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How does the Exchange Rate Movement Affect Macroeconomic Performance? A VAR Analysis with Sign Restriction Approach– Evidence from Turkey

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Abstract

In this paper, we assess the effect of exchange rate movement on macroeconomic performance by differentiating the source of exchange rate movement as either an expansionary monetary policy or a portfolio preference shock using quarterly data from Turkish economy for the period 1987:Q1 to 2008:Q3. Empirical evidence suggest that if the depreciation of the exchange rate stems from an expansionary monetary policy shock, then the effect of currency depreciation on the economy is expansionary. On the other hand, if currency depreciation comes from a portfolio choice allocation, then the effect of exchange rate depreciation on the economy is contractionary.

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1. Introduction

The effect of exchange rate fluctuations on macroeconomic performance is a heavily researched topic. The conventional Mundell-Fleming model clearly depicts the relationship between the exchange rate and an economy's output level. According to the conventional model, expansionary monetary policy reduces the interest rate, which leads to a depreciation of a country's exchange rate. Hence, the depreciation of currency stimulates the aggregate demand by boosting exports and discouraging imports in favor of domestically produced goods. Many studies provide empirical evidence for the depreciation (or devaluation) of a national currency stimulating economic activity. For example, Agénor (1991) analyzed the effect of real exchange rate changes on output in a rational expectations macro-model with imported intermediate goods. Using the data for a group of 23 developing countries over the period from 1978-87, he found that an unanticipated real exchange rate depreciation boosts the output growth. The study by Hoffmaister and Végh (1996) was the first attempt to provide empirical evidence on the recession-now-recession-later hypothesis for the Uruguayan economy using a vector-autoregression model (VAR) under the exchange rate-based disinflation program. They found that a permanent depreciation in the exchange rate leads to a long-lasting positive effect on output. Santaella and Vela (1996) reached similar results in a VAR for the Mexican economy. However, the positive effect of nominal exchange rate depreciation on output was reversed after three years (Connolly 1983 and Arize 1994). Contrary to conventional wisdom, there is a substantial literature to show that exchange rate devaluation might have contractionary effects on economic activities. According to Krugman and Taylor (1978) and Cooper (1971), pioneers of the "contractionary devaluation" argument, the outcome of exchange rate devaluations might be contractionary by focusing on the adverse income effects of the devaluation. Nominal rigidities, external debt and foreign-currency-denominated liabilities, supply-side-related problems, capital account problems, and associated economic policies in the economy are some of the various channels that explain the contractionary effects of devaluations (see Kamin and Rogers 2000, and Berument and Pasaogullar 2003 for the details). Many empirical studies such as Kamin (1988), Edwards (1989), Agoner (1991), and Morley (1992) are among those that support the argument of the "contractionary effect of exchange rate depreciation on output and/or economic growth." Copelman and Werner (1996) empirically analyzed the relationship among the output, real exchange rate, rate of depreciation of the nominal exchange rate, real interest rate, and a measure of real credit or real money balances variables in a VAR model for the Mexican data. They found that positive shocks to the rate of exchange rate depreciation significantly reduce credit availability and depress the level of output. The study by Kamin and Rogers (2000) yielded similar results with a five-variable VAR --- output, the real exchange rate, inflation, and the U.S. interest rate --- applied to Mexico. They found that although the variation of output was explained mostly by its own innovations, the response of output to a permanent depreciation was permanent and negative.

The fluctuations of exchange rate movement can be attributable to different shocks such as real (e.g., productivity, labor supply or structural reforms), and/or policy induced/demand shocks (e.g., fiscal and monetary policies). It is generally accepted that an expansionary monetary policy shock leads to currency depreciation, which generates an expansionary effect through aggregate demand by lowering interest rates. On the other hand, it seems likely that fluctuations in the exchange rate are related to the shifts in portfolio preferences of economic agents to guard themselves from an adverse future development. In the presence of financial market uncertainty, such as the expectation of future inflation or political developments, private investors (economic agents) may respond to this uncertainty by shifting out of domestic currency dominated portfolios to foreign currency dominated assets.

The significant shifts in portfolio preferences may lead to depreciation in the domestic currency, which may result in an adverse effect on price levels and a weakening of the confidence level of economic agents. Therefore, a significant shift in portfolio preferences generates a contractionary effect on the economy through aggregate demand. Moreover, the source of exchange rate movements may have different effects on macroeconomic performance. This paper assesses the effect of exchange rate depreciation on macroeconomic performance due to either expansionary monetary policy or portfolio preference changes of economic agents by using quarterly data from Turkey for the period from 1987:Q1 to 2008:Q3.

The Turkish economy offers several unique structural economic characters in the context of assessing the effect of exchange rate movements on macroeconomic performance. First of all, Turkey is a small-open economy with a historically high level of inflation. Turkey has experienced a high and persistent level of inflation for more than three decades without running into hyperinflation. Therefore, the relationships between the money aggregates and macroeconomic variables are more visible because of the high variability of monetary policy changes and the high degree of price level variability (Berument 2007, and Kara *et al.* 2007). The high variability of these series decreases the chance of a *Type II error*- error made when the incorrect null hypothesis is not rejected. Therefore, it is easier to find economic relationships in the Turkish data that could not be observed from any other country's data set. In addition, Turkey has never adopted the fixed exchange rate regime, so Turkish monetary policy is not endogenous. This allows us to assess the role of monetary policy on the exchange rate (see Berument *et al.* 2011 for details). Finally, Turkey has relatively well developed and liberal financial markets; in particular, money, foreign exchange, and bond markets operate without heavy regulation. The fluctuations of economic variables are due to viable financial markets rather than the initiations of a few speculators/manipulators.

The contribution of this paper to the existing literature is two fold. First, we employ Uhlig's (2005) sign restriction approach to identify the source of exchange rate movements as either a monetary policy shock or a portfolio choice shock. Second, this study assesses how these two shocks affect the overall macroeconomic performance of the Turkish economy. The findings suggest that: (i) effects of exchange rate movement on macroeconomic activities are expansionary if the exchange rate depreciation stems from an expansionary monetary policy; (ii) if the currency depreciation stems from a portfolio choice allocation, then this effect is contractionary.

The following section introduces the methodology. Both data and empirical evidence are discussed in sections 3 and 4, respectively. The last section is for the conclusion.

2. Methodology

This paper employs VAR methodology to assess the different effects of exchange rate movements that stem from different sources on macroeconomic performance. In order to distinguish the differential effect of exchange rate movements, Uhlig's (2005) sign restriction methodology is employed. To describe the relationship between structural VAR's one-step-ahead prediction errors and structural macroeconomic shocks, we use a VAR in a reduced form

$$Y_{t+1} = c(t) + B_1 Y_t + \dots + B_k Y_{t-k+1} + u_{t+1} \quad (1)$$

where Y_{t+1} is an $(m \times 1)$ vector containing each of the m variables included in the VAR model, B_j are coefficient matrices of size $m \times m$, $c(t)$ contains constant and possible time trend term, and u_{t+1} is the one-step ahead prediction error with variance-covariance matrix $E[u_{t+1}u'_{t+1}] = \Sigma$.

The usual structural VAR approach assumes that the error terms u_{t+1} are related to the structural macroeconomic shocks, v_{t+1} , via matrix A such that

$$u_{t+1} = Av_{t+1} \quad , \quad E[v_{t+1}v'_{t+1}] = I_m \quad (2)$$

In this study, since two different exchange rate shocks are identified, any type of shock to an exchange rate is estimated by v^{ER} . The prediction errors in the VAR model are characterized as being decomposed in the following way

$$u_{t+1} = A_1 v_{t+1}^{ER} + \tilde{A}' \tilde{v}_{t+1} \quad (3)$$

where A_1 is the i^{th} column of the matrix A , \tilde{A}' is the $(m \times (m - 1))$ matrix of the remaining columns of A and \tilde{v} is the $((m - 1) \times 1)$ matrix of the remaining unidentified fundamental shocks. Therefore, all the identified shocks can have an instantaneous effect on all variables. Where, the j th column of A represents the immediate impact on all variable of the j th innovation.

$$\Sigma = E[u_t u'_t] = AE[v_t v'_t]A' = AA' \quad , \quad A = \tilde{A}Q \quad (4)$$

In order to achieve identification, $m(m-1)/2$ degrees of freedom in specifying A are needed. In the study by Uhlig (2005), Q is an orthogonal and \tilde{A} is the Cholesky decomposition of the estimated matrix of covariance residuals $\hat{\Sigma}$ ($\tilde{A}\tilde{A}' = \Sigma$). Thus, determining the free elements in A can be conveniently transformed into the problem of choosing elements in an orthogonal set. The impulse vector a is a column of the matrix A . In our study, a is an impulse vector for any type of exchange rate shock, if and only if there is an m -dimensional vector α of unit length so that

$$a = \tilde{A}\alpha \quad (5)$$

where α is a column of the matrix Q . Given an impulse vector a , it is easy to calculate the appropriate impulse response in the following way. Let $r_i(k)$ be the impulse response at period k to the i th shock obtained by the \tilde{A} , so the impulse response for a at horizon k is given as follows

$$r_a(k) = \sum_{i=1}^m \alpha_i r_i(k) \quad (6)$$

For any type of shock to the exchange rate, the methodology tests whether $a \in A(\hat{B}, \hat{\Sigma}, K)$ is an exchange rate shock, by checking the appropriate sign restrictions on the impulse responses for all relevant horizon periods k .

Uhlig's (2005) sign-restriction methodology is an agnostic identification procedure, which imposes sign-restrictions on the impulse responses of selected variables for a certain period following the shock. The brief summary of Uhlig's (2005) pure-sign restriction approach can be given as follows

- (1) Take n_1 draws from the VAR posterior Normal-Wishart distribution and, for each of these draws, n_2 draws a from independent uniform prior.
- (2) Construct the impulse vector
- (3) For each impulse, calculate $n_1 \times n_2$ impulse responses at horizon $k=0, \dots, K^1$.
- (4) Check whether the impulse response functions satisfy the sign restrictions and keep it, if the impulse response satisfies the sign restrictions, otherwise discard it.
- (5) Collect the n_3 impulse responses for each shock using the loss function and plot their 16th, 50th and 84th percentiles².

This pure-sign restriction approach has several advantages. First, to identify a shock (in this study, any type of exchange rate shock: a monetary policy shock or portfolio choice

¹ We take $n_1=n_2=200$, so there are 40000 draws in total in this study.

² We take $n_3=100$ in this study.

shock), the signs of the impulse responses of a shock are restricted based upon received opinions on what these signs should be for a period of time. Second, since a shock is identified by using impulse responses for several periods following the shock, a wide range of shocks can be captured. Third, impulse responses are drawing from the posterior distribution of the reduced form VAR covariance matrix and coefficients, and from the set of structural matrices consistent with the assumed sign restrictions. So the pure-sign restriction performs relatively well compared to the identification methods based on contemporaneous zero restrictions (Mountford 2005).

3. Data

In order to assess the different effects of exchange rate movements on economic performance, in this study, we gather data from Turkey. We use quarterly data of the interbank interest rate as our measure of the interest rate, M1 plus REPO³ as money supply, Turkish Lira (TL) value of US dollar as an exchange rate, GDP deflator as prices, and GDP as income. The quarterly data are obtained from the Central Bank of the Republic of Turkey (CBRT) Electronic Data Delivery System and the estimation period is from 1987:Q1 to 2008:Q3.

All data are expressed in the logarithmic form except the interest rate. Prior to selecting the specification of the variables in the VAR system, one needs to examine the time series properties of the variables. An Augmented Dickey Fuller (ADF, 1981), Phillips-Perron (PP, 1989) and Kwiatkowski, Phillips, Schmidt and Shin (KPSS, 1992) unit root tests are performed. Table I and II present the results for seasonally unadjusted data and seasonally adjusted data, respectively.

Table I
The Results of ADF, PP and KPSS Unit Root Test

ADF						
	Constant		Constant and trend		First difference	
	Lag ^a		Lag ^a		Lag ^a	
Real GDP	8	-0.740	8	-2.640	7	-3.074**
Nominal GDP	8	-2.47	8	-0.397	7	0.47
GDP Deflator	4	-2.18	4	-0.10	3	-1.13
Interest Rate	2	-2.52	0	-4.49***	1	-10.33***
Exchange Rate	1	-2.50	1	0.30	0	-5.95***
M1+R	0	-0.650	0	-2.571	0	-10.089***
PP						
	Constant		Constant and trend		First difference	
Real GDP	-4.98***		-8.96***		-14.31***	
Nominal GDP	-3.26**		1.20		-9.18***	
GDP Deflator	-4.41***		1.49		-8.90***	
Interest Rate	-3.69***		-4.33***		-21.33***	
Exchange Rate	-2.56		0.61		-6.01***	
M1+R	-0.678		-2.534		-10.135***	
KPSS						

³ The reasons for including REPO in money aggregates: this money aggregate is liquid because most of the repo transactions are overnight, and agents prefer to repo their savings rather than to open deposit accounts since the repo rates are considerably higher during the period that we consider.

	Constant	Constant and trend	First difference
Real GDP	1.32***	0.09	0.12
Nominal GDP	1.18***	0.29***	0.34
GDP Deflator	1.17***	0.28***	1.05***
Interest Rate	0.60**	0.29***	0.50
Exchange Rate	1.15***	0.26***	0.70**
M1+R	1.204***	0.124*	0.077***

Note: * significant at the 10% level. ** significant at the 5% level. *** significant at the 1% level.
^a the lag order is determined by Shwarz Bayesian Criteria

Table II
Unit Root Test Results for Seasonally Adjusted Data

ADF						
	Constant		Constant and trend		First difference	
	lag ^a		lag ^a		lag ^a	
Real GDP	0	-1.21	0	-2.64	3	-6.14***
Nominal GDP	9	-2.44	2	1.49	5	-0.08
PP						
	Constant		Constant and trend		First difference	
Real GDP	-1.21		-2.89		-9.18***	
Nominal GDP	-4.16**		2.98		-3.11**	
KPSS						
	Constant		Constant and trend		First difference	
Real GDP	1.17***		0.07		0.07	
Nominal GDP	1.18***		0.28***		1.05***	

Note: * significant at the 10% level. ** significant at the 5% level. *** significant at the 1% level.
^a the lag order is determined by Shwarz Bayesian Criteria

These two tables suggest that all variables have a unit root. This paper uses the multivariate cointegration technique proposed by Johansen and Juselius (1990) in order to test whether there is a long-run relationship among all variables. Table III reports the results of maximum eigenvalue and trace tests statistics.

Table III
Johansen's Cointegration Tests

The number of cointegrating relations	Trace statistic	Max-Eigen statistic
None*	218.638 (0.000)	141.317 (0.0000)
At most 1*	77.321 (0.000)	57.589 (0.0001)
At most 2	19.731 (0.441)	12.715 (0.478)
At most 3	7.016 (0.575)	5.923 (0.623)
At most 4	1.092 (0.295)	1.092 (0.295)

Note: 1. While maximum lag length is 4, the order level VAR is estimated as 1 using Schwarz criteria.
2. Values in parentheses are MacKinnon-Haug-Michelis (1999) p-values. Both trace and max-eigenvalue tests indicate 1 cointegrating equation at the 10% level.
3. * Statistically significant at the 5% level (p value in parentheses).

The trace test and maximum eigenvalue tests show that the null hypothesis of $r = 0$ against the alternative $r = 1$ is rejected at the 95 percent level. This suggests that there is at least one cointegrating relationship; therefore, the estimation of the VAR in (log) levels provides consistent estimates (Sims *et al.* 1990, and Lütkepohl and Reimers 1992). Moreover, in the Bayesian VAR methodology of Sims and Uhlig (1991) and Uhlig (2005), the parameters of VAR in level are estimated. This methodology is robust in the presence of non-stationarity, and although it does not impose any cointegrating long-run relationship between the variables and it does not rule out their existence either (Mountford 2005). Therefore, the variables in VAR are used in levels for this study.

4. Empirical Evidence

The impulse responses are reported in Figure 1a-1b and Figure 2a-2b. The confidence intervals are generated by using the Bayesian approach of Sims and Zha (1998) and Uhlig (1994), by taking draws from the posterior distribution, and identifying the exchange rate shocks for each case (i.e. a monetary policy shock or portfolio choice shock). The middle lines in the figures represent the impulse responses. One standard deviation confidence interval around the response line are shown in blue. If the confidence interval includes the horizontal line for value of zero, the null hypothesis that there is no effect cannot be rejected.

Figure 1a

Currency Depreciation Due to Expansionary Monetary Policy

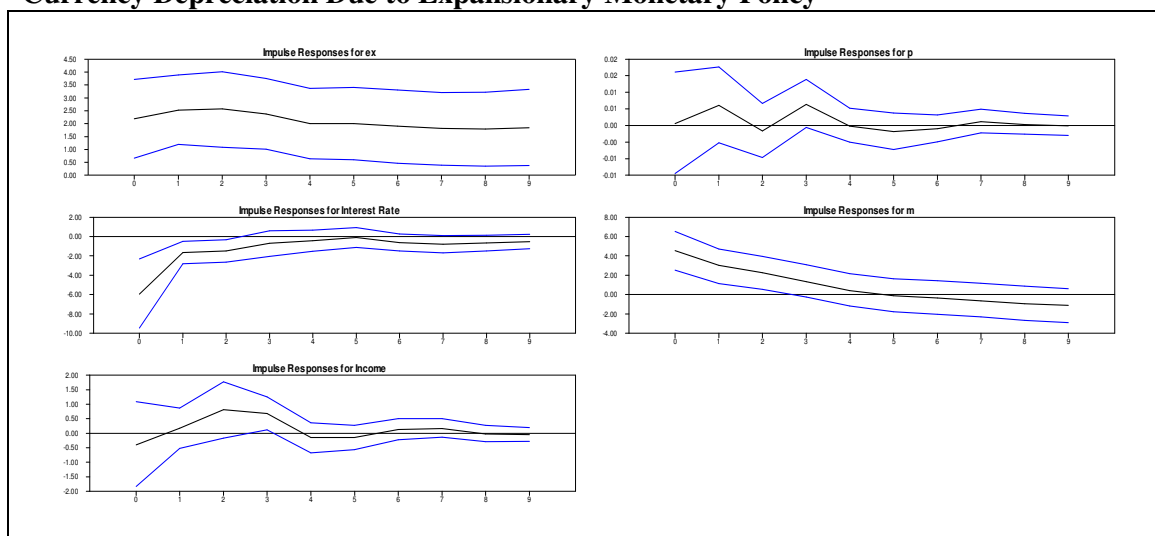


Figure 1a contains impulse responses of exchange rate, price level, interest rate, money aggregate, and real income to a positive exchange rate shock due to an expansionary monetary policy stance. Our sign restrictions for the currency depreciation due to a monetary policy shock are given in Table IV.

Table IV

Identifying Sign Restrictions for Depreciation due to Monetary Policy

Shocks	Exchange rate	Interest Rate	GDP	Price	M1+R
Depreciation due to monetary policy	+	-	NR	NR	+

Note: The table shows the sign restrictions on the impulse responses for each identified shock. '+' means that the impulse response of the variable in question is restricted to be positive for two quarters following the shock, including the quarter of impact. Likewise, '-' indicates a negative response. A 'NR' indicates that no restrictions have been imposed.

We assume that the exchange rate shock stemming from expansionary monetary policy does not lead to a decrease in the exchange rate, a decrease in the money aggregate, and increase in the interest rate in the first two quarters following the shock. Our results indicate that the impulse response of exchange rate increases after a shock and this effect is persistent and statistically significant for the ten periods that we considered. Second, the price level is affected positively at the beginning and after the fourth quarter this effect converges to zero. However, this effect is not statistically significant. Third, the effect of interest rate increases through the first 5 quarters and then this effect dies out. The money aggregate is signed as expected and is statistically significant for almost three quarters, after which decays and converges to zero. Finally, output increases but the effect is statistically insignificant.

Figure 1b
Currency Depreciation Due to Portfolio Changes

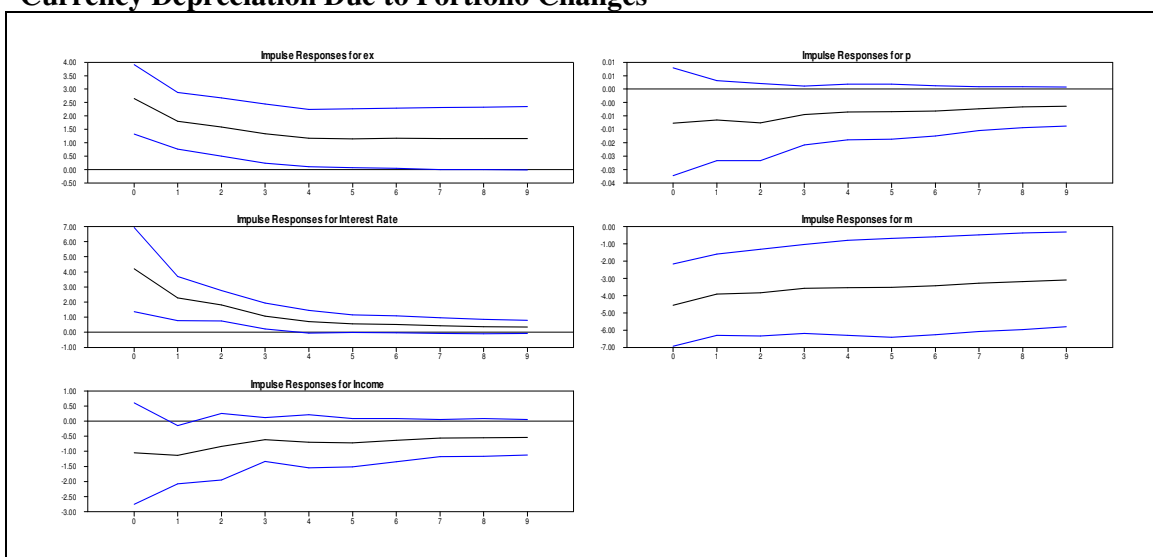


Figure 1b presents the results of the impulse responses for the exchange rate, price level, interest rate, money aggregate, and real income to a positive exchange rate shock due to a non-monetary shock (portfolio preferences). Our sign restrictions for an exchange rate shock stemming from portfolio preferences are given in Table V.

Table V
Identifying Sign Restrictions for Depreciation due to Portfolio Changes

Shocks	Exchange rate	Interest Rate	GDP	Price	M1+R
Depreciation due to portfolio changes	+	+	NR	NR	-

Note: The table shows the sign restrictions on the impulse responses for each identified shock. '+' means that the impulse response of the variable in question is restricted to be positive for two quarters following the shock, including the quarter of impact. Likewise, '-' indicates a negative response. A 'NR' indicates that no restrictions have been imposed.

The responses of exchange rate and interest rate have been restricted not to be negative, and the money aggregate not to be positive for the first two quarters. During the financial stress, the demand for foreign exchange increases, which may be accompanied by the selling Treasury bills (or bonds) and the liquidation of bank deposits. Our study demonstrates that the effect of a depreciation shock to the exchange rate is positive, persistent and statistically significant until the fifth quarter. In general, the price level increase is accompanied by a currency depreciation. However, this study finds that the price level reacts negatively to the

shock, but it is statistically insignificant. In addition, the response of the interest rate is positive and significant for the first three periods, and then this effect becomes statistically insignificant. However, the decrease in the money aggregate is statistically significant for all periods. Finally, the negative income response to exchange rate shock is statistically insignificant.

Figure 2a
Currency Depreciation Due to Expansionary Monetary Policy

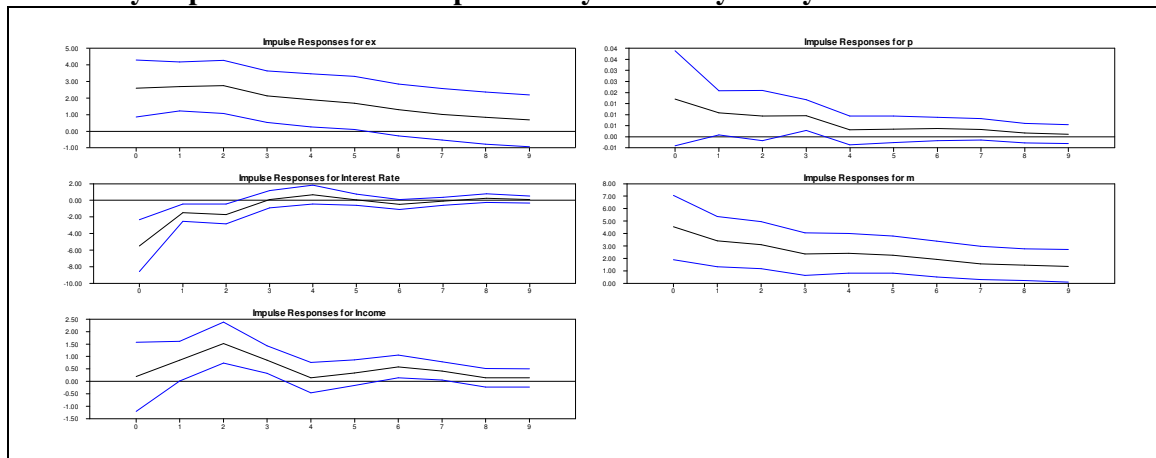
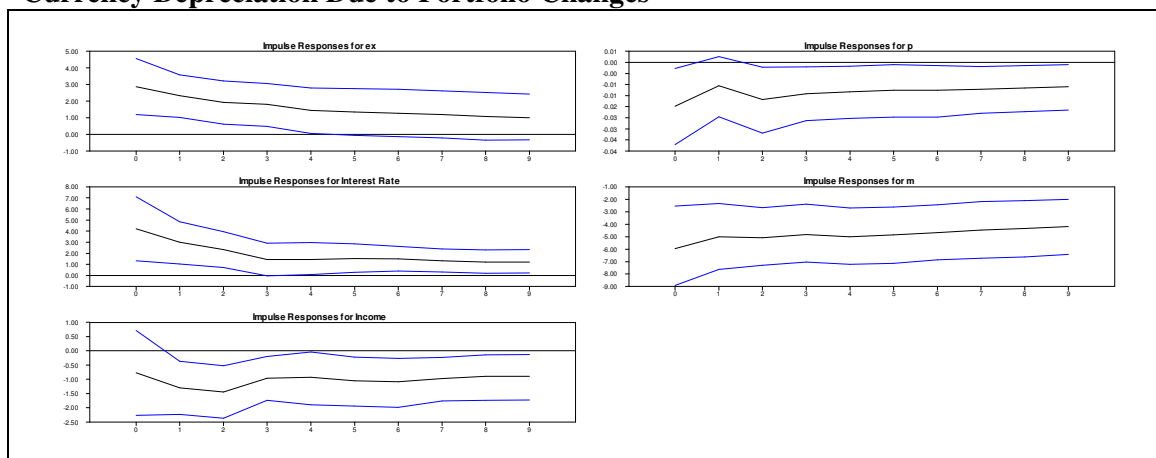


Figure 2b
Currency Depreciation Due to Portfolio Changes



The Turkish economy went through a major structural change after 1994 (see Berument, 2007). To check the robustness of our findings with respect to this major structural change, we re-estimate our benchmark VAR model with the subsample covering the period after 1994 era to 2008:Q3. The corresponding impulse responses of our sub-sample results are reported in Figures 2a and 2b. The findings are very similar compared with the full-sample results of our benchmark specification. However, we should mention the two minor differences arising from the sample selection. First, the effect of an exchange rate shock on macroeconomic variables becomes more persistent. For example, the effect of exchange rate depreciation on output is now statistically significant for 9 periods for the post 1994 era, but this effect was significant only for 1 period for the full-sample specification. In addition, the negative increase in the money aggregate is statistically significant for all periods for two types of depreciation. Overall, we can conclude that our findings are *not* sensitive to the sample

selection for identifying the effects of the monetary and non-monetary shocks on the macroeconomic performance of the Turkish economy.

5. Conclusion

This paper assesses the effect of positive exchange innovation on the macroeconomic performance of the Turkish economy. By using Uhlig's sign restriction approach, the study identifies the source of exchange rate movements as an either monetary policy shock or a portfolio choice shock. The finding suggests that the effects of exchange rate movements on macroeconomic variables are different depending upon the source of the shock to the exchange rate. If currency depreciation stemming from an expansionary monetary policy shock is associated with a lower interest rate and higher liquidity, then the effect of currency depreciation on the economy is expansionary. On the other hand, if the currency depreciation stemming from portfolio choice allocation is associated with lower output and liquidity, then the effect of exchange rate depreciation on the economy is contractionary.

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