A monetary model of TL/US$exchangerate: aco-integratingapproach$

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A monetary model of TL/US$ exchange rate: a co-integrating approach

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Abstract
In our paper, we investigate the exchange rate determination mechanism of TL/US$ for the 1987Q1-2006Q4 period using quarterly observations. Following the monetary model exchange rate determination based on the economic fundamentals, the multivariate Johansen-Juselius type co-integrating modeling is employed to reveal the long-run stationary relationships leading to the determination of nominal exchange rate for the Turkish economy. Our findings give strong support to the monetary model of exchange rate and indicate that nominal exchange rate is co-integrated with the fundamentals suggested by economics theory.
Key Words: Exchange Rates; Monetary Model; Turkish Economy;

TL/US$ DÖVİZ KURU PARASAL MODELİ: EŞ-BÜTÜNLEŞİK BİR YAKLAŞIM

Özet
Bu çalışmada, 1987Q1-2006Q4 dönemi için üçer aylık gözlem aralığı kullanılarak TL/US$ döviz kuru belirlenme mekanizması araştırılmaktadır. Ekonomik temellere dayalı olarak belirlenen döviz kuru parasal modeli takip edilerek çok değişkenli Johansen-Juselius eş-bütünleşim modellemesi Türkiye ekonomisi için nominal döviz kuru belirlenme mekanizmasına neden olan uzun dönem durağan ilişkilerin ortaya çıkarılması için kullanılmıştır. Bulgularımız döviz kuru parasal modeline önemli ölçüde destek vermekte ve nominal döviz kurunun ekonomi kuramı tarafından önerilen temeller ile eş-bütünleşik bir ilişki içinde olduğunu göstermektedir.
Anahtar Sözcükler: Döviz Kurları; Parasal Model; Türkiye Ekonomisi;

INTRODUCTION

Determination of exchange rates and the exchange rate policies applied for stabilization purposes constitute one of the most controversial issues of interest in the contemporaneous economics literature. Such a phenomenon has been of a special importance especially for the developing countries, since policy makers tend to canalize the use of exchange rate to gain an *ex-ante* designed macroeconomic growth performance as well as to break the inertial nature of the prices dominated in the economy in fighting inflation. Thus, the long-run course of the exchange rates would have serious consequences on the efficiency of the *ex-post* policy implementations.

As a small open developing country, the Turkish economy can be considered an interesting case study to examine the issue of exchange rate determination, which was subject to chronic two-digits inflationary framework as the characteristic which identifies the economy over a 20 years period till the early 2000s. By the beginning of 2000, an anti-inflationary stabilization program based on a quasi-currency board, suggesting the exchange of domestic currency against the foreign currencies selected on a constant rate of exchange (Ozdemir and Sahinbeyoglu, 2000), was established to fight domestic inflation, and in this way, policy makers aimed at mainly forming the expectations of economic agents in pricing behavior following the policy based on nominal exchange anchor. Although seemed to be successful in bringing inflation down as the the one-half of the initial level for the first 10 months realization, the subsequent two economic crisis periods ended the program with a depreciating real income. Following such developments, the Turkish economy has still been trying to establish an inflation targeting (IT) framework supported by free-floating exchange rate system, explicitly announcing annual targets through the Central Bank of the Republic of Turkey, and aimed at also providing the forward looking nature of the policy stance as a main characteristic of the IT (Leigh and Rossi, 2002).

In this line, modeling the determinants of exchange rate for a developing country would help researchers conduct empirical investigations for testing the coherence of international macroeconomic theories such as purchasing power parity (PPP) and uncovered interest parity (UIP) as well as the theories explaining the determination of exchange rates assuming open economy conditions. Such researches would reveal the extent to which discretionary economic policies can succeed in attaining the *ex-ante* policy targets, as well. Following the seminal paper by Meese and Rogoff (1983), many papers have been attributed to modeling the behavior of exchange rates so as to see whether monetary fundamentals are able to explain the long-run course and short-run dynamics of exchange rates. Among many others, MacDonald and Taylor (1993), McNown and Wallace (1994), Mark (1995), MacDonald and Marsh (1997), Kilian (1999), Groen (2000), Bahmani-Oskooee and Kara (2000), Mark and Sul (2001), Civcir (2003) and Rapach and Wohar (2004) try to explore whether the models based on structural relations or deriven by naïve-random walks or considering more recent multivariate co-integration techniques must be of special interest, and to the extent that they produce more accurate results, models have been accepted to be superior when compared with to others.

In this paper, our aim is to examine the empirical validity of the monetary model of exchange rate determination in the Turkish economy. For this purpose, the next section highlights the construction of a simple flexible price monetary exchange rate model. The third section constructs an empirical model for the Turkish economy, while the last section consludes.

1. MODEL CONSTRUCTION

Following Neely and Sarno (2002), we begin our analysis by explaining the flexible price monetary model (FPMM). Model is constructed in line with the assumptions based on the quantity theory of money (QTM) and the purchasing power parity (PPP) relating the changes in the price level and exchange rate to the money supply changes. McNown and Wallace (1994) express that if the demand for money is stable, the monetary approach is a richer formulation than PPP combining money demand variables with money supplies in the determination of exchange rate. Thus, the model assumes that the determination of the supply of and demand for money leads to the existence of a stable money demand function. As Neely and Sarno (2002) noted, perfect capital mobility assumption implicit in the model also requires that the real interest rate be exogenous in the long run and be determined in the world markets.

Consider that equilibrium in the monetary markets for the domestic and foreign country requires:

$$m_t = p_t + \alpha y_t - \beta i_t \tag{1}$$

$$m_t^* = p_t^* + \alpha^* y_t^* - \beta^* i_t^* \quad (2)$$

where m_t, p_t, y_t, and i_t denote the measure of money supply, price level, real income and the interest rate at any time t, respectively, which all are in natural logarithms except the interest rate, while those carrying an asterisk represent the identical foreign variables. The coefficients α and β are the positive constants used for the income elasticity of demand for money and interest rate semi-elasticity, respectively.

The second building block of the monetary model assumes that the absolute PPP would hold and that prices in two currencies would tend to be equalized *via* exchange rate movements resulted from goods market arbitrage. Writing down such a relationship below in Eq. 3. :

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

where s_t represents the domestic price of foreign currency, i.e., nominal exchange rate, in natural logarithms.

Subtracting Eq. 2 from Eq. 1, solving for $(p_t - p_t^*)$ and inserting the result into Eq. 3 yield the FPMM of the nominal exchange rate determination:

$$s_t = (m_t - m_t^*) - (\alpha y_t - \alpha^* y_t^*) + (\beta i_t - \beta^* i_t^*) \quad (4)$$

Let us assume as a simplifying assumption for the ease of applying to the modern time series estimation techniques that the income elasticities and interest rate semi-elasticities of money demand equal each other for the home and foreign countries:

$$s_t = (m_t - m_t^*) - \alpha(y_t - y_t^*) + \beta(i_t - i_t^*) \quad (5)$$

Following Karfakis (2003) and Nwafor (2006), finally, expectations can be introduced in Eq. 5. Since the nominal interest rate consists of the real interest rate (r) and the expected inflation (π^e):

$$i_t = r_t + \pi_t^e \quad (6)$$

$$i_t^* = r_t^* + \pi_t^{e*} \quad (7)$$

and supposing that real interest rates are equalized in home and foreign countries:

$$i_t - i_t^* = \pi_t^e - \pi_t^{e*} \quad (8)$$

Thus FPMM could be re-arranged such as:

$$s_t = (m_t - m_t^*) - (\alpha y_t - \alpha^* y_t^*) + (\theta\pi_t^e - \theta\pi_t^{e*}) \quad (9)$$

In line with this model specification, we expect a positive relationship between nominal exchange rate and relative money supply, and a negative relationship between relative income level and nominal exchange rate. Thus the larger the home relative to the foreign money supply, the larger would be the nominal exchange rate, and the larger the home relative to the foreign real income level, the lower would be the nominal exchange rate. As for the sign of the relative expected inflation, since an increase in π_t^e decreases the demand for money and increases the demand for domestic and foreign assets, we expect that an increase in expected relative inflation would lead to a depreciation of domestic currency.

2. EMPIRICAL MODEL

2.1. Data

We now construct a model of exchange rate determination of the TL/US$ for the Turkish economy. We consider data for the investigation period of 1987Q1-2006Q4 using quarterly observations. All the data take the form of seasonally unadjusted values in their natural logarithms, and all are taken from the electronic data delivery system of the Central Bank of the Republic of Turkey (CBRT) for the domestic variables and from the FRB of St. Louis electronic data delivery system for the external variables. For the exchange rate data, the spot Turkish lira per US dollar, i.e. TL/US$ exchange rate, is used. Money supply measures are represented by M1 broad money supplies, and real gross domestic product (GDP) data are used for the real income variables. Expected inflation data are represented by the annualized inflation rate based on the GDP-deflator.

As next step, we investigate the time series properties of the variables. At first by using the augmented Dickey-Fuller (ADF) unit root tests under the null hypothesis for the presence of a unit root against the stationary alternative hypothesis, we check for the stationarity condition of our variables and compare the estimated ADF statistics with the MacKinnon (1996) critical values. For the case of stationarity, we expect that these statistics are larger than the critical values in absolute value and that they have a minus sign. We also apply to the KPSS unit root test of Kwiatkowski et al.(1992) to verify the ADF results. The KPSS test differs from the ADF unit root test in that the series considered is assumed to be stationary under the null in the KPSS test:

Table 1: Unit Root Tests

Variable	τ_C	τ_T	$Z(\tau_C)$	$Z(\tau_T)$
s_t	-2.16	0.71	1.22	0.23
Δs_t	-5.70*	-6.31*	0.38*	0.15*
$(m_t - m_t^*)$	-1.77	0.63	1.24	0.18
$\Delta(m_t - m_t^*)$	-6.95*	-7.25*	0.46*	0.14*
$(y_t - y_t^*)$	-1.64	-2.16	0.51	0.18
$\Delta(y_t - y_t^*)$	-2.91*	-2.87	0.41*	0.09*
$(\pi_t - \pi_t^*)$	-0.07	-1.39	0.72	0.25
$\Delta(\pi_t - \pi_t^*)$	-7.22*	-7.41*	0.09*	0.03*
5% critical values	-2.90	-3.47	0.46	0.15

Above, τ_C and τ_T are the test statistics with allowance for only constant and constant&trend tems in the unit root tests, respectively, and $Z(\tau_C)$ and $Z(\tau_T)$ are the relevant KPSS statistics. 'Δ' denotes the first difference operator. The results of the ADF unit root tests reveal that the null hypothesis that there is a unit root cannot be rejected for all the variables in the level form, but inversely, for the first differences the stationary alternative hypothesis can be accepted. Likewise, the KPSS tests under the null hypothesis of stationarity indicate that all the variables are difference-stationary.

2.2. Methodology

Let us assume a z_t vector of non-stationary n endogenous variables and model this vector as an unrestricted vector autoregression (VAR) involving up to k-lags of z_t:

$$z_t = \Pi_1 z_{t-1} + \Pi_2 z_{t-2} + \ldots + \Pi_k z_{t-k} + \varepsilon_t \tag{10}$$

where ε_t follows an i.i.d. process N$(0,\sigma^2)$ and z is $(nx1)$ and the Π_i an (nxn) matrix of parameters. Eq. 10 can be rewritten leading us to a vector error correction (VEC) model of the form:

$$\Delta z_t = \Gamma_1 \Delta z_{t-1} + \Gamma_2 \Delta z_{t-2} + \ldots + \Gamma_{k-1} \Delta z_{t-k+1} + \Pi z_{t-k} + \varepsilon_t \tag{11}$$

where:

$$\Gamma_i = -I + \Pi_1 + \ldots + \Pi_i \;\; (i = 1, 2, \ldots, k\text{-}1) \qquad \text{and} \qquad \Pi = I - \Pi_1 - \Pi_2 - \ldots - \Pi_k \tag{12}$$

Eq. 11 can be arrived by subtracting z_{t-1} from both sides of Eq. 10 and collecting terms on z_{t-1} and then adding $-(\Pi_1 - 1)X_{t-1} + (\Pi_1 - 1)X_{t-1}$. Repeting this process and the collecting the terms would yield Eq. 11 (Hafer and Kutan, 1994). This specification of the system of variables carries on the knowledge of both the short- and the long-run adjustment to changes in z_t, via the estimates of Γ_i and Π. Following Harris (1995), $\Pi = \alpha\beta'$ where α measures the speed of adjustment coefficient of particular variables to a disturbance in the long-run equilibrium relationship and can be interpreted as a matrix of error correction terms, while β is a matrix of long-run coefficients such that $\beta' z_t$ embedded in Eq. 11 represents up to $(n$-1) cointegrating relations in the multivariate model which ensure that z_t converge to their long-run steady-state solutions. Note that all terms in Eq. 11 which involve Δz_{t-i} are $I(0)$ while Πz_{t-k} must also be stationary for $\varepsilon_t \sim I(0)$ to be white noise of an N$(0, \sigma_\varepsilon{}^2)$ process.

For the lag length of the unrestricted VAR model, we consider the sequential modified LR statistics, which compare the modified LR statistics to the 5% critical values starting from the maximum lag, and decreasing the lag one at a time ontil first getting a rejection. In our case, the reduction of the system is first rejected when we consider the lag length 5. We add a set of centered seasonal dummies which sum to zero over a year as exogenous variable. In this way, the linear term from the dummies disappears and is taken over completely by the constant term, and only the seasonally varying means remain. (Johansen, 1995). As a next step, we estimate the long run co-integrating relationships between the variables by using two likelihood test statistics known as maximum eigenvalue for the null hypothesis of r versus the alternative of r+1 co-integrating relationships and trace for the null hypothesis of r co-integrating relations against the alternative of n co-integrating relations, for r = 0,1, ... ,n-1 where n is the number of endogenous variables.

2.3. Results

Following the model specification issues expressed above, we give below the co-integration test results of the monetary model exchange rate determination in which a lon-run trend is restricted.

In Tab. 2, we find that both rank statistics indicate that a unique co-integrating vector lies in the long-run variable space which represents the existence of a stationary relationship. Normalizing the first vector with the largest eigenvalue on the exchange rate yields:

$$s_t = 1.418\,(m_t - m_t^*) - 2.064\,(y_t - y_t^*) + 9.007\,(\pi_t^e - \pi_t^{e*}) - 0.020\text{TREND} + 1.393 \quad (16)$$

t-stats. (4.910) (-1.819) (7.494) (0.535)

Results from Eq. 13 give strong support to the FPMM in which inflationary expectations are introduced. The relative money supply has a positive and relative real income has a negative significant long-run relationship with nominal exchange rate. When we imposed the unitary relative income elasticity of exchange rate, such a restriction is accepted using $\chi^2(1) = 2.43$ against the table-value 3.84 considering 5% significance level. Following Karfakis (2003), therefore, a positive monetary shock would raise permanently the level of exchange rate, and an increase in the relative income would lead to an appreciation of the domestic currency against the US$ in the long-run. Karfakis attributes such an estimation result to that any policy which boosts economic growth would mean a strong domestic currency. Besides, we find that inflation differentails lead to a depreciation of the domestic currency as expected. In

Table 2: Co-integration Test Results

Null Hypothesis	r = 0	r ≤ 1	r ≤ 2	r ≤ 3
Eigenvalue	0.50	0.21	0.14	0.07
λ trace	80.63*	32.57	15.82	4.96
5% Critical Value	63.88	42.92	25.87	12.52
Prob.	0.00	0.36	0.51	0.60
λ max	48.06*	16.74	10.87	4.96
5% Critical Value	32.12	25.82	19.39	12.52
Prob.	0.00	0.48	0.53	0.60

* Denotes rejection of the hypothesis at the 0.05 level.

Standardized Eigenvectors

s_t	$(m_t - m_t^*)$	$(y_t - y_t^*)$	$(y_t - y_t^*)$	$(\pi_t^e - \pi_t^{e*})$
1.000	-1.418	2.064	-9.007	0.020
-2.927	1.000	-23.959	2.061	0.283
7.825	10.918	1.000	-4.028	0.318
-0.386	0.536	0.184	1.000	0.020

Weak Exogeneity Test Statistics

	s_t	$(m_t - m_t^*)$	$(y_t - y_t^*)$	$(\pi_t^e - \pi_t^{e*})$
LR test $\chi^2(3)$	34.043	36.185	34.165	9.408
Probs.	(0.000)	(0.000)	(0.000)	(0.024)

the long-run variable space, we cannot reject the weak exogeneity of relative money supply and relative income, and accept the endogeneity of exchange rate and inflation differentials as for the co-integrating model specification. We can easily notice from Tab. 2 that non-stationary time-series characteristics of the variables are verified by the multivariate statistics for testing the stationarity derived from the co-integration analysis in the sense that no variable alone can represent a stationary relationship in the co-integrating vector. We must finally note that we obtain just the same estimation results if we exclude the trend factor from the long-run variable space. These results not reported here to save space are available from the authors upon request.

CONCLUDING REMARKS

Determination of exchange rates using the economic fundamentals produces the significant knowledge of monetary equilibrium, combining some other contemporaneous monetary theories explaining the equilibrium conditions for the goods and assets markets. In our paper, we examine the exchange rate determination of TL/US$ constructed on the economic fundamentals employing data from the Turkish economy. Considering the time period of 1987Q1-2006Q4 with quarterly observations, our estimation results obtained through the multivariate Johansen-Juselius type co-integration modeling indicate that there is a strong support to the flexible price monetary model and that the nominal exchange rate is co-integrated with the fundamentals suggested by economics theory.

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