{s}_t) + \gamma_s E_t \pi_{t+1} + \gamma_y y_t \quad (11)$$

In addition to previously defined variables, $\bar{s}_t$ is the exchange rate target, E_t is the mathematical expectation operator. While the equation (10) is known as the standard Taylor rule, equation (11) is obtained by adding the nominal exchange rate and its target to the standard rule. As expressed by Engel – West (2006), it is accepted that two countries have similar monetary policy parameters. Most of the studies about Taylor rule incorporate the expected inflation to the monetary policy rule. Since central banks do not have any information about the current price level when they specify the interest rate targets (domestic and foreign), including expectations into the model is acceptable. However, as we discuss below, the aim of this study is not to develop a monetary policy rule but to estimate the exchange rate.

In order to transform the model to an exchange rate determination model, purchasing power parity should be inserted to the model as follows:

$$\bar{s}_t = p_t - p_t^* \tag{12}$$

Since the exchange rate is defined as the value of one unit of foreign currency in terms of domestic currency and, therefore, $\gamma_q > 0$, according to equation (11) central bank increases the interest rate when domestic currency depreciates regarding target level. If we subtract the foreign country monetary policy rule from that of home country we obtain

$$i_t - i_t^* = \gamma_q(s_t - \bar{s}_t) + \gamma_\pi[E_t\pi_{t+1} - E_t\pi_{t+1}^*] + \gamma_y(y_t - y_t^*) \tag{13}$$

If we add the uncovered interest rate parity condition to the above equation and use the definition of exchange rate target, we write the following equation for exchange rate:

$$s_t = \gamma_q(i_t - i_t^*) + \gamma_q(p_t - p_t^*) - \gamma_\pi(E_t\pi_{t+1} - E_t\pi_{t+1}^*) - \gamma_y(y_t - y_t^*) + (1 - \gamma_q)E_t(s_{t+1}) \tag{14}$$

In this equation the expression $(i_t - i_t^*) + (p_t - p_t^*)$ refers to fundamentals that determine the exchange rate. If we exclude the unobservable variables from the above specified equation, we obtain the following equation that could be used to estimate the exchange rate:

$$s_t = \alpha_0 + \alpha_1(i_t - i_t^*) + \alpha_2(p_t - p_t^*) + \zeta_t \tag{15}$$

Considering the aforementioned discussions on Taylor rule model, it will be included into this study with two different specifications:

$$s_t = \beta_0 + \beta_1(\pi_t - \pi_t^*) + \beta_2(y_t - y_t^*) + \beta_3(i_t - i_t^*) + \zeta_t \tag{16}$$

$$s_t = \beta_0 + \beta_1(\pi_t - \pi_t^*) + \beta_2(y_t - y_t^*) + \beta_3(i_t - i_t^*) + \beta_4(q_t) + \zeta_t \tag{17}$$

In these specifications, two points should be clarified. First, none of the specifications covers the partial adjustment mechanism. Since testing the partial adjustment hypothesis is out of this study's goals and requiring the inclusion of it after testing the hypothesis, we have not put the partial adjustment process into the models we discussed. Second, recently developed Taylor rule models include expectations on the right hand side as an additional explanatory variable. However, modelling expectations is also an issue that should be tested. Due to lack of the data related to expectations in Turkey, we have not put the expectations into the Taylor rule model.

IV. Analysis

In this part of the study we shortly discuss the methodology that we use to test the existence of a multivariate cointegration relationship and test procedure to be applied in the rest of the paper. First of all we present the scope and the sources of the data that will be used in estimation process. After reviewing the estimation procedure we evaluate the estimation results on the basis of econometrics and economic policy.

IV.1. Sources of the Data

The data to be used in this study consists of monthly observations. It is accepted that the domestic country is Turkey and the foreign is the United States because all the estimations will be carried out by using USD/TL foreign exchange rate. All the data related to Turkey, except the data representing the risk premium, comes from CBRT's EDDS data base. The US data comes from the Federal Reserve Bank of St. Louis' FRED data base.

Because the study aims to model the exchange rate under the inflation targeting monetary policy regime in Turkey, estimation periods starts with the introducing date of this framework, 2002. On this ground the estimation period is determined as January 2002 – December 2013. The out of sample forecasting period covers the whole year of 2013.

IV.2. Estimation Procedure

The estimation procedure to be used in this study consists of various consecutive and interdependent estimations and tests. Below this procedure is outlined:

1) In the framework of Engle – Granger methodology, in order to seek for the existence of cointegrating relationship and to obtain statistically significant cointegrating vector, all the variables should present a first degree integration characteristic. To investigate this issue unit root tests should be performed.

2) There are various techniques to determine the maximum lag length. These techniques often produce similar results and, therefore, the Akiake Information Criteria (AIC) as the most common used procedure in the literature will be used for this purpose.

3) In order to identify cointegration rank and to get the deterministic components the likelihood ratio tests should be used in the process of generating the optimal model. To do this we are going to use the Trace and Maximum Eigen Value tests by considering the MacKinnon – Haug – Michelis critical values. After deciding the deterministic components and the number of cointegrating vectors, we estimate and normalize the cointegrating vectors among related variables.

4) Diagnostic checking of the estimated models are going to be performed by using the weak exogeneity, stationarity and exclusion tests while residuals are tested in terms of autocorrelation and normality.

IV.3. Pre-Tests and Estimation Results

Before analyzing the estimation results, as a first step, we should examine the test results for the degree of integration of the variables. In this study, the null hypothesis that the variable under consideration is integrated of first-degree is tested against the alternative by using Augmented Dickey – Fuller (ADF) and Phillips – Peron tests. Obtained results of these tests are given as Table A1 in the Appendix. According to the table all of the variables are integrated of first degree, that is, they are the time series with I(1) characteristic. This shows us that the cointegration relationship can be investigated in terms of the models economic theory state.

The first model to estimate is the flexible price monetary model given by equation (5). The results of the estimation and diagnostic checking are presented in Tables A2, 3, 4 and 5 in appendix. Both Trace and Maximum Eigen Value tests indicate two cointegrated vectors among variables in Table A2. Diagnostic checking of this relationship is given in Table A3. According to test results none of the variables should be excluded from the model and they are all non-stationary time series. Table A4 and A5 show the normalized cointegrating vector estimates and the results of diagnostic tests for residuals, respectively. According to the results the second cointegrating vector has the expected sign and all of the variables used in the model are beneficial to explain the exchange rate behavior. However, the monetary aggregates and the manufacturing production index are the variables come forward. Estimation results also show that the adjustment speed of exchange rate is almost 3% monthly. In other words, disequilibrium in that variable tends to equilibrium with that speed. Of the diagnostic tests for residuals, the LM test shows no serial correlation while Lutkepohl test indicate a normally distributed error terms obtained from the estimation of the model.

Cointegration test results among variables related to sticky price monetary model already given in equation (6) are presented as Table A6 in the appendix. Considering the results, there is no evidence that there is a cointegrating relationship. Both Trace and Maximum Eigen Value tests indicate rejection of the existence of cointegration in all cases. Existence of 5 cointegrating vectors among 5 variables means that there is no tendency to reach an equilibrium point in the long run and this removes the possibility of cointegration among variables. This result points out that flexible price monetary model is more expressive than the sticky price monetary model in clearing up the behavior of exchange rate.

After estimating the flexible and sticky price monetary models we can go forward with Balassa – Samuelson model's estimation. Including the productivity differential $(z_t - z_t^*)$, the estimation results of Balassa – Samuelson model given by equation (7) in the text are shown in tables A7 through A10 in appendix. Table A7 shows the results of likelihood ratio tests for Balassa – Samuelson model. Considering the Trace and Maximum Eigen Value tests, there are at least three cointegrating vectors among time series representing the variables covered in the model. If we accept the existence of these vectors any of the variables in the model cannot be excluded as shown in Table A8 and all the variables are not stationary. Table A9 and A10 show the estimations for normalized cointegrating vectors for Balassa – Samuelson model and results of the diagnostic tests for the residuals, respectively. As it is seen in Table A9, second and third cointegrating vectors have the expected signs and the coefficients of the third vector are greater than those of second one. Monthly adjustment speed of exchange rate to its equilibrium level is almost 6%. The adjustment is almost twice compared with flexible price monetary model. The reason for that is the inclusion of productivity differential between two countries into the model. The other diagnostic tests also reveal the serial correlation and the normality of the error terms as seen in Table A10.

The next model to estimate is uncovered interest rate parity model and has already been given by equation (8). Table A11 through A14 in the appendix present the estimation results. As Table A11 shows there is one cointegrating vector among the variables belong to uncovered interest rate parity model. Both cointegration tests used in this study indicate the existence of cointegrating relationship under the inflation targeting regime although the model contains only one explanatory variable, namely the interest rate differential. In fact this is an unexpected result for the conductor of this study since the mentioned variable does not reflect through cost of borrowing in Turkey. Consequently, diagnostic tests gain more importance to validate this result. The first step diagnostic tests show that the interest rate differential should take part in the model and the non-stationary hypothesis is not broken. If we look up the normalized cointegrating vector and the adjustment speed of exchange rate, the results are economically confusing. First, the coefficient of interest rate differential does not have the expected sign. Second, although the expected value of the coefficient is to be greater than one after normalization procedure, the estimated value shows considerable deviations from the expected value. Monthly adjustment speed is 4%, a value between the models already been estimated. However, considering transaction speed in today's financial markets, it is expected that the adjustment process would be even faster. Although the LM test for residuals shows the indication of no serial correlation, Lutkepohl test indicates that the error term is not normally distributed. This increases doubts on the model giving the idea that including the risk premium into the model to solve the problem. Equation (9) presents the extended uncovered interest rate parity model by using the risk premium that has been proxied by EMBI+ Turkey index. Estimation and diagnostic checking tests can be seen in Tables A15 through A18 in the appendix. As stated by Moura-Lima-Mendonca (2008), especially in emerging markets like Turkey, there may be some risk factors that the basic uncovered interest rate parity model does not cover. Table A15 shows the existence of two cointegrating vectors in the extended model while Table A16 indicates the absence of variables to be excluded and non-stationary of the time series used to estimate the model. However, only the second cointegrating vector has the expected sign and the interest rate elasticity of exchange rate is remarkably lower than the expected (Table A17). This result shows that the inclusion of risk premium into the model improves the efficiency of estimation, but it couldn't remove the doubts about model's ability to explain exchange rate behavior. The other noticeable point in the estimation results is the increase in adjustment speed. The monthly adjustment speed was 4% in the uncovered interest rate parity model contrary to our expectations, however, it is more than doubled in the extended model reaching the 9% monthly. The diagnostic tests do not signify any problem on serial correlation and normality (Table A18).

After investigating the outcomes of traditional exchange rate models we should deal with the estimation issue in terms of Taylor rule model. The first model we handle is the so called basic Taylor rule model specified as equation (16). The results of the estimation of this model and of the diagnostic tests are given in the appendix as Table A19 – A22. Table A19 indicates the existence of two cointegrating vectors among the variables included in the basic Taylor rule model. There isn't any variable to be excluded from the model and all the time series represent a non-stationary characteristic (Table A20). In Table A21 which gives the normalized cointegrating vectors and adjustment speed estimations, the first point we have to emphasize is that the coefficients of interest rate differential have different signs in two vectors. As Molodtosova-Papell (2009) points out, it is more suitable to expect that an increase in interest rate causes to appreciate of domestic currency instead of depreciating at first. This issue is conflicting with the traditional uncovered interest rate parity model stating reverse interaction. Since in Taylor rule models an increase in inflation results in a raised interest rate by the central bank, domestic currency appreciates initially. If this is the case, the obtained result has an opposite sign. The reason for that situation is that the exchange rate pass through mechanism does not work simultaneously in accordance with the Taylor rule model.

Albeit the CBRT does not announce any target level for exchange rates under the floating regime, the real exchange rate is included into the model with the idea that it represents the tendency of exchange rates in the long run. In other words, the real exchange rate in the extended Taylor rule model is not a policy variable of the central bank, but is a proxy variable for long run tendency in exchange rate. Accordingly, the real exchange rate extended Taylor rule model specified in equation (17) is estimated with the same systematic we have already followed. The results of this procedure are given as Table A22 in the appendix. There isn't any cointegration relationship in the real exchange rate extended Taylor rule model. Most probably this result is due to absence of exchange rate target announced by the CBRT under the inflation targeting monetary policy regime and the direct intervention of the CBRT to foreign exchange rate market when the volatility in the market is increasing.

V. Out of Sample Forecasting Performance

In this section the out of sample forecasting performance of the exchange rate models estimated are evaluated. First, we shortly discuss the methodology for this purpose and, second, analyze the results of out of sample forecasts under "Performance Analysis" title.

V.1. The Methodology

In this part of the study we are going to use the methodology suggested by Meese-Rogoff (1983) to evaluate the forecasting performance of the models we have already estimated. In the mentioned study traditional exchange rate models are compared to random walk model without trend. Therefore we will only take into account the models that prove the existence of cointegrating relationship. It will be remembered that flexible price monetary model, Balassa-Samuelson model, uncovered interest rate parity model, risk premia extended uncovered interest rate parity model and basic Taylor rule model prove the existence of cointegrating vector or vectors while sticky price monetary model and real exchange rate extended Taylor rule model show no cointegrating relationship among variables related each model. In the estimation process of the cointegration tests the January 2002 – December 2013 period has been taken as basis. If there is at least one cointegrating vector in the model the future values of exchange rate should be estimated by vector error correction model with different time dimensions ahead. In this study future values of the exchange rate will be estimated by 1, 3, 6 and 12-month time periods. The main objective here is the usage of rolling regression technique in order to constitute a forecasted time series for exchange rate. At the beginning, the first estimation of the model is carried out by using the data for January 2002 – December 2011. The second estimation is performed by using the data for February 2002 – January 2012, the third estimation is performed for March 2002 – February 2012 and the process continues until reaching the last observation. In other words, until reaching the December 2013 observation the process is repeated and the sample size of estimation period considered at the beginning is preserved. The reason for selecting the last two years as the out of sample period is that the CBRT has started to use an interest rate corridor system (a kind of Lombard system) instead of traditional monetary policy measures from the beginning of 2010 and to increase the intervention frequency to the foreign exchange market. Naturally this process requires a static forecasting methodology instead of dynamic one because the policy makers use the actual data (not the forecasted) when they form their decisions for the future.

After obtaining the forecasts of time series by using the above outlined procedure, results are compared to the results of random walk model without trend. This random walk process is defined as:

$$s_{t+k} = s_t \tag{17}$$

In order to evaluate the out of sample forecasting performance of the models we are going to use three indicators two of which are statistical values and the other is a statistical test. These indicators can be listed as RMSE, MAE and sign test. The statistical values known with the abbreviations RMSE (Root Mean Squared Error) and MAE (Mean Absolute Error) are the performance appraisal criteria when the same variable is estimated by using different models. The sign test however is a test methodology to analyze the difference of the forecasts produced by the various specifications.

The ratio of the RMSE value of each model to the RMSE value of random walk model is used whether the exchange rate model shows a better performance than random walk model or not. The same procedure is also applied and evaluated for the MAE values of exchange rate models and random walk model. When there are a small number of ahead estimations, the sign suggested by Diebold-Mariano (1956) is used to test for the validation of estimates. This is a test based on the usage of loss function. RMSE, MAE and the related ratios are calculated by using the following formulas:

$$RMSE = \sqrt{\frac{\sum_{s=0}^{N_{k-1}}(F_{t+s+k}-A_{t+s+k})^2}{\mathrm{N}_k}} \tag{18}$$

$$MAE = \frac{1}{N_k}\sum_{s=0}^{N_{k-1}}|F_{t+s+k} - A_{t+s+k}| \tag{19}$$

$$R_{RMSE} = \frac{RMSE_{fxmodel}}{RMSE_{random}} \tag{20}$$

$$R_{MAE} = \frac{MAE_{fxmodel}}{MAE_{random}} \tag{21}$$

where F_t and A_t show the forecasted and actual exchange rate values for t period, respectively. In the equations k represents the dimension of estimates while N_k indicates the number of forecasts in the estimation period. If the ratio (R_{RMSE}) of $RMSE_{fxmodel}$ (RMSE value for the exchange rate model) to $RMSE_{random}$ (RMSE value for the random walk model) is greater than 1 we conclude that the random walk model has a better performance than the related exchange rate model. Similarly, R_{MAE} value represents the ratio of MAE value for the exchange rate model ($MAE_{fxmodel}$) to MAE value for the random walk model (MAE_{random}). If the R_{MAE} ratio is greater than 1 it is concluded that random walk model shows a better performance than exchange rate model.

The loss function to calculate the sign statistic is based on the SPE (Squared Predicted Error) values of each exchange rate and random walk models. The values of SPE are calculated for each date in the whole out of sample period by using the formula:

$$SPE_t = (F_t - A_t)^2 \tag{22}$$

After this calculation a new indicator "d" is created representing the difference between loss functions

$$d = \left(SPE_{random} - SPE_{fxmodel}\right) \tag{23}$$

The null hypothesis that the difference between loss functions (i.e. the indicator d) equals zero is tested by using sign test with calculation of S statistic. According to Diebold-Mariano (1956), the S statistic to perform sign test is calculated as:

$$S = \sum_{s=0}^{N_{k-1}} I(d_{t+s+k})$$

$$I(d_{t+s+k}) \begin{cases} 1 \text{ eğer } d_{t+s+k} > 0 \\ 0 \text{ eğer } d_{t+s+k} \leq 0 \end{cases} \qquad (24)$$

The significance of this statistic is tested by using cumulative binomial distribution.

V.2. Performance Analysis

Table-1 shows the calculated RMSE and MAE ratios (R_{RMSE} and R_{MAE}) for the all exchange rate models representing cointegration relationship. Considering the 1 month forecasting, all of the exchange rate models have a better performance than random walk model without trend. Flexible price monetary model exhibits fairly strong prediction ability in both short and long term periods (1 month and 12 months). Uncovered interest rate parity model has a better performance than the random walk model in 1, 2 and 6 months, however, the calculated RMSE and MAE ratios are close to unity. This shows us that there is no distinctive predictability difference between uncovered interest rate parity and random walk models. A similar situation is valid for the risk premium extended uncovered interest rate parity model. Although this model has superiority in 3 months forecasting horizon in addition to 1 month compared to random walk model, the ratios are very close to each other in 3 months estimations and this casts a doubt on relative performance of both models.

Table 1: RMSE ve MAE Ratios (R_{RMSE} ve R_{MAE})

Model	1 month	3 months	6 months	12 months
Flexible Price Monetary Model				
RMSE	0,2569*	1,1500	1,0020	0,5110*
MAE	0,2511*	1,1687	1,0827	0,4749*
Balassa-Samuelson Model				
RMSE	0,1516*	0,9235*	1,1456	2,1016
MAE	0,1618*	0,8851*	1,0636	2,0316
Uncovered Interest Rate Parity Model				
RMSE	0,3642*	0,9325*	0,9989*	1,1511
MAE	0,3773*	0,8993*	0,9433*	1,1662
Risk Premium Extended Uncovered Interest Rate Parity Model				
RMSE	0,2881*	0,9279*	1,1000	1,6762
MAE	0,3101*	0,8664*	1,1032	1,6874
Basic Taylor Rule Model				
RMSE	0,2497*	1,2361	1,1871	1,7323
MAE	0,2481*	1,1948	1,1951	4,4120

* indicates the higher performance of the exchange rate model

An unexpected result of out of sample forecasts according to table above is related to Taylor rule model. It exhibits a better performance than the random walk model only in 1 month forecast horizon. This result is opposed to the results of earlier studies conducted for emerging markets and can be explained by exclusion of the interest rate smoothing from the model. The interest rate variable does appear in the model without any lag and the model is estimated by considering only the simultaneous relationship between exchange rate and interest rate. Macroeconomic theory shows that the effect of interest rate changes on different macroeconomic variables emerges gradually. Yet, this study aims to explain the behavior of exchange rate in an endogenous monetary policy environment. In other words, determining the time at which the interest changes affect the exchange rate is outside the scope of this study. The other reason for the unexpected low forecasting performance of the Taylor rule model may be the exclusion of expectations from the model. As New Keynesian models show, expectations have an important role in modelling the interest rate rules. As a matter of course this is a separate topic for a different research.

Table 2 presents the sign test cumulative binomial distribution values for the models having cointegrating relation.

Table 2: Sign Test Significance Levels

Model	1 month	3 months	6 months	12 months
Flexible Price Monetary Model	0,9988	0,3036	0,1132	1,0000
Balassa-Samuelson Model	0,9999	0,9407	0,7255	0,1093
Uncovered Interest Rate Parity Model	0,9999	0,8491	0,7256	0,1093
Risk Premium Extended Unc. Interest Rate Parity Model	0,9998	0,8491	0,2744	0,0156
Basic Taylor Rule Model	0,9988	0,8491	0,5000	0,6562

The results summarized in the table confirm the results of RMSE and MAE ratios. As before, the flexible price monetary model is the highest predictive power among the exchange rate models estimated against the random walk model. The other models exhibit a serious loss in predictive power especially when the forecasting horizon is extended to 6 and 12 months.

VI. Conclusion

This study aims to analyze the relevance of different exchange rate models under the inflation targeting monetary policy regime and to identify which one includes the fundamental determinants of exchange rates in Turkey during 2002-2013 period. The analysis is performed by using the traditional models like sticky and flexible price monetary models, Balassa – Samuelson model, uncovered interest rate parity model and also recently developed models like basic and extended Taylor rule models. By including the different models, the hypothesis that traditional exchange rate models based on the endogenous monetary policy assumption have a more predictive power than the random walk model is tested. Furthermore, including the endogenous models into the analysis gives the opportunity to explain the relationship between exchange rate and interest rate.

Shortly after the February 2001 economic crisis, in the implicit and explicit inflation targeting period of 2002-2013, Turkey achieved some positive improvements in some economic indicators like price stability, investment volume and economic growth. It is generally accepted that these improvements are partly due to conducted monetary policy, but no one can deny the contribution of positive global conditions like low inflationary environment, excess liquidity and rapid economic growth up to the end of 2010. The fiscal discipline and political stability have also contributed to positive economic performance of Turkey during the period under investigation.

All of the exchange rate models analyzed in this study, except the sticky price monetary model and real exchange rate extended Taylor rule model, prove the existence of cointegrating relationship among the variables related to each model. As stated by the flexible price monetary model, this finding shows that prices adjust quickly for the case of excess demand. In the private case of Turkey, the finding that the real exchange rate extended Taylor rule model does not produce a cointegrating relationship is a result stemming from the absence of the exchange rate target of the CBRT. Interventions to foreign exchange market by the CBRT aiming to control of the volatility in exchange rates also contribute to this result.

In terms of the out sample forecasting performance, flexible price monetary model specified to include uncovered interest rate parity and purchasing power parity conditions is the best model against the random walk model both in short and long run horizons. Balassa – Samuelson model specified as excluding the uncovered interest rate parity and purchasing power parity conditions shows a good performance especially in 1 and 3 months forecasting horizons. Similar to this model, uncovered interest rate parity model has a better performance than the random walk model in short forecasting horizons. Surprisingly, the Taylor rule model outperforms the random walk model only 1 month ahead exchange rate forecast. Theoretically it is expected that the Taylor rule model should have a better performance than the random walk model at least in the short and long run forecasting (1 and 12 months). The results obtained in this study, however, show that only in the short run this expectation comes true. Consequently, the inclusion of expectations to the Taylor rule model would increase the predictive power against the random walk model. Furthermore, the high volatility of exchange rates as recently experienced makes difficult to define the factors that improve the forecasting performance of Taylor rule model. This study, at least, put definitely forward the following conclusion: There is a strong relationship between exchange rates and economic fundamentals and interest rate rules, at least in the short run, are substantial in explaining and predicting the exchange rate in Turkey.

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Appendix: Tables

Table A1: Unit Root Test Results

Variable	ADF	Lag	PP	Band	Variable	ADF	Lag	PP	Band
s	-2,22	1	1,38	9	$\Delta(\pi - \pi^*)$	-8,51	1	12,83	2
Δ(s)	-6,37	0	4,73	12	$z - z^*$	-1,09	1	2,16	5
$m - m^*$	-1,31	0	0,29	10	$\Delta(z - z^*)$	-7,27	0	9,44	8
$\Delta(m - m^*)$	-8,65	2	9,45	9	EMBI+	-1,99	1	1,45	6
$y - y^*$	0,05	2	0,92	3	Δ(EMBI+)	-7,28	1	12,14	6
$\Delta\ (y - y^*)$	-16,19	1	13,40	3	$ygap - ygap^*$	-1,13	2	0,81	5
$i - i^*$	-1,40	1	1,42	8	$\Delta(ygap - ygap^*)$	-6,11	0	9,55	7
$\Delta(i - i^*)$	-8,90	0	25,29	8	q	-1,51	0	1,04	6
$\pi - \pi^*$	-1,65	2	1,75	3	Δ(q)	-5,25	0	10,13	3

Table A2: Flexible Price Monetary Model
Likelihood Ratio Test Results

Number of Cointegrating Vectors	Eigen Value	Eigen Value Statistic	5% Critical Value	Probability**
Trace Test				
0*	0,4270	119,0107	63,8761	0,0000
At most 1*	0,2933	62,2012	42,9152	0,0002
At most 2	0,1459	24,7875	25,8721	0,0584
At most 3	0,0995	10,6923	12,5179	0,0991
Maximum Eigen Value Test				
0*	0,4270	56,8094	32,1183	0,0000
At most 1*	0,2933	35,4137	25,8232	0,0002
At most 2	0,1459	16,0952	19,3870	0,1412
At most 3	0,0995	10,6923	12,5179	0,0991

(*) indicates the rejection of null hypothesis at the 5% level of significance. (**) MacKinnon-Haug-Michelis critical values.

Table A3: Cointegrating Vector Diagnostic Tests

Test	%5 Critical value	s	$m - m^*$	$y - y^*$	$i - i^*$
Exclusion	5,99	12,22	6,92	7,61	11,70
Stationary	7,81	10,66	15,53	16,67	13,34
Weak exogenity	5,99	6,73	7,56	7,94	22,64

Table A4: Normalized Cointegrated Vectors

Variable	Cointegrating Vectors (β') 1st	2nd	Adjustment Speed (α') 1st	2nd
s	1,00	1,00	-0,05	-0,03
$m - m^*$	0,64	-7,79	-0,03	0,04
$y - y^*$	0,47	9,12	0,07	-0,04
$i - i^*$	-0,09	-0,16	1,27	0,33

Table A5: Residual Tests

Test	Statistic	Probability
LM	LM(4) = 14,74	0,54
Lütkepohl	$\chi^2(8) = 11,95$	0,15

Table A6: Sticky Price Monetary Model
Likelihood Ratio Tests

Number of Cointegrating Vectors	Eigen Value	Eigen Value Statistic	5% Critical Value	Probability**
Trace Test				
0*	0,5705	224,2454	88,8038	0,0000
At most 1*	0,4279	138,0362	63,8761	0,0000
At most 2*	0,3856	81,0703	42,9152	0,0000
At most 3*	0,1608	31,3822	25,8721	0,0093
At most 4*	0,1238	13,4896	12,5179	0,0343
Maximum Eigen Value Test				
0*	0,5705	86,2091	38,3310	0,0000
At most 1*	0,4279	56,9659	32,1183	0,0000
At most 2*	0,3856	49,6881	25,8232	0,0000
At most 3*	0,1608	19,8925	19,3870	0,0413
At most 4*	0,1238	13,4896	12,5179	0,0343

(*) indicates the rejection of null hypothesis at the 5% level of significance. (**) MacKinnon-Haug-Michelis critical values.

Table A7: Balassa – Samuelson Model
Likelihood Ratio Tests

Number of Cointegrating Vectors	Eigen Value	Eigen Value Statistic	5% Critical Value	Probability**
Trace Test				
0*	0,5876	157,3740	69,8188	0,0000
At most 1*	0,2684	67,0258	47,8561	0,0003
At most 2*	0,1892	35,1420	29,7970	0,0110
At most 3	0,1079	13,7401	15,4947	0,0903
At most 4	0,0202	2,0863	3,8414	0,1486
Maximum Eigen Value Test				
0*	0,5876	90,3482	33,8768	0,0000
At most 1*	0,2684	31,8848	27,5843	0,0131
At most 2*	0,1892	21,4009	21,1316	0,0458
At most 3	0,1079	11,6538	14,2646	0,1243
At most 4	0,0202	2,0863	3,8414	0,1486

(*) indicates the rejection of null hypothesis at the 5% level of significance. (**) MacKinnon-Haug-Michelis critical values.

Table A8: Cointegrating Vector Diagnostic Tests

Test	5% Critical Value	s	$m - m^*$	$y - y^*$	$i - i^*$	$z - z^*$
Exclusion	7,81	21,48	19,05	15,98	50,25	20,21
Stationary	5,99	11,17	17,62	18,30	14,98	16,96
Weak Exogenity	7,81	26,28	13,11	16,47	25,39	38,18

Table A9: Normalized Cointegrated Vectors

	Cointegrating Vectors (β’)			Adjustment Speed (α’)		
Variable	1st	2nd	3rd	1st	2nd	3rd
s	1,00	1,00	1,00	-0,16	-0,24	-0,06
$m - m^*$	-0,52	-1,01	-7,31	-0,04	0,09	0,01
$y - y^*$	1,86	1,69	2,74	0,09	0,25	-0,01
$i - i^*$	-0,09	-0,03	-0,16	1,22	1,78	0,15
$z - z^*$	-0,95	2,57	2,95	0,06	-0,12	0,01

Table A10: Residual Tests

Test	Statistic	Probability
LM	LM(4) = 23,61	0,54
Lütkepohl	$\chi^2(10) = 10,53$	0,40

Table A11: Uncovered Interest Rate Parity Model
Likelihood Ratio Tests

Number of Cointegrating Vectors	Eigen Value	Eigen Value Statistic	5% Critical value	Probability**
Trace Test				
0*	0,2729	41,0223	25,8721	0,0003
At most 1	0,0799	8,5019	12,5179	0,2134
Maximum Eigen Value Test				
0*	0,2729	32,5204	19,3870	0,0004
At most 1	0,0799	8,5019	12,5179	0,2134

(*) indicates the rejection of null hypothesis at the 5% level of significance. (**) MacKinnon-Haug-Michelis critical values.

Table A12: Cointegrating Vector Diagnostic Tests

Test	5% Critical Value	s	$i - i^*$
Exclusion	3,84	7,26	22,28
Stationary	5,99	23,90	22,92
Weak Exogenity	3,84	6,41	20,93

Table A13: Normalized Cointegrated Vectors

Variable	Cointegrating Vector (β') 1st	Adjustment Speed (α') 1st
s	1,00	-0,04
$i - i^*$	-0,11	1,06

Table A14: Residual Tests

Test	Statistic	Probability
LM	LM(4) = 5,19	0,27
Lütkepohl	$\chi^2(4) = 11,06$	0,03

Table A15: Risk Premium Extended
Uncovered Interest Rate Parity Model
Likelihood Ratio Tests

Number of Cointegrating Vectors	Eigen Value	Eigen Value Statistic	5% Critical Value	Probability**
Trace Test				
0*	0,3551	72,5920	42,9152	0,0000
At most 1*	0,1931	27,8461	25,8721	0,0281
At most 2	0,0566	5,9533	12,5179	0,4663
Maximum Eigen Value Test				
0*	0,3551	44,7459	25,8232	0,0001
At most 1*	0,1931	21,8927	19,3870	0,0212
At most 2	0,0566	5,9533	12,5179	0,4663

(*) indicates the rejection of null hypothesis at the 5% level of significance. (**) MacKinnon-Haug-Michelis critical values.

Table A16: Cointegrating Vector Diagnostic Tests

Test	5% Critical Value	s	$i - i^*$	embi+
Exclusion	5,99	20,92	37,07	21,85
Stationary	5,99	19,23	23,76	23,78
Weak exogenity	5,99	13,85	32,00	9,61

Table A17: Normalized Cointegrated Vectors

	Cointegrating Vectors (β')		Adjustment Speed (α')	
Variable	1st	2nd	1st	2nd
s	1,00	1,00	-0,01	-0,09
$i - i^*$	-1,25	-0,02	0,18	0,52
embi+	5,40	-0,49	-0,03	0,33

Table A18: Residual Tests

Test	Statistic	Probability
LM	LM(4) = 7,74	0,56
Lütkepohl	$\chi^2(6) = 6,45$	0,37

Table A19: Basic Taylor Rule Model
Likelihood Ratio Tests

Number of Cointegrating Vectors	Eigen Value	Eigen Value Statistic	5% Critical value	Probability**
Trace Test				
0*	0,4244	130,1720	63,8761	0,0000
At most 1*	0,3681	73,8202	42,9152	0,0000
At most 2*	0,1641	26,9920	25,8721	0,0362
At most 3	0,0817	8,7021	12,5179	0,1995
Maximum Eigen Value Test				
0*	0,4244	56,3517	32,1183	0,0000
At most 1*	0,3681	46,8282	25,8232	0,0000
At most 2*	0,1641	18,2898	19,3870	0,0716
At most 3	0,0817	8,7021	12,5179	0,1995

(*) indicates the rejection of null hypothesis at the 5% level of significance. (**) MacKinnon-Haug-Michelis critical values.

Table A20: Cointegrating Vector Diagnostic Tests

Test	5% Critical Value	s	$\pi - \pi^*$	$y - y^*$	$i - i^*$
Exclusion	5,99	26,07	36,82	9,01	34,31
Stationary	7,81	38,02	29,10	30,05	28,65
Weak Exogenity	5,99	5,32	33,68	2,34	30,44

Table A21: Normalized Cointegrated Vectors

	Cointegrating Vectors (β')		Adjustment Speed (α')	
Variable	1st	2nd	1st	2nd
s	1,00	1,00	-0,01	-0,05
$\pi - \pi^*$	-0,82	-0,05	0,55	2,16
$y - y^*$	4,41	3,81	0,01	0,05
$i - i^*$	0,44	-0,06	-0,24	1,48

Table A22: Residual Tests

Test	Statistic	Probability
LM	LM(4) = 22,02	0,14
Lütkepohl	$\chi^2(8) = 9,21$	0,33

Table A22: Extended Taylor Rule Model
Likelihood Ratio Tests

Number of Cointegrating Vectors	Eigen Value	Eigen Value Statistic	5% Critical Value	Probability**
Trace Test				
0*	0,5285	223,3232	88,8038	0,0000
At most 1*	0,4566	146,6242	63,8761	0,0000
At most 2*	0,3337	84,3979	42,9152	0,0000
At most 3*	0,2458	42,9774	25,8721	0,0002
At most 4*	0,1299	14,1952	12,5179	0,0259
Maximum Eigen Value Test				
0*	0,5285	76,6990	38,3310	0,0000
At most 1*	0,4566	62,2262	32,1183	0,0000
At most 2*	0,3337	41,4204	25,8232	0,0002
At most 3*	0,2458	28,7822	19,3870	0,0016
At most 4*	0,1299	14,1952	12,5179	0,0259

(*) indicates the rejection of null hypothesis at the 5% level of significance. (**) MacKinnon-Haug-Michelis critical values.