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Sources of Exchange Rate Fluctuations With an Application to Turkish Data

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Abstract: Identifying the sources of exchange rate fluctuations is important for both establishing the validity of PPP and achieving successful exchange rate stabilization. The decomposition of exchange rate shocks into real and nominal components can be implemented by using a structural vector auto regression (SVAR) model. In this study, the SVAR methodology is employed to identify the sources of exchange rate fluctuations of the Turkish Lira against four currencies, the US Dollar, the British Pound, the Italian Lira and the German Mark for the period covering 1982 January to 1999 December. The variance decompositions of the forecast error and the structural impulse response functions are calculated to uncover the relative importance of real and monetary shocks in determination of real and nominal exchange rates. The results indicate that real shocks (or supply side shocks) constitute a relatively more important source for the fluctuations of nominal exchange rates while real shocks significantly dominate monetary shocks for real exchange rates.

Keywords: Real Exchange Rates, SUAR Analysis, PPP Hypothesis.

Introduction

One of the most controversial issues in international finance is the appropriate modelling of real and nominal exchange rates. The behaviour of real

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exchange rates in a floating system, for example, may reflect the sluggish price adjustment or the impact of real shocks such as changes in economic fundamentals. The overshooting models of exchange rates (Dornbusch, 1976) predict that fluctuations in real exchange rates are primarily driven by nominal shocks such as an unanticipated increase in money supply, which would cause the exchange rates to overshoot their long run value due to price stickiness in the short run. The equilibrium approach, on the other hand, asserts that short run to medium run movements in real exchange rates are due to the real shocks rather than monetary shocks (e.g., Stockman, 1987).

Simple PPP model suggests that nominal exchange rates respond fully to monetary shocks over the long run and real exchange rates would respond only to real shocks. Since real exchange rate is simply a relative price, in other words, price level corrected relative price of two currencies, it is subject to several real and nominal shocks. If real exchange rates series can be represented by a unit root model, i.e., if it is no stationary, we expect that shocks would have permanent effects in a freely floating exchange rate system. For example, consider the following random walk representation of real exchange rates

$$q_t = q_{t-1} + \varepsilon_t, \tag{1}$$

where q_t is defined as

$$q_t = s_t + p_t^* - p_t, \tag{2}$$

where s_t is the nominal exchange rate and p_t^* and p_t are price levels of foreign and home countries, respectively. All variables are in natural logarithms. ε_t is mean zero, iid process with $\sigma_\varepsilon^2 < \infty$. In this model, any shocks to the system (either $\varepsilon_t > 0$ or $\varepsilon_t < 0$) will have permanent effects on real exchange rates over the long run. This view has found some support in the literature (e.g. Hakkio, 1986 and Mark, 1990).

The empirical verification of the PPP hypothesis still remains to be a controversial issue in international finance. For example, a recent study by Lothian (2000), using 400 years of exchange rate and price level data of the Netherlands and Britain, argued that real exchange rates can be approximated as stationary processes. He conducts augmented Dickey-Fuller

(ADF) and Phillips-Perron (PP) unit root tests to both levels and first differences of q_t and rejects the hypothesis that the series have a unit root in each case. Thus, he claims, for very long time periods (i.e., 400 years) real exchange rates appear to be mean-reverting. However, the mean-reverting behaviour of q_t disappears when the subdivisions of his data are analyzed.

The question of whether real exchange rate is no stationary or not is also closely linked to the theoretical modelling of exchange rates. In equilibrium models, real exchange rate fluctuations reflect the influence of real shocks with significant permanent components. Stockman (1987) points out those changes in nominal and real exchange rates are highly persistent, i.e., they are not mean-reverting. Sticky price or disequilibrium models, on the other hand, predict that any deviations of exchange rates from their long run value will be transitory (e.g., Dornbusch's overshooting model). The competing models of exchange rate behaviour also have radically different policy implications. Stockman (1987) argues that, in equilibrium models, government cannot affect the real exchange rate by simply changing nominal exchange rate. Foreign exchange market intervention cannot be used as a tool to "reduce' or "cause" inflation (Stockman, 1987: 27).

Recent studies employ the structural vector auto regression analysis to identify the relative importance of real and nominal exchange rate fluctuations. An unrestricted VAR can be used for forecasting systems of interrelated time series and for analyzing dynamic effects of random disturbances on endogenous variables in the system. Lastrapes (1992), using SVAR modeling, analyzed monthly exchange rate and price level data for the US, Germany, the UK, Japan, Italy and Canada. He found that over the current flexible exchange rate period, fluctuations in q_t and s_t is due primarily to real shocks. Chen and Wu (1997) provide empirical evidence from four Pacific Basin countries: Korea, Taiwan, Philippines and the Republic of China. Their analysis indicates that real shocks do have significant impact on the variability of real exchange rates. Other studies with similar results include Clarida and Gali (1994) for the US data, Erlat and Erlat (1998) for Turkish data and Apergis and Karfakis (1996) for Greece.

This paper is an attempt to uncover the relative importance of real and nominal shocks in determination of real exchange rates in the post-1980 stabilization period in Turkey. The empirical analysis assumes that the shocks can be divided into two parts: real (supply side) disturbances and nominal (or monetary) disturbances. The SVAR model is identified by further assuming that nominal shocks do not have permanent effects on real exchange rates in the long run. The analysis is conducted for four bilateral exchange rates: US, UK, Italy and Germany, which are major trade partners of Turkey.

This paper is organized as follows. The next section briefly outlines the econometric methodology used in the empirical analysis. We apply the SVAR methodology in section three to four bivariate Turkish exchange rates for the period 1982.01-1999.12. We first provide tests of the degree of statistical integration followed by the empirical results from four bivariate SVAR models. The last section concludes the study.

Structural VAR Model

Consider the following unconstrained bivariate VAR

$$\mathbf{y_t} = \mathbf{A_1 y_{t-1}} + \mathbf{A_2 y_{t-2}} + \cdots + \mathbf{A_p y_{t-p}} + \varepsilon_t \qquad (3)$$

where $\mathbf{y_t} = (q_t, s_t)'$, $\varepsilon_t = (\varepsilon_t^q, \varepsilon_t^s)'$ and $\mathbf{A_i}'s$ are matrices of unknown parameters. To implement VAR and to get impulse response functions q_t and s_t must be nonstationary or integrated to reach stationarity. After estimating the model the infinite order moving average representation of the model can be obtained by inverting the VAR, i.e.,

$$\mathbf{y_t} = \sum_{i=1}^{\infty} \mathbf{B_i} \varepsilon_{t-i} \qquad (4)$$

where $\mathbf{B_i}$'s are matrices of moving average parameters. This representation of the VAR system allows us to analyze the impact of one unit (e.g., standard deviation) change in innovations on the system variables. These impulse responses can, then, be graphed against the horizon to see the relative importance of real shocks. The error vector in (3) can be given an economic interpretation: $\varepsilon_t^q, \varepsilon_t^s$ are assumed to represent real and nominal shocks respectively. The estimation of this model cannot be implemented directly. However, using the decomposition due to Blanchard and Quah (1989), the behavior of unobserved disturbances can be inferred from the observed data by imposing the long-run neutrality restriction. Blanchard and Quah (1989) assumed that there are two kinds of disturbances each uncorrelated with each other: demand disturbances which have temporary effect and supply disturbances which have permanent effect on GNP fluctuations. To understand their approach in the context of exchange rates consider the following model:

$$\mathbf{A_0 y_t} = \mathbf{A(L) y_t} + \varepsilon_t \ , \qquad (5)$$

where L is the lag operator. This model is structural in the sense that we can distinguish between real and nominal shocks since $\mathrm{cov}(\varepsilon_t) = \mathbf{I}$, where I is the identity matrix. The model (5) cannot be estimated directly but can be recovered from the data using the procedure proposed by Blanchard and Quah (1989). The estimated VAR will have the following form,

$$\mathbf{y_t} = \Pi(L)\mathbf{y_t} + \mathbf{u_t} \qquad (6)$$

Letting $C_0 = A_0^{-1}$ we have $\Pi(\mathrm{L}) = \mathrm{C}_0 A(L)$ and $\mathbf{u_t} = C_0 \varepsilon_t$ such that $E(\mathbf{u_t}) = 0$ and

$\mathrm{Cov}(\mathbf{u_t}) = \Sigma = \mathbf{C_o C_0'}$. The vector moving average representation (VMA) of this system will take the following form:

$$\mathbf{y_t} = C(L)\varepsilon_t , \qquad (7)$$

where $C(L) = [\mathbf{I} - \Pi(\mathbf{L})]^{-1} C_0$

If C_0 is known, then $C(L)$ can be recovered from the estimated VAR. This can be done by imposing the long-run restriction on the covariance matrix Σ. If we assume that nominal shocks do not have any impact on q_t in the long run, then we can identify each element in C_0, in particular,

$$C_0 = \Phi^{-1} C(1) = [\mathbf{I} - \Pi(\mathbf{L})] C(1) \qquad (8)$$

In the limit we have $C(1)=\sum_{i=0}^{\infty} C_i$ which will be lower triangular[1] (i.e., C_{12}=0). C(1) can be estimated by taking the Cholesky decomposition of

$$\Phi(1)\Sigma\Phi(1)^{'} = C(1)C(1)' \ , \qquad (9)$$

Therefore, $C_0 = \Phi(1)^{-1} H$, where H denotes the Cholesky decomposition of the left hand side of (9). This is not lower triangular implying that both shocks have effects on real exchange rates but only real shocks have permanent effects.

There are two potential problems with this model. First, it does not test the restriction imposed on the long run response of real exchange rates to nominal shocks. As discussed in Erlat and Erlat (1998) and Chen and Wu (1997), the long-run restriction just identifies the model, hence it is not possible to test the restriction imposed.[2] Second, the fluctuations in exchange rates may be driven by more than two disturbances. The results in this paper hold under the assumption that they are primarily driven by real and monetary shocks.

Empirical Evidence for Turkey

Data: We have applied the structural VAR methodology outlined in the previous section to the Turkish data for the period 1982.01-1999.12. There are two variables in the model; Q, real exchange rates and S, nominal exchange rates; four countries, the United States (US), the United Kingdom (UK), Germany (GE) and Italy (IT). Monthly data for Turkey was obtained from the Central Bank of Turkey[3]. The data for other countries were obtained from IMF, International Financial Statistics CD-ROM. The nominal

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[1] A matrix is called lower triangular if its elements above the main diagonal are all zeros. In our case, the 2x2 matrix C will be lower triangular when we impose the long-run neutrality restriction.

[2] It is argued in Blanchard and Quah (1989) that if nominal shocks have permanent effect on real exchange rates then the restriction may be assumed to hold only in the limit, i.e., their effects tend to get smaller relative to real shocks.

[3] The Turkish data can be obtained freely from the website: www.tcmb.gov.tr

exchange rate is defined as TL per foreign currency. The real exchange rate comes from the PPP model:

$$Q_t = S_t \, P^*_t \, / \, P_t ,$$

where S_t and Q_t are nominal and real exchange rates (in levels), and P^*_t and P_t are foreign and domestic price levels, respectively. The CPI was used to measure price levels and the base year is chosen to be 1995. All variables are in natural logarithms as described in equation (2).

Figure 1 shows price level behavior in the sample countries. Panel A plots logs of CPI for Italy, the UK, Germany and the US, and Panel B does the same but includes Turkey. Panel C displays changes in CPI. Also Panel D shows ratios of US CPI to the CPI's of Germany, UK and Italy. Clearly there is a convergence towards low inflation rates among four countries, however, Turkey maintains relatively high inflation rates throughout the sample period.

Figure 1 : Clockwise: logs of CPI excluding Turkey, logs of CPI including Turkey, inflation rates and ratio of US CPI to CPI's of Germany, UK and Italy

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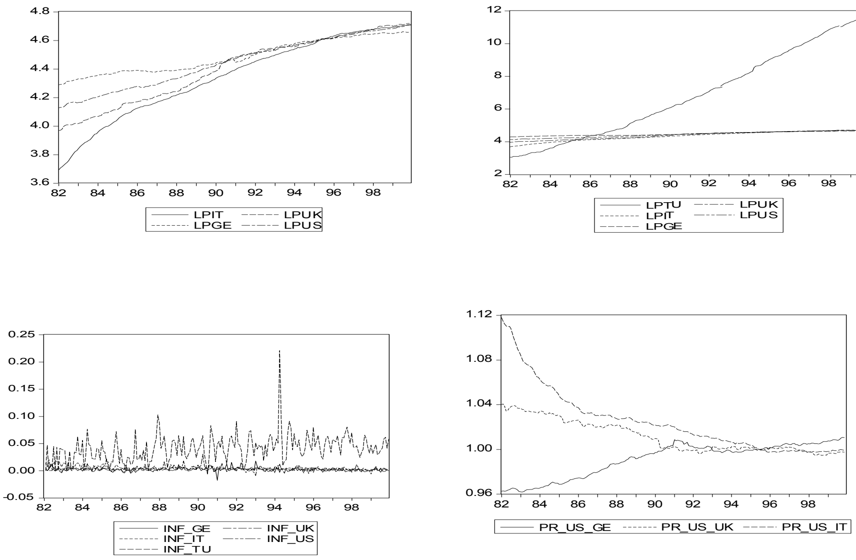


Figure 2 : Logarithms of real exchange rates (levels).

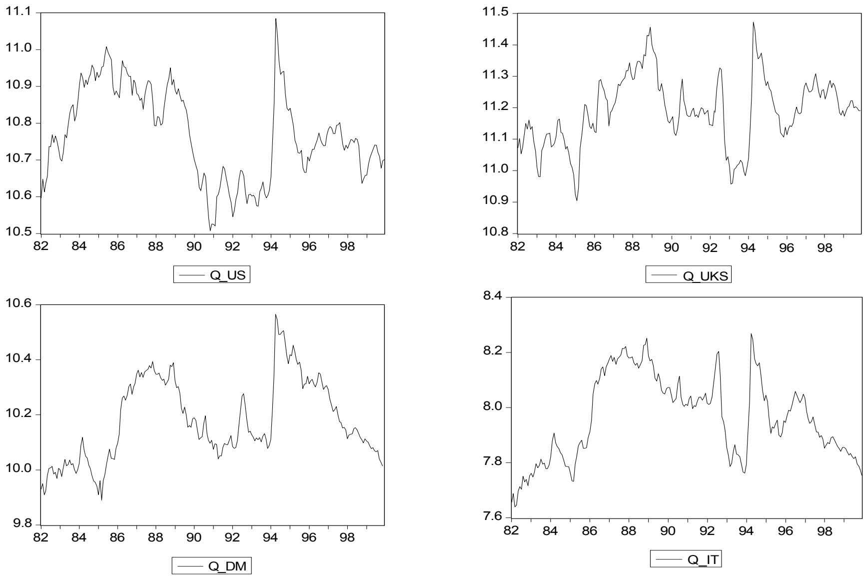


Figure 3 : Logarithms of real (dashed lines) and nominal (solid lines) exchange rates (levels) for the US, the UK, Germany and Italy

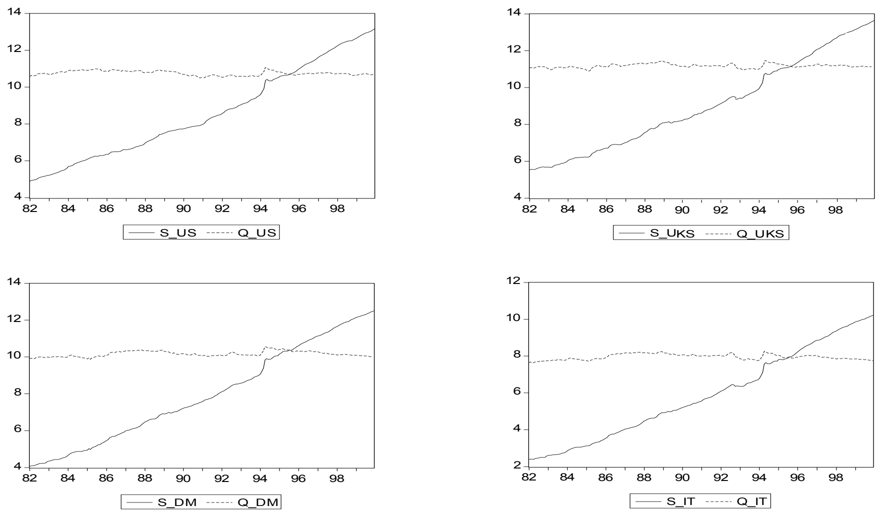


Table 1 : Unit Root Tests

	ADF		PHILLIPS-PERRON	
Country	Variable	Test statistic	Variable	Test statistic
United States	s	-1.18	s	-1.15
	q	-2.88	q	-3.06
	Δs	-4.05*	Δs	-9.75*
	Δq	-4.10*	Δq	-10.39*
Germany	s	-2.18	s	-2.26
	q	-2.08	q	-1.86
	Δs	-3.74**	Δs	-10.08*
	Δq	--3.78**	Δq	-10.69*
UK	s	-1.65	s	-1.91
	q	-0.29	q	-3.41
	Δs	-4.31*	Δs	-9.59*
	Δq	-4.58*	Δq	-9.66*
Italy	s	-2.13	s	-2.36
	q	-2.01	q	-2.27
	Δs	-4.71*	Δs	-9.65*
	Δq	-4.64*	Δq	-9.68*

Note: * (**) shows that the test statistic is significant at 1% (5%) level.

Figure 2 displays real exchange rates (levels) and Figure 3 displays nominal exchange rates together with real exchange rates. From Figure 3 we may say that there is not much variation in Q, but this is due to large range of the y-axis. Figure 2 draws much clearer pictures of the real exchange rates. There are huge fluctuations over 1982-1999 period. For example, consider Q_US; beginning from 1989 there is a large appreciation of TL until 1991. Between 1991-1993, Q_US fluctuates significantly but the amount of depreciation is not sufficient enough as it overshoots in 1994 (March-April). This is the 1994 financial crisis that required an implementation of a stabilization program. Between 1994 and 1996 it appreciates gradually and fluctuates less hazardously afterwards. The same behavior can be observed for Q_UK, Q_DM (Germany) and Q_IT.

Results: As mentioned before, to be able to use SVAR analysis we need to show that the system's variables are nonstationary or integrated of order one, I (1). Also, if the nominal and real exchanges rates contain a unit root then they should not be co-integrated. If they are found to be co-integrated then the appropriate model will be a structural error correction model. The augmented Dickey-Fuller (1979, 1981) (ADF) and the Phillips-Perron (1988) (PP) tests were applied to each pair of bilateral exchange rates and results are tabulated in Table 1. For each country, the ADF and PP tests fail to reject the null hypothesis of unit root for the levels of real and nominal exchange rates, but first differences (Δs and Δq) appear to be stationary.

Table 2 : Engle-Granger Co-integration Tests

Country	ADF test statistics
Unites States	-1.0633
Germany	-1.7673
UK	-0.4959
Italy	-2.7443

Note: Results are based on the residuals from the OLS regressions of nominal exchange rates on real exchange rates. Critical values are –3.4608, -2.8748 and –2.5739 for 1%, 5% and 10% significance levels, respectively (MacKinnon, 1996).

Having established this, we now need to test for co-integration. Since the model of real exchange rates comes from the PPP, each bilateral series must not be co-integrated. If they are co-integrated, then the VAR model should be replaced by an error correction model (ECM). For this purpose, we have applied Engle-Granger (1987) co-integration tests to each country and the results are tabulated in Table 2. The results indicate that the null hypothesis of no co-integration was not rejected for each country.

We now proceed to the estimation of the structural VAR model as outlined in the previous section. Since each series is non-stationary and not co-integrated we have estimated VARs in first differences. The lag length for each bivariate VAR system was chosen using likelihood ratio tests. The LR test selected a six-lag VAR system for the US Dollar and British Pound, one-lag for Italian Lira and German Mark. We first discuss the variance decompositions of real and nominal exchange rates and then plot and analyze the structural impulse response functions.

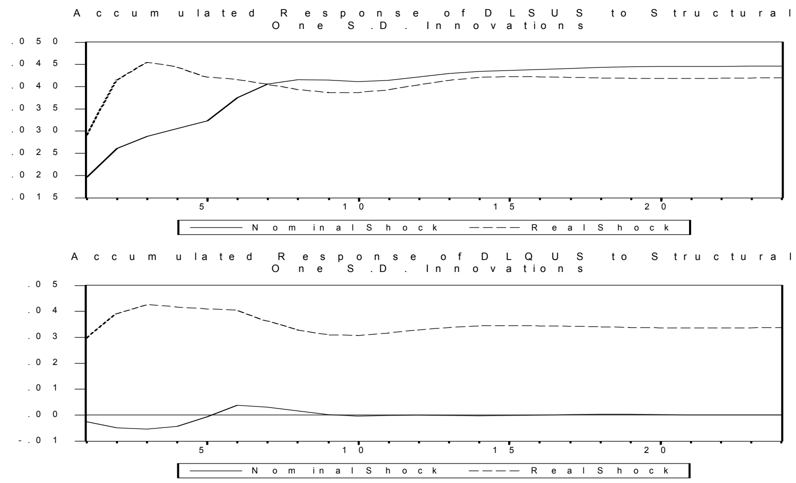
Table 3 summarizes the variance decompositions of real and nominal exchange rates for horizons 1, 3, 12 and 24 months. Variance decompositions measure the relative contribution of forecast error variance of real and nominal shocks as a function forecast horizon. As such, it is a measure of relative importance of shocks in the model. From Table 3 it is apparent that real shocks significantly dominates nominal shocks in explaining the forecast error variance of real exchange rates for all countries. For example, for US, real shocks account for 99.18 % of the forecast error variance at horizon 1 and it settles at its steady state value of 95.05 % within 12 months. Similarly, for Germany, 97.13 percent of the forecast error variance can be attributed to real shocks at horizon 1, 96.82 % at horizon 2 and 96.7 % at horizon 12, its long run value. In explaining the forecast error variance of real exchange rates, real shocks account for about 90 % for UK and 96.82 % for Italy. The last two columns of Table 3 show the variance decomposition of nominal exchange rates with respect to nominal and real shocks.

Real shocks dominate nominal shocks in explaining the forecast error variance of nominal exchange rates for the US and the UK while nominal shocks (slightly) dominate real shocks for Italy and Germany. At horizon 1, 68.72 % and 79.81 % of forecast error variance of nominal exchange rates can be attributed to real shocks for the US and the UK, respectively. Similarly, 44.76 % and 43.11 % of the forecast error variance of nominal exchange rates are due to real exchange rates for Italy and Germany at horizon 1. They reach to their long run value of 49.09 % and 46.40 % in less than 12 months. While we have found that the contribution of real shocks to error variance of the real exchange rates are similar for all countries (above 90 percent), the contribution of each shock to the error variance of nominal exchange rates is quite different. Still, real shocks play an important role in nominal exchange rate determination.

Table 3 : Variance Decompositions

Country	Horizon	Real Exchange Rates (Q)		Nominal Exchange Rates (S)	
		Nominal Shocks	Real Shocks	Nominal Shocks	Real Shocks
US	1	0.82	99.18	31.28	68.72
	3	1.29	98.71	29.92	70.08
	12	4.95	95.05	31.81	68.19
	24	4.95	95.05	31.81	68.19
UK	1	2.77	97.23	20.19	79.81
	3	4.76	95.24	17.19	82.81
	12	9.17	90.83	21.89	78.11
	24	9.19	90.81	21.89	78.11
Italy	1	3.05	96.95	55.24	44.76
	3	3.01	96.99	51.10	48.90
	12	3.18	96.82	50.91	49.09
	24	3.18	96.82	50.91	49.09
Germany	1	2.87	97.13	56.89	43.11
	3	3.18	96.82	53.68	46.32
	12	3.30	96.70	53.60	46.40
	24	3.30	96.70	53.60	46.40

Figure 4 : Impulse Response Functions for US



Based on the estimated structural VAR model, Figures 4-8 plot the impulse response functions for US, UK, Italy and Germany, respectively. Impulse response functions measure the dynamic impact of a one-time shock on the variables in the system. The upper panel of Figure 4 shows the impact of real and monetary shocks on the US nominal exchange rate (DLSUS). The initial response of DLSUS to a one standard deviation structural innovation is 2 percent, which gradually increases and reaches its long run value within 16 months. The impact of a real shock on nominal US exchange rates is initially 3 % and increases to 4 % within the first quarter and then peaks at about 4.5 percent after which it gradually settles toward its long run value of about 4 percent.

The lower panel of Figure 4 shows the impact of real and monetary shocks on real exchange rates for the US (DLQUS). The response of DLQUS to a nominal shock quickly dies out to zero within less than 10 months. A structural shock causes the real exchange rate to depreciate first, within 4 months, then to appreciate slightly and gradually converge to its long run value of 3.3 percent within about 15 months. The response of real exchange rates to real shocks is persistent. Also, the real exchange rate adjustment mechanism to such shocks seems to be very fast.

Figure 5 : Impulse Response Functions for UK

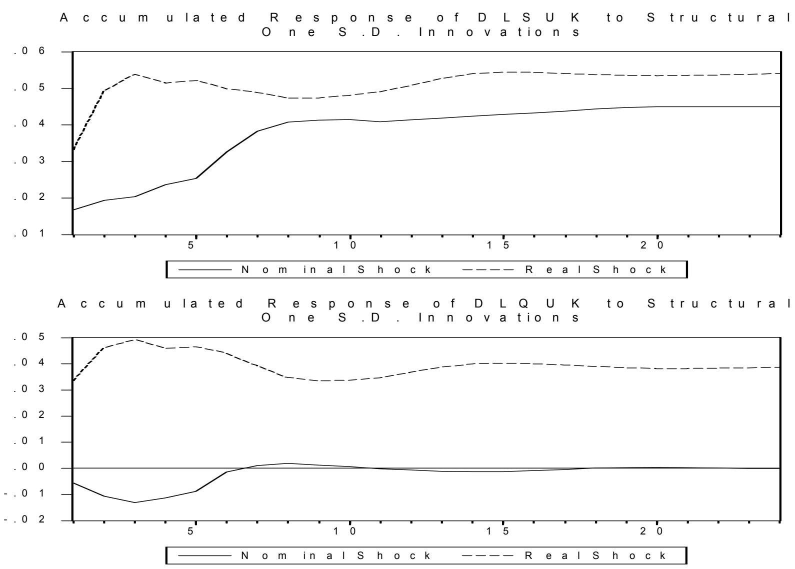


Figure 5 shows impulse response functions for the UK. The shape of the impulse response function is similar to that of the US. The nominal exchange rate (upper panel) depreciates initially in response to both nominal and real shock and the impact of structural innovation dies out relatively quickly (approximately within 15 months). The real British pound first appreciates (lower panel) in response to a positive nominal shock. The impact of nominal shock on real exchange rate dies out relatively faster than that of the US. The real exchange rate depreciates in response to a real shock and appreciates gradually before it settles around its long run value within less than 15 months.

Figures 6 and 7 display the impulse response functions for Italy and Germany. The behavior of these functions are similar to each other, thus we will handle them together. The nominal exchange rates depreciate initially for both countries in response to either a nominal or a real shock (see upper panels of both figures). The real exchange rates rise in response to a real shock and reach their permanent value within less than 5 months. The impact of monetary shocks, however, goes to zero within a couple of months.

Figure 6 : Impulse Response Functions for Italy

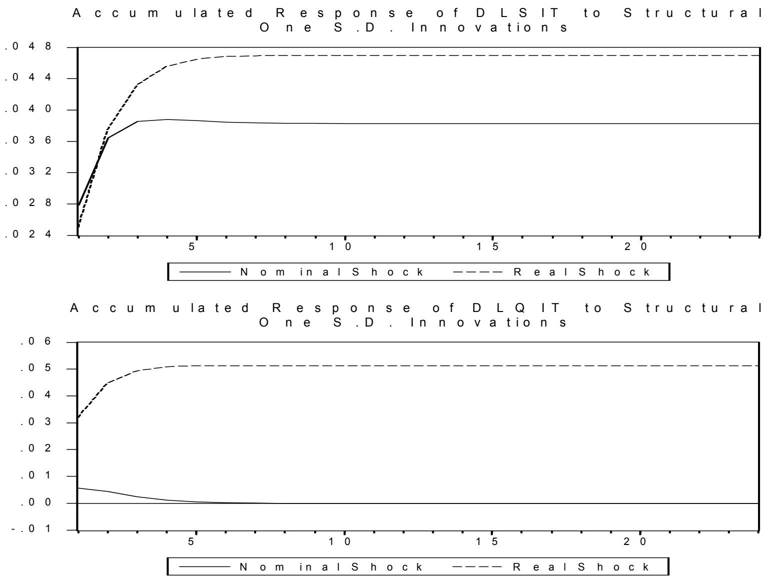
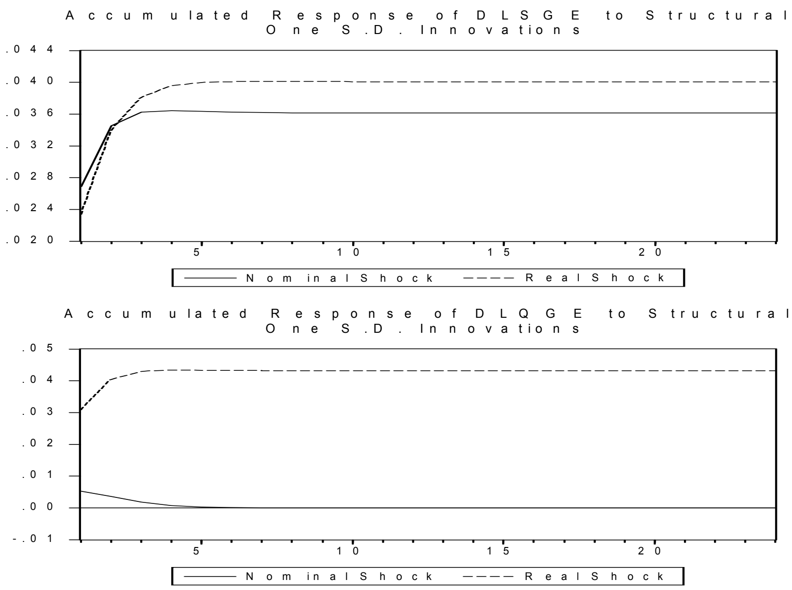


Figure 7 : Impulse Response Functions for Germany



Conclusion

This paper employed the long-run structural VAR approach to decompose the fluctuations in exchange rates into real and nominal components using four bilateral exchange rates for Turkey. The system is identified by assuming that the nominal disturbances do not have permanent effects on real exchange rates in the long-run. We analyzed the variance decompositions and structural impulse response functions. The results indicated that real shocks do have significant impact on the real exchange rates. Real shocks are relatively more important in the determination of real exchange rates as well as nominal exchange rates (except for the cases of Italy and Germany). Although the purpose of this paper was not to discriminate between competing theories of exchange rate determination, the results imply that the government cannot use the nominal exchange rates for the purpose of price stabilization. As mentioned by Stockman (1987) the government intervention in the foreign exchange market cannot be used as a tool to reduce or change inflation.

Döviz Kurundaki Dalgalanmaların Kaynakları ve Türkiye Üzerine Bir Uygulama

Özet: Döviz kurundaki dalgalanmaların kaynaklarının ortaya çıkarılması hem satın alma gücü paritesi hipotezinin geçerliliğinin gösterilmesi hem de döviz kuru istikrarının başarılı olması açısından önemlidir. Döviz kuru şoklarının reel ve nominal kısımlara ayrıştırılması yapısal vektör oto regresyon (SVAR) modeli kullanılarak gerçekleştirilebilir. Bu çalışmada SVAR yöntemi kullanılarak dört adet döviz kurundaki -sırasıyla, Amerikan doları, İngiliz sterlini, İtalyan lireti ve Alman markı- dalgalanmaların kaynakları 1982 Ocak-1999 Aralık dönemi için ortaya konmaya çalışılmaktadır. Döviz kurlarında reel ve nominal şokların göreceli önemini açıklayabilmek için kestirim hata varyansı ayrıştırmaları ve yapısal etki-tepki fonksiyonları hesaplanmaktadır. Bu bulgulara göre reel (ya da arz yanlı) şoklar nominal döviz kuru dalgalanmalarında göreceli olarak daha önemliyken, reel döviz kurlarının belirlenmesinde reel şoklar parasal şoklardan yüksek düzeyde daha baskındır.

Anahtar Kelimeler: Reel Döviz Kurları, SUAR Analizi, PPP Hipotezi.

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