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## Exchange rate overshooting in Turkey

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### Abstract

Exchange rate overshooting is said to be a short-run phenomenon. However, when a currency like Turkish lira depreciates from 13 to almost 400 000 lira per dollar over three decades, one wonders whether it has overshoot its long-run value as well. In this paper we employ a relatively new method of error-correction modeling to show how one could test for overshooting in the short-run as well as in the long-run. © 2000 Elsevier Science S.A. All rights reserved.

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In an effort to explain the abnormal fluctuation in an exchange rate, Dornbusch (1976) introduced his Sticky-Price monetary model which contained an ‘overshooting’ hypothesis. The main feature of his model is that since prices are sticky in the short-run, an increase in money supply which results in lower interest rates and thus capital outflow, will cause currency depreciation. The currency will actually depreciate over and beyond its long-run value, i.e., in the short-run it will overshoot itself. However, over time, commodity prices will rise and result in a decrease in real money supply and thus, in a higher interest rate. This, in turn, will cause the currency to appreciate. What happens to the long-run value of a currency is an empirical question. The empirical research is mixed at best. While Frankel (1979), Driskill (1981), Papell (1988), and Park (1997) do provide supportive results, Hacche and Townend (1981), Backus (1984), and Flood and Taylor (1996) do not.

In this paper we try to test the overshooting hypothesis by employing Turkish data and most recent advances in applied research. In 1973 when the international monetary system changed from fixed to relatively flexible exchange rate system, thirteen Turkish lira was buying one U.S. dollar. Today, that rate stands at more than 400 000.00 lira per dollar. We would like not only to test the monetary approach but also to determine whether Turkish lira has overshoot its short-run as well as its long-run

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value. To this end, we introduce the model in Section 1. Section 2 introduces the methodology and reports the empirical results supporting the overshooting hypothesis. Section 3 concludes. Data definition and sources are cited in Appendix A.

## 1. The model

The central theme of the monetary approach is that it combines the Purchasing Power Parity (PPP) theory with the Quantity Theory of Money. Let  $S$  denote the number of lira per U.S. dollar;  $P_T$  the Turkish price level and  $P_{US}$ , the U.S. price level. The PPP theory then is outlined as:

$$S = (P_T/P_{US}) \quad (1)$$

The theory then proceeds by identifying the determinants of price levels in two countries through the quantity theory of money where  $M_T \cdot V_T = P_T \cdot Y_T$  in Turkey and  $M_{US} \cdot V_{US} = P_{US} \cdot Y_{US}$  in the U.S. Solving these two equations for  $P_T$  and  $P_{US}$  and substituting into (1) we arrive at:

$$E = \begin{pmatrix} M_T & V_T & Y_{US} \\ (-) & (-) & (-) \\ M_{US} & V_{US} & Y_T \end{pmatrix} \quad (2)$$

Eq. (2) indicates that the relative money supply, relative velocity, and relative income are the determinants of the exchange rate. Taking log from both sides of (2) yields:

$$\text{Log } S = (\text{Log } M_T - \text{Log } M_{US}) - (\text{Log } Y_T - \text{Log } Y_{US}) + (\text{Log } V_T - \text{Log } V_{US}) \quad (3)$$

The last step in arriving at the monetary model is to identify the determinants of velocity in two countries. We shall assume that interest rate and inflation rate in two countries are the main determinant of velocities. Thus, denoting the interest rates by  $i_T$  and  $i_{US}$ , and inflation rates by  $\pi_T$  and  $\pi_{US}$ , the monetary model that we plan to estimate takes the following form:

$$s_t = a + bm_t + cy_t + di_t + e\pi_t + \epsilon_t \quad (4)$$

where  $s = \text{Log } S$ ;  $m = \text{Log } M_T - \text{Log } M_{US}$ ;  $y = \text{Log } Y_T - \text{Log } Y_{US}$ ;  $i = i_T - i_{US}$ ;  $\pi = \pi_T - \pi_{US}$ ; and  $\epsilon$  is an error term.<sup>1</sup> It is expected that estimate of  $b > 0$  indicating that a faster growth of money supply in Turkey over that of the U.S. will depreciate the lira. Indeed, monetarists would predict estimate of  $b = 1$ . Following the monetarist prediction, estimate of  $c$  is expected to be negative indicating an appreciation of the lira due to an increase in Turkish income relative to that of the U.S. Estimates of  $d$  and  $e$  are expected to be positive indicating a depreciation of the lira due to an increase in Turkish interest rate and inflation rate respectively. Note that in Dornbusch (1976) sticky price model estimate of  $d = 0$ .

<sup>1</sup>A model similar to this is also used by Baillie and Selover (1987) and Macdonald and Taylor (1993). While the first study does not find cointegration among the variables, the later study does.

## 2. The method and the results

Since the overshooting hypothesis is a short-run phenomenon, an appropriate method to test it would be to employ error-correction modeling and cointegration techniques. The first step in applying such techniques is to determine the order of integration of each variable. However, depending on the power of unit root tests, different tests yield different results (Bahmani-Oskooee, 1998). Due to this uncertainty, specially when some variables in the model are at their level (e.g.,  $s$ ,  $m$ ,  $y$ ) and some are at the rate of change (e.g.,  $\pi$ ), Pesaran and Shin (1995) and Pesaran et al. (1996) introduce yet another method of testing for cointegration. The approach known as the Autoregressive Distributed Lag (ARDL) approach has the advantage of avoiding the classification of variables into  $I(1)$  or  $I(0)$  and unlike standard cointegration tests, there is no need for unit root pre-testing. The error correction version of the ARDL model pertaining to the variables in Eq. (4) is as follows:

$$\Delta s_t = a_0 + \sum_{j=1}^n b_j \Delta s_{t-j} + \sum_{j=1}^n c_j \Delta m_{t-j} + \sum_{j=1}^n d_j \Delta y_{t-j} + \sum_{j=1}^n f_j \Delta i_{t-j} + \sum_{j=1}^n g_j \Delta \pi_{t-j} + \delta_1 s_{t-1} + \delta_2 m_{t-1} + \delta_3 y_{t-1} + \delta_4 i_{t-1} + \delta_5 \pi_{t-1} + \epsilon_t \quad (5)$$

Two steps are involved in the ARDL procedure. First, the null of no cointegration defined by  $H_0: \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$  is tested against the alternative of  $H_1: \delta_1 \neq 0, \delta_2 \neq 0, \delta_3 \neq 0, \delta_4 \neq 0$  by the means of familiar  $F$ -test. However, the asymptotic distribution of this  $F$ -statistic is non-standard irrespective of whether the variables are  $I(0)$  or  $I(1)$ . Pesaran et al. (1996) have tabulated two sets of appropriate critical values. One set assumes all variables are  $I(1)$  and another assumes that they are all  $I(0)$ . This provides a band covering all possible classifications of the variables into  $I(1)$  and  $I(0)$  or even fractionally integrated. If the calculated  $F$ -statistic lies above the upper level of the band, the null is rejected, indicating cointegration. If the calculated  $F$  statistic falls below the lower level of the band, the null cannot be rejected, supporting lack of cointegration. If, however, it falls within the band, the result is inconclusive. Using monthly data over January 1987–December 1998 period we carried out the first step by imposing eight lags on each first difference term in the ARDL model. An  $F$ -statistic of 5.05 was obtained when a trend term was included in the model. This is greater than the upper level of the critical band (i.e., 3.827) supporting cointegration. Now that it is justified to retain the lagged value of all five variables (a linear combination of which is denoted by error-correction term,  $EC_{t-1}$ ) in the ARDL model, we reestimate the model using an appropriate lag selection criterion such as AIC. Only an appropriate lag selection criterion will be able to identify the true dynamics of the model. The full information estimate of this step is reported in Table 1.

Concentrating on the sign of lagged coefficient estimates of  $\Delta m$  variable, it appears that the Lira depreciates first (indicated by the first three positive coefficients) and then it appreciates (indicated by negative coefficients) supporting the overshooting hypothesis in the short-run, though many of these coefficients are insignificant. The other variables all carry significant coefficient estimates that are in line with monetarist prediction. The negative coefficient estimates of  $\Delta y$  variable indicates that a high economic growth in Turkey relative to the U.S. appreciates the Lira. The interest rate and inflation differentials also carry significant coefficient estimates that are mostly in line with monetarist prediction. Finally, the lagged error-correction term ( $EC_{t-1}$ ) that was supposed to carry a negative coefficient, carries a positive one. We interpret this as exchange rate staying above its long-run value or overshooting itself in the long-run. To support this, we need to take a look at the estimates of  $\delta_1 - \delta_5$

Table 1  
Full information estimate of ARDL model using AIC criterion<sup>a</sup>

Variable	Lag order									
	0	1	2	3	4	5	6	7	8	
$\Delta s$		0.2872 (2.57)	-0.4741 (4.63)	0.2576 (3.66)	-0.2170 (3.05)	0.2762 (3.59)				
$\Delta m$	0.0407 (0.77)	0.0311 (0.54)	0.0452 (0.79)	-0.0695 (1.29)	-0.0147 (0.27)	0.0479 (0.87)	-0.1097 (2.01)			
$\Delta y$	-0.0028 (0.11)	-0.1624 (2.44)	-0.1440 (2.76)	-0.1164 (2.33)	-0.1031 (2.07)	-0.1081 (2.26)	-0.0838 (2.34)	-0.0695 (2.70)		
$\Delta i$	0.0044 (8.82)	-0.0017 (2.75)	0.0022 (3.05)							
$\Delta \pi$	0.0021 (4.55)	-0.0008 (1.65)	0.0012 (2.37)							
Constant	-0.5731 (1.67)									
Trend	0.0008 (0.80)									
EC		0.0352 (1.76)								

<sup>a</sup> Note: Number inside the parentheses beneath each coefficient is the absolute value of  $t$ -ratio. The adjusted  $R^2=0.7723$  and DW=1.9539.

that were used to form the error-correction term in Table 1. Normalizing on  $s$ , the following estimates were used to form the error-correction term:

$$s = 16.3 - 0.02 * Trend + 1.56m - 5.00y + 0.001i + 0.008\pi \quad (6)$$

As can be seen, the elasticity obtained for relative money supply  $m$  is greater than unity (1.56) indicating that one percent increase in Turkish relative money supply will cause a long-run depreciation of the lira by 1.56%, a result consistent with overshooting hypothesis. Note also that the relative income, interest and inflation rate elasticities are all in line with the monetarists prediction.

### 3. Summary and conclusion

Since 1973 the Turkish lira has lost its value from 14 lira per dollar to almost 400 000 lira per dollar. In this paper we tried to determine whether the lira has overshoot its short-run as well as its long-run values by employing a variant of the monetary model of an exchange rate determination. Application of cointegration and error-correction modeling revealed that first, the lira has followed a path outlined by monetary approach to exchange rate determination. Second, it has overshoot itself in response to rapid increase in Turkish relative money supply not only in the short-run but also in the long-run.

## Appendix A. Data definition and sources

All data are monthly covering January 1987–December 1998 and are collected from the following sources: (a) International Financial Statistics of IMF; (b) Federal Reserve Bank of St. Louis; (c) The Central Bank of Turkey.

### *Variables*

- $s$  = spot exchange rate defined as number of Turkish lira per U.S. dollar, source c.  
 $M$  = M1 monetary aggregate for the U.S. comes from source b and for Turkey from source c.  
 $Y$  = index of industrial production for the U.S. comes from source a and for Turkey from source c.  
 $i$  = three month T-Bill rate for the U.S. is collected from source b and for Turkey from source c.  
 $\pi$  = CPI based rate of inflation. The CPI data for the U.S. and Turkey come from source a.

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