The Long-run Validity of Monetary Exchange Rate Model for a High Inflation Country and Misalignment: The Case of Turkey

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Abstract
This paper applies the Johansen cointegration technique to examine the validity of the monetary model of exchange rate determination as an explanation of the Turkish Lira-United States dollar relationship over 1987:1-2000:12. A single cointegrating vector is identified, lending support to the interpretation of the model as describing a long-run equilibrium relationship. We also test for weak exogeneity of the nominal exchange rates and monetary fundamentals from the estimated vector error correction models. This gives us insight into the adjustment process through which the long-run equilibrium relationship between exchange rates and monetary fundamentals is maintained. In addition, we calculate misalignment from estimated long-run relationship to evaluate whether the lira was overvalued before the eve of 2001 financial crisis in Turkey. Calculated misalignment figures show substantial overvaluation before the crisis.

JEL classification: F31; F41; F47
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1. Introduction

The monetary model of exchange rate determination suggests a strong link between the nominal exchange rate and a set of monetary fundamentals. The monetary model implies that price level of a country is determined by its supply and demand for money and that the price level in different countries should be the same when expressed in the same currency. This makes it an attractive theoretical tool for understanding fluctuations in exchange rates over time. It also provides a long-run benchmark for the nominal exchange rate between two currencies and thus a clear criterion for determining whether a currency is significantly "overvalued" or "undervalued."

A number of early studies on industrial nations find little evidence of cointegration among nominal exchange rates and monetary fundamentals during the post-Bretton Woods float (see for example, Baillie and Selover (1987), McNown and Wallace (1989), and Baillie and Pecchenino (1991)). The lack of empirical evidence for a stable long-run relationship among nominal exchange rates and monetary fundamentals implies that the monetary model has little practical relevance. A similar situation exists in the empirical purchasing power parity (PPP) literature. Long-run PPP posits a stable long-run relationship between nominal exchange rates and relative price levels, but empirical supports for such relationships are limited using data from the modern float.

However, recent studies using long span of data and/or panel data find support for long-run PPP for the post-Bretton Woods era, including Frankel and Rose (1996), Papell (1997), and Taylor and Sarno (1998) Lothian and Taylor (1996), and Taylor (2001). In regard to the monetary model, recent studies by Groen (2000), Mark and Sul (2001) and Rapach and Wohar (2001) test for a stable long-run relationship between nominal exchange rates and monetary fundamentals using panel cointegration tests for the post-Bretton Woods float. Interestingly, these studies find strong evidence of cointegration among nominal exchange rates, relative money, and relative real output using panel cointegration tests. Mark and Sul (2001) actually find support for a very simple long-run monetary model that imposes basic homogeneity restrictions. They also find that nominal exchange rate forecasts based on the monetary model are generally superior to forecasts of a naive random walk model. The recent findings of Groen (2000) and Mark and Sul (2001) again have renewed hope in the ability of monetary fundamentals to track nominal exchange rates.

Previous studies on high inflation countries show that monetary fundamentals are important in determining behavior of the exchange rate (see McNown and Wallace (1994), Bahmani-Oskooee and Kara (2000) and Moosa (2000). In this paper, we test a popular monetary model for a high-inflation, developing country like Turkey. The test of the monetary model is motivated by the findings of PPP in Turkish data (see Civcir 2002) and Erlat (2001)). In particular, we apply augmented Dickey-Fuller and Phillips-Perron unit root tests and Johansen (1995) cointegration tests using monthly data for 1987:1-2000:12 to test the long-run validity of monetary model of exchange rate determination.

Our estimation results exhibit considerable support for the monetary model of exchange rate determination. We find evidence of a theoretically consistent long-run link between nominal exchange rates and a set of monetary fundamentals. Our findings are noteworthy given the lack of empirical support in much of the existing literature for the long-run relationship among exchange rates and monetary fundamentals implied by the monetary model. After finding empirical support for the long-run monetary model, we consider two extentions. First, we test for the weak exogeneity of the nominal exchange rates and monetary fundamentals based on the estimated vector error correction models. This gives insights into the adjustment process through which a long-run equilibrium relationship between exchange rates and monetary fundamentals is maintained. Second, we calculate misalignment from the estimated long-run relationship to test whether the lira was overvalued exchange rate before the eve of 2001 financial crisis in Turkey. Evidence shows substantial overvaluation of the lira prior to the crisis.

The rest of the paper is organized as follows. Section 2 presents the flexible price and sticky price monetary models of exchange rate determination augmented with relative price differentials. Section 3 outlines data and testing strategy. Section 4 reports test results for the long-run monetary model. Section 5 summarizes main findings.

2. The Monetary Model

The monetary models of exchange rate determination start with the assumption of perfect capital mobility. PPP and interest rate parity conditions are used in the models to define equilibrium conditions. Bonds (foreign and domestic) are assumed to be perfect substitutes. In this section, we focus on three versions of the monetary models, namely the Flexible Price Monetary Model (FPM), the Sticky Price Monetary Model (SPM) and the Sticky Price Monetary Model augmented with relative price differential.

The first building block of the monetary model assumes that purchasing power parity holds continuously

$$s_t = p_t - p_t^* + c \tag{1}$$

where c is a constant, s is the logarithm of exchange rate expressed in units of home currency per foreign currency, and p and p^* are, respectively, domestic and foreign price levels. If $c = 0$, equation (1) implies that absolute PPP holds and if $c \neq 0$, equation (1) implies that relative PPP holds.

The second building block of the model assumes a stable money demand function in domestic and foreign countries. The money market equilibrium conditions for domestic and foreign countries are assumed to depend on the logarithm of real income, y and the logarithm of price level, p and the nominal interest rate, i. An identical relationship can also be assumed for the foreign country, where foreign variables are denoted by asterisks. Monetary equilibria in the domestic and foreign country are then given by equation (2) and (3):

$$m_t = p_t + b_2 y_t - b_3 i_t \tag{2}$$

$$m_t^* = p_t^* + b_2^* y_t^* - b_3^* i_t^* \tag{3}$$

where m_t and m_t^* are the domestic and foreign money supply, respectively. b_2 is the income elasticity of demand for money and b_3 is the interest rate semi-elasticity. Rearranging equation (2) and (3) for domestic and foreign price levels and substituting into equation (1) yields the following flexible price monetary model of exchange rate equation of Bilson (1978), Frankel (1978) and Hodrick (1978):

$$s_t = b_1 (m_t - m_t^*) - b_2 (y_t - y_t^*) + b_3 (i_t - i_t^*) + c + e_t \tag{4}$$

where βs are parameters and c is an arbitrary constant and e_t is a disturbance term. Equation (4) assumes that equilibrium exchange rate is driven by relative excess money supplies[1].

In equation (4) the nominal interest rate consists of two components, namely the real interest rate, and the expected inflation rate, that is:

$$i_t = r_t + p_t^e \tag{5}$$

$$i_t^* = r_t^* + p_t^{e*} \tag{6}$$

where r_t and r_t^* are the domestic and foreign real interest rate and p_t and p_t^e are the expected rates of domestic and foreign inflation, respectively. Assuming that the real interest rates are equalized in both countries, we have

$$i_t - i_t^* = p_t^e - p_t^{e*} \tag{7}$$

Thus, equation (4) can be rewritten as:

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[1] This specification assumes equal and opposite sign on relative money, income and interest rates, that is $b_i = -b_i^*$. The validity of these restrictions should be tested before estimating the model, however, due to the degrees of freedom considerations, it is usually assumed away.

$$s_t = \boldsymbol{b}_1\,(m_t - m_t^*) - \boldsymbol{b}_2(y_t - y_t^*) + \boldsymbol{b}_3(\boldsymbol{p}_t^e - \boldsymbol{p}_t^{e*}) + c + \boldsymbol{e}_t \tag{8}$$

The equation (8) is the Flexible Price Monetary Model (FPM). The coefficient of the relative money supply is positive and equal to one based on the neutrality of money. The rationale is that for a given percentage increase in the money supply, prices will increase by the same percentage. If PPP holds continuously, this would mean a depreciation of the domestic currency (s_t increase) by the same amount, to achieve equilibrium. However, the prediction of a negative coefficient for relative income is opposite to what the Mundell-Fleming approach predicts. In the latter model, a higher real income will increase imports; this will worsen the trade balance and will require a depreciation of the domestic currency in order to restore equilibrium. In the FPM, a rise in the domestic real income creates an excess demand for the domestic currency. Agents will then decrease their expenditures in order to increase their real money balances, leading to a fall in prices. Then via PPP, an appreciation of the domestic currency will ensure that equilibrium is restored.

Furthermore, an increase in the expected long-run inflation results in agents switching from domestic currency to bonds (both domestic and foreign). Thus the demand for domestic currency decreases, causing a depreciation of the domestic currency (an increase in s_t). Thus we expect the coefficient of the relative expected rate of inflation to be positive.

Frankel (1979) developed a sticky price monetary model of the exchange rate (SPM), which incorporates a short-run interest rate to capture liquidity effects. Frankel assumes that the expected rate of depreciation of the exchange rate is a positive function of the gap between the current exchange rate and the long-run equilibrium rate and, the expected long-run inflation differential between the domestic and foreign countries. This yields the following equation:

$$E(\dot{s}_t) = -\boldsymbol{l}\,(s_t - \overline{s}_t) + \boldsymbol{p}_t^e - \boldsymbol{p}_t^{e*} \tag{9}$$

where $\boldsymbol{l}$ is the speed of adjustment towards equilibrium. This equation states that the current exchange rate is expected to return to its long-run equilibrium at the rate of $\boldsymbol{l}$. In the long-run, $s_t = \overline{s}_t$, then the expected rate of depreciation of the currency will just be equal to the difference of domestic to foreign inflation. Combining equation (5), (6) and (9) gives:

$$s_t - \overline{s}_t = -\frac{1}{\boldsymbol{l}}[(i_t - \boldsymbol{p}_t^e) - (i_t^* - \boldsymbol{p}_t^{e*}) \tag{10}$$

Equation (10) shows that the gap between the current exchange rate and its long-run equilibrium exchange rate is proportional to the real interest differentials between the two countries. Thus, if the foreign real interest rate is higher than the domestic real interest rate, then there will be capital outflows from domestic bonds to foreign bonds until the real interest rates are equalized.

The long-run PPP relationship in SPM is represented by :

$$\bar{s}_t = \bar{p}_t - \bar{p}_t^* \tag{11}$$

In the long-run, the interest differential must be equal to the long-run expected inflation differential,

$$\bar{r}_t - \bar{r}_t^* = \boldsymbol{p}_t^e - \boldsymbol{p}_t^{e*} \tag{12}$$

Thus equation (10) can be rewritten as :

$$s_t - \bar{s}_t = -\frac{1}{\boldsymbol{l}}[(\bar{i}_t - i_t) - (\bar{i}_t^* - i_t^{e*})] \tag{13}$$

The above equation states that the exchange rate will overshoot its long-run equilibrium rate whenever the relative nominal interest differential increase above their equilibrium levels. Combining equation (4), (12) and (13) gives,

$$s_t = \boldsymbol{b}_1(\bar{m}_t - \bar{m}_t^*) - \boldsymbol{b}_2(\bar{y}_t - \bar{y}_t^*) + \boldsymbol{b}_3(\boldsymbol{p}_t^e - \boldsymbol{p}_t^{e*}) + c + \boldsymbol{e}_t \tag{14}$$

Equation (14) is actually identical to the reduced equation of FPM , thus the SPM reduces to a FPM in the long run.

The short-run dynamics of the SPM is obtained by substituting equation (14) into (13) which gives the sticky price monetary model of Dornbusch (1976) and Frankel (1979),

$$s_t = \boldsymbol{b}_1(m_t - m_t^*) + \boldsymbol{b}_2(y_t - y_t^*) + \boldsymbol{b}_3(i_t - i_t^*) + \boldsymbol{b}_4(\boldsymbol{p}_t^e - \boldsymbol{p}_t^{e*}) + c + \boldsymbol{e}_t \tag{15}$$

In equation (15) the FPM is nested within the reduced equation of SPM. According to equation (15) the signs of the coefficients of $\boldsymbol{b}_1$, $\boldsymbol{b}_2$ and $\boldsymbol{b}_4$ are the same as that for FPM. The $\boldsymbol{b}_3$ coefficient is negative; an increase in the domestic interest rate leads to a capital inflow, which increases the demand for the domestic currency and, in turn, leads to the appreciation of the domestic currency.

The monetary model of exchange rate traces movements in the exchange rate by examining monetary variables under the crucial assumption that PPP is maintained between countries for broad price indices. Several studies using Turkish time series reveals mixed results on the validity of the PPP, see Metin (1994) and Telatar and Kazdagli (1998) find no evidence of PPP by using cointegration techniques and annual

data for 1948-1988 and monthly data for 1981-1993 period respectively. A recent study by Civcir (2002) provides evidence for the weak form of PPP, where symmetry restrictions on the prices hold but unitary coefficients on the prices are rejected. Further, Erlat (2001) uses sequential unit-root tests with shifts in trend and constant, and fractional integration techniques and finds empirical support for the PPP. Given these findings on PPP, we add relative prices to the equation (15). This additional variable allows for movements in relative prices of tradable to nontradables within and across countries (see Cheung and Chinn (1998) and Husted and MacDonald (1999)). The relative price variable may be determined by any number of factors. In the Balassa (1964) and Samuelson (1964) model, relative prices are driven by relative differentials in productivity in the tradable and non-tradable sectors. Relative prices may also be affected by demand side factors (see DeGregorio and Wolf, 1994). In the long-run, the rising preference for services, which are largely non-tradable, may induce a secular trend in the relative price of non-tradables. Hence, such Balassa-Samuelson and demand side effects can be proxied with a relative price variable[2].

Our empirical monetary exchange rate model is augmented with relative prices of tradable to nontradables can be written as:

$$s_t = b_1 m_t^d + b_2 y_t^d + b_3 i_t^d + b_4 p_t^d + b_5 P_t^{dTN} + c + e_t \qquad (16)$$

where $m_t^d = (m_t - m_t^*)$, $y_t^d = (y_t - y_t^*)$, $i_t^d = (i_t - i_t^*)$, $p_t^d = (p_t - p_t^*)$, and $P_t^{dTN} = [(P_t^T - P_t^N) - (P_t^{T*} - P_t^{N*})]$. The tradable price variable is proxied with producer price index while nontradable price is represented by the consumer price index.

3. Data and Methodology

3.1. Data

Most series are obtained from the Central Bank of Turkey and IMF's *International Financial Statistic*s and span the 1987:1-2000:12 period. The exchange rate is average-of-month data, expressed in TL per US$ unit. For the broad deflator, the consumer price index (CPI) *IFS* line 64 is used. The 'tradable' price deflator is proxied by the producers price index (PPI) or wholesale price index (WPI) data reported in *IFS* line 63. The

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[2] In principle, one would like to substitute out for the determinants of the relative price variable in the square brackets, especially since the price of tradables is likely to be endogenous with respect to the exchange rate. Unfortunately, sectoral productivity data is not available at a monthly frequency for Turkey.

measure of money supply is monthly average broad money (M2). Monthly average industrial production was used as a proxy for real output. Short term interest rates are monthly average interbank rates for Turkey and monthly average federal funds rate for the United States. The producer price index (PPI) and consumer price index (CPI) are used as proxies for the relative price of tradable and non-tradable, respectively. All variables are in natural logs except the interest rates.

3.2 Methodology

All variables in the models above can be considered to be endogenous and the possibility of short-run deviations from, and adjustment to, the long-run cointegration relationship, makes the vector error correction model (VECM) applicable.

Johansen cointegration analysis involves estimating the following vector error correction model in reduced form

$$\Delta z_t = \sum_{i=1}^{k} \Gamma_i \Delta z_{t-i} + \Phi z_{t-1} + \Psi d + \boldsymbol{e}_t \tag{17}$$

where z_t is a vector of non-stationary (in levels) variables, The matrix Φ has reduced rank equal to r and can be decomposed as $\Phi = \alpha\beta'$, where α and β are $p \ x \ r$ full rank matrices, and contains adjustment coefficients and the cointegrating vectors respectively. d is the vector of deterministic variables which may include constant term, the linear trend, seasonal dummies and impulse dummies. Finally, the error term is normal process. Following Hendry and Doornik (1994) and Doornik et al (1998) impulse indicator variables are entered unrestrictedly to the cointegration space.

In order to test for the number of cointegration relationships amongst the variables, Johansen (1988) and Johansen and Juselius (1990) provide two different tests to determine the number of cointegrating vectors, namely trace and maximum eigenvalue tests. In the trace test, the null hypothesis is that there are at most r cointegrating vectors and it is tested against a general alternative. In the maximum eigenvalue test, the null hypothesis of r cointegrating vector is tested against $r + 1$ cointegrating vectors.

Once we determine the number of relationships, r, we can do hypothesis testing on both loadings and cointegrating vectors. Restrictions can be imposed on the coefficients to test theory based hypothesis on the long-run value of variables.

One problem with the Johansen procedure is that it is not able to identify exactly the parameters in **a** and **b** matrices. Only if there is just one cointegrating vector found, then we can make truly concrete conclusions about any unique long-run relationship between the variables, otherwise theoretical restrictions should be used to identify the long run relationships.

4. Monetary Model Test Results

4.1 Cointegration Test Results

Before conducting the analysis of long-run relationships between exchange rate and monetary fundamentals, we first investigated the time series properties of the variables using augmented Dickey-Fuller (1979) unit root tests. Test results showed that all of the variables are I(1). The implications of our unit root test results for testing the long-run monetary model is to use cointegration procedures.

Johansen procedure is used to determine the rank r and to identify a long-run monetary model of exchange rate amongst the cointegrating vectors. The first stage of estimating the VECM is to determine the proper lag length. Lag length decision is based on the evidence provided by both the likelihood ratio test and AIC, however, in the case of serial correlation sufficient number of lags are introduced to eliminate the serial correlation of the residuals. The cointegration tests amongst s_t, m_t^d, y_t^d, i_t^d, p_t^d and P_t^{dTN} include 12 lags in the VECM. To capture the effects of seasonality on the variables, we introduced a set of monthly centered seasonal dummy variables, a constant term, and also three impulse dummy variables: D91 is included to capture the effects of Gulf War, D94 is included to capture the currency crises in 1994 and D00 to capture the 2000 stabilization program. The diagnostics in the form of vector statistics and single equation statistics indicate that our VAR model is satisfactorily a close approximation to actual data generating process, apart from some non-normality of residuals[3]. Gonzalo (1994) has shown that the performance of the maximum likelihood estimator of the cointegrating vectors may not be affected significantly by non-normal errors.

Panel A in Table 1 reports the estimates of Johansen procedure and standard statistics. In determining the number of cointegrating vectors we used degrees of freedom adjusted version of the maximum eigenvalue and trace statistics, since for

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[3] These results are available upon request from the author.

small samples with too many variables or lags, Johansen procedure tends to overestimate the number of cointegrating vectors (see Cheung and Lai (1993)). The computed test statistics strongly reject the null hypothesis of no cointegration in favor of one cointegration relationship[4]. Panel B in Table 1 reports standardized eigenvectors, b'. The first row of b' is the estimated cointegration vector, can be written as

$$s_t = 5.384 + 0.827\, m_t^d - 0.887\, y_t^d - 0.002\, i_t^d + 0.025\, \boldsymbol{p}_t^d + 3.309\, P_t^{dTN}$$
$$\text{(std. err.)} \quad (0.147)\ (0.034) \quad (0.337) \quad (0.0003)\ (0.002) \quad (1.191)$$

All of the coefficients in this vector have anticipated signs and are statistically significant. The reported likelihood ratio test statistics also confirms significance of the variables in the long-run relationships. Magnitudes of money and income (proxied by industrial production) differential variables are consistent with the predictions of the monetary model. The interest differential enters with negative sign, which indicates that an increase in the Turkish interest rate relative to U.S. interest rate leads to an appreciation of the Turkish Lira. The estimated value of the interest rate differential equation is 0.002, which is very small. This finding implies a very quick rate of price level adjustment. These results are consistent with the sticky price monetary model of the exchange rate. Inflation differential enters with a positive sign, indicating that an increase in the inflation relative to US leads to a depreciation of the domestic currency. Finally, the relative price variable has a positive sign and is statistically significant.

Panel C in Table 1 reports a the estimated response of each of the variables to the error correction terms. The exchange rate responds to the error correction term by moving to reduce the disequilibrium. The rate of response is very slow, however. Adjustment to the conditional mean appears to be affected by the changes in the interest rate. When the error correction term is negative at time t so that the lira is weak, between time period t and $t+1$ the lira strengthens and domestic interest rate rises relative to that of US. Therefore, an increase in the interest rate is associated with strengthening currency. Further, to a smaller degree, adjustment is affected by changes in the monetary policy in that money supply adjusts to close the gap.

[Insert Table 1 about here]

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[4] . However, without the degrees of freedom adjustment result did not alter.

Various hypotheses on the parameters of a matrix can be tested. A first interesting aspect is represented by the possibility of identifying long-run weak exogeneity of the variable(s) with respect to the parameters of equilibrium relationships. If the cointegration vector does not have any influence on a particular variable, a case in which case, all the weights are zero, then that variable is said to be long-run weakly exogenous with respect to long-run parameters. This implies that if $\alpha=0$ for a given variable, that variable is weakly exogenous. In other words, when the deviations from the long-run equilibrium occurs in the lira, it is primarily the exchange rate that adjusts to restore the long-run equilibrium. If α is statistically different from zero for a variable, then that variable adjusts to restore equilibrium, but the variable should have the correct (minus) sign.

Weak exogeneity tests are presented in Panel D of Table 1. If a given row in a is equals to zero, disequilibrium in the cointegrating vector does not feed back directly onto the corresponding variable. Specifically, the first term in α represents the speed at which the dependent variable in the first equation of the VECM moves towards restoring the long-run equilibrium, and second term shows how fast the differential money term responds to the short-run disequilibrium in the cointegration relation. The test results show that interest rate differential and relative prices are weakly exogenous at 5 percent significance level, but we can not reject weak exogeneity of relative prices at 10 percent significance level. The evidence found here consistent with the fact that interest rates in Turkey are mainly determined outside the system by the dynamics of the public sector deficit. The joint tests of weak exogeneity show that both of these variables are weakly exogenous at 5 percent significance level, as the computed likelihood ratio statistic $\chi^2(2) = 5.864$ and associated p-value [0.0533] indicate. The joint tests for weak exogeneity with respect to the exchange rate, money, income, and inflation differentials reject the null hypothesis of weak exogeneity, given the corresponding likelihood ratio test statistics and the p-values, which are $\chi^2(4)= 70.999$, 0.000, respectively. The results also justify using a system approach to analyzing cointegration relationship[5].

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[5] Parameter constancy is an additional and crucial issue to ensure a well-specified equation. The potential for parameter instability increases significantly during and after financial crises, and the factors affecting exchange rate may change. In order to evaluate the parameter stability, the cointegration analysis is redone by using the recursive estimation method. Constancy of the parameters can not be rejected for the whole sequences of forecasts. Constancy of the parameters indicates that, in general, the exchange rate process in the long run remained unchanged over the sample period.

Finally Panel E in Table 1 reports multivariate stationarity of the given variable. The tests based on the assumption that there is only one cointegrating vector. Here, the null hypothesis is the stationarity of the variable, furthermore, since it is multivariate and so includes a larger set of information these statistics may have stronger power against the ones based on the univariate test (see Johansen, 1995). We reject the null hypothesis of stationarity of all the variables.

4.2 An Estimate of Equilibrium Exchange Rate

Recently, a new literature has been developed to further test equilibrium exchange rate relationships (see Williamson (1994), Hinkle and Monteil (1999) MacDonald (2000)). Increasingly such models have been used by both practitioners and policy makers to address issues of exchange rate misalignment and to test for overvalued currencies. In the literature, the monetary model is widely used for testing the validity of the approach for exchange rate determination and in terms of its out-of-sample forecasting properties. However, this model or its variants are not widely used for assessment purposes. Notable exceptions are Chinn (2000), Husted and MacDonald (1999), and La Cour and MacDonald (2000). These papers assess whether some currencies are overvalued or undervalued against the US dollar or Japanese Yen before the 1997 Asian crises. In this paper, cointegration vector is used to generate equilibrium exchange rate and then a misalignment rate is calculated as a residual between generated equilibrium exchange rate and actual exchange rate in period t, minus sign indicates overvaluation of the lira. Table 2 reports the implied misalignments for all of the year 2000. As of 2000:1 the Turkish Lira was overvalued. Overvaluation increases leading up to the crises in February 2001.

[Insert Table 2 about here]

Figure 1 presents a plot of a representative equilibrium and actual exchange rates. The figure clearly suggests that the TL was misaligned before the crisis. Of course, the derived equilibrium in this paper sidesteps the issue of the appropriateness of the underlying fundamentals, but nevertheless this kind of exercise is useful to illustrate an equilibrium relationship.

[Insert Figure 1 here]

5. Summary and Conclusions

We have attempted to model the lira-US dollar exchange rate over the 1987:1-2000:12 period, using a popular monetary model of the exchange rate. We have tested the monetary exchange rate model augmented with relative prices. Evidence is in favor of the monetary model. Cointegration relationship between exchange rate, the monetary fundamentals and relative prices is found, indicating that monetary fundamentals affect the exchange rate in the long-run.

The equilibrium relationships are used to construct an equilibrium measure of the lira. Results in this paper indicate that a sensible estimate about the equilibrium value of the lira/US dollar exchange rate can be obtained. The estimated model has suggested that the lira was overvalued vis-à-vis US dollar before the crisis. This finding has important implications for policy makers and other foreign exchange market participants.

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Table 2: Cointegration Analysis of the Monetary Exchange Rate Model						
Panel A: Johansen Cointegration tests						
Hypotheses	r = 0	R <= 1	r <= 2	r <= 3	r <= 4	r <= 5
Lmax	57.52**	24.220	18.950	8.939	6.616	1.572
95% critical values	40.300	34.400	28.100	22.000	15.700	9.200
Ltrace	117.8**	60.290	36.070	17.130	8.188	1.572
95% critical values	102.100	76.100	53.100	34.900	20.000	9.200

Panel B: Standardized eigenvectors (Beta')

s	m^d (M2)	y^d	i^d (IB)	p^d (WPI)	P^{dTN}	Constant
1.000	-0.827	0.887	0.002	-0.025	-3.309	-5.384
-1.333	1.000	-1.382	-0.003	0.013	5.126	6.865
0.310	-0.206	1.000	0.000	-0.009	-2.851	-1.649
-1187.900	1248.000	653.360	1.000	2.182	-6633.200	5225.400
-250.640	242.920	-766.440	0.117	1.000	-409.190	1204.800
0.843	-0.844	1.615	0.001	-0.008	1.000	-3.694

Panel C: Standardized alpha coefficients

s	-0.014298	-0.010349	0.026242	-6.7462E-06	-0.000015902	0.015388
m^d (M2)	-0.030865	-0.023695	-0.033756	-0.000009792	0.00010958	0.0055514
y^d	-0.14534	0.057451	0.041537	0.000044793	0.000062975	0.011056
i^d (IB)	-108.14	13.92	290.19	-0.086413	0.089881	-95.966
p^d (WPI)	13.093	2.1651	3.6213	0.001266	0.0084116	1.9543
P^{dTN}	-0.014668	-0.015634	0.01746	0.000018424	-0.000024858	-0.002852

Panel D: Weak Exogenity Tests (Chi-sqr (1)

	s	m^d (M2)	y^d	i^d (IB)	p^d (WPI)	P^{dTN}
	3..741	4.6209	25.874	2.6284	38.827	3.4831
	[0.0531]	[0.0316] *	[0.0000] **	[0.1050]	[0.0000] **	[0.0620]

Panel E: Multivariate Unit Root Tests (Chi-sqr (6)

	s	m^d (M2)	y^d	i^d (IB)	p^d (WPI)	P^{dTN}
	63.822	82.911	88.895	68.583	40.027	84.818
	[0.0000] **	[0.0000] **	[0.0000] **	[0.0000] **	[0.0000] **	[0.0000] **

Notes:
1) The estimation period is 1987:1-2000:12. VAR includes 12 lags on each variable, a constant term, centered seasonal monthly dummy variables, D91 dummy and D94 dummy and D00 variables.
2) The Lmax and Ltrace are maximum eigenvalue and trace test statistics, adjusted for degrees of freedom. The critical values are taken from Osterwald-Lenum (1992).
3) The multivariate stationarity, weak exogeneity and significance tests statistics are evaluated by assuming a single cointegration vector.
4) The * and ** indicate rejection of likelihood ratio tests at 5% and 1% significance levels, respectively

Table 2 : Monetary Model Based Misalignment ($\hat{S}_t - S_t$)											
Period	2000:1	2000:2	2000:3	2000:4	2000:5	2000:6	2000:7	2000:8	2000:9	2000:10	2000:11	2000:12
Misalignment	-0.15	-0.16	-0.17	-0.18	-0.2	-0.225	-0.225	-0.225	-0.24	-0.26	-0.255	-0.25

Notes:

1) S_t is logarithm of the lira per US dollar

2) Equilibrium exchange rates ($\hat{S}_t$) are obtained from cointegrating vector reported in Table 1. Misalignment is the residual between equilibrium exchange rate and actual exchange rate. Negative value indicates an overvaluation.

Figure 1: Monetary model based misalignment (in log)