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# EFFECTS OF THE REAL EXCHANGE RATE ON OUTPUT AND INFLATION: EVIDENCE FROM TURKEY

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This paper assesses the effects of real depreciation on the economic performance of Turkey by considering quarterly data from 1987:I to 2001:III. The empirical evidence suggests that, contrary to classical wisdom, the real depreciations are contractionary, even when external factors like world interest rates, international trade, and capital flows are controlled. Moreover, the results obtained from the analyses indicate that real exchange rate depreciations are inflationary.

## I. INTRODUCTION

The 1995 Mexican Tequila and the 1997 Asian crises have stimulated a growing interest among academics and policymakers on the controversial issue of exchange rate policies in general and exchange rate regimes and real exchange rates in particular. The effects of financial crises on the global economy are getting more severe, and international trade and capital movements have begun to be central factors in the evolution of such a crisis. Domestic factors that lead to crises in various countries are different, but there are also common features of these crises: big devaluations or depreciations in domestic currency and the subsequent significant output losses of the crisis-hit countries.

Turkey has often experienced financial crises in its history. In 1994 and 2001, the nominal domestic currency depreciated 62 per cent and 53 per cent, respectively. This made the effects of large depreciations an interesting event to study and also provided a natural laboratory where the effect of depreciation on economic performance could be observed. Starting in 1987, in a managed float exchange rate regime, the Central Bank of the Republic of Turkey (hereafter, the CBRT) announced daily quotations, and the domestic currency was depreciated continuously parallel to inflation expectations. However, when there was considerable market pressure in times of crisis, large devaluations occurred. As in the case of the Asian and Mexican crises, common features, such as large devaluations or high levels of

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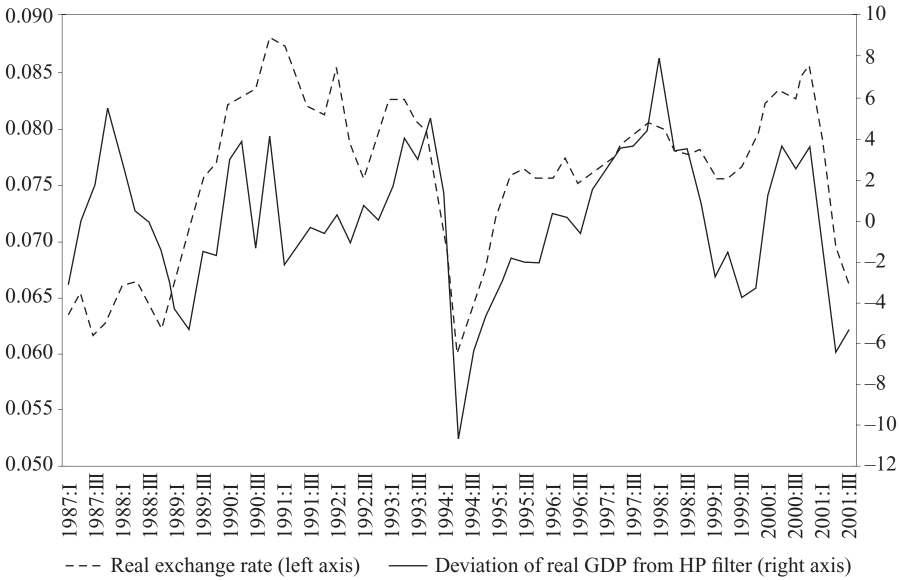
depreciation in domestic currency and significant output losses, were experienced after both the 1994 and the 2001 crises. In 1994, output declined by 6.2 per cent after the financial crisis and sharp devaluation.

However, between these two severe financial crises, the Turkish economy exhibited strong performance on the output side, and the average growth of output between 1995 and 1999 was 4.2 per cent, despite the detrimental effects of the 1998 Russian crisis, the two earthquake catastrophes and the recession that took place in 1999. During the 1995–99 period, the real exchange rate, defined as the nominal exchange rate deflated by the wholesale price index, was relatively stable and there were times when sizeable capital inflow entered Turkey. With the Year 2000 Disinflation Program, the exchange rate regime was shifted from a managed float to a crawling peg regime. With the implementation of this program, a remarkable growth in the GDP and decline in inflation were seen, but the real exchange rate began to appreciate because of the differential between inflation and the preannounced change in the path of nominal exchange rates. However, after the banking and resulting liquidity crisis in November of 2000 and the serious attack on foreign exchange reserves in February of 2001, Turkish authorities decided to switch the exchange rate regime to a floating regime. As expected, the exchange rate surged and there was excessive volatility in the nominal exchange rate even after the first six or seven months of the crisis. Output responsed detrimentally to the large depreciation of the domestic currency and the real GNP and the real GDP declined by 9.4 per cent and 7.4 per cent, respectively, in 2001. The level of output performances was approximately the same as in 1997, indicating a decline in the welfare level of the Turkish public to the levels of four years before.

The 1994 and 2001 crises had different origins and different characteristics; however, the crises also have common elements: namely, huge exchange rate depreciation, preceding and/or coupled with capital outflows, preceding current account deficits, output declines, and high interest rates. There was a sizeable increase in the current account deficit preceding the crisis in 1993, and domestic currency was devalued by more than 62% in nominal terms and 12.1% in real terms after the crisis. Similarly, in 2000, the year preceding the crisis, there was a considerable current account deficit of approximately 4.9% of GDP. The Turkish lira depreciated by 53% in nominal terms and by 11.9% in real terms in 2001. In addition to these facts, output declined severely after both of the devaluations. The output responses after the great devaluations or depreciations suggest that the Turkish case constitutes a possible example of the contractionary devaluation hypothesis, and in this study we basically aim to find empirical support for this suggestion. This study mainly uses the method proposed by Kamin and Rogers (2000), which found empirical evidence for contractionary devaluation in the case of Mexico by analyzing the output and inflation response to real exchange rate movements.

Figure 1 shows the real GDP deviation from its HP-filtered level and the real ex-

Fig.1. Real GDP Deviation from the Equilibrium Level and the Real Exchange Rate




Note: In the figure, depreciations are shown by declines in the level of real exchange rate and appreciations by rises in the level of real exchange rate.

change rate on a quarterly basis. As seen in the figure, large devaluations are coupled with large declines in output, and appreciations are coupled with growth in output. The figure suggests a negative relationship between those two variables. In this paper, we will investigate this negative correlation. However, before proceeding further, we have to say that the findings of this study will be carefully considered. For example, a finding that supports a view contradictory to the contractionary devaluation hypothesis may not recommend keeping the domestic currency at highly competitive levels because of the inflationary effects of such an action; or a finding that supports the contractionary devaluations hypothesis may not be implemented because of the higher risk of financial crisis in the presence of an overvalued domestic currency, when the 1994 and 2001 cases are taken into consideration. However, this study aims mainly at showing the output and inflation responses after the devaluation.

The importance of this study is threefold. Firstly, volatile and persistent inflation and exchange rate movements allow us to observe the effect of real exchange rate movements on economic performance, which might not be observed for other developing countries. The Turkish case constitutes an interesting laboratory where high and persistent inflation without any hyperinflation has been a characteristic of the economy for three decades. During this period, although the inflation rate was high, there were times when high growth rates were seen. Another challenging outcome is that our findings for Turkey, a developing country, are parallel to other studies focusing on developing countries. Other empirical studies testing the contractionary devaluation hypothesis focus mostly on the experiences of Latin American countries; however, our study has found a similar situation in Turkey. Hence, this may imply that the contractionary devaluation hypothesis is not contingent on a country's specific characteristics; rather it is valid for developing countries. Lastly, it is the first empirical study showing that real devaluations have a contractionary effect on output for Turkey. It is important to find in Turkey such support for the contractionary devaluation hypothesis because the capital account regime has been liberalized since 1989, and Turkey entered a customs union in 1996 with the European Union, its main trading partner. Hence, the effects of devaluation are expected to be reflected in external trade and in output by the so-called expenditure switching effects, but the findings show the opposite.

Section II considers the theoretical explanations and channels of the negative output–real exchange rate relationship. Section III discusses previous empirical studies regarding the contractionary devaluation hypothesis. Section IV examines the data for the empirical work in this study and gives a brief summary of real exchange rate movements during the sample period. Section V looks at the bivariate relationship and Granger causality test results between the variables of interest. Section VI analyzes the statistical properties of the data, which include unit root and Johansen cointegration tests. In Section VII, the vector autoregression (VAR) models developed for the dynamic analysis of the data are formed and the results from the various models are explained. The final section summarizes the findings.

## II. POTENTIAL EXPLANATIONS FOR OUTPUT–REAL EXCHANGE RATE LINKAGES

The tight negative relationship between the real exchange rate and output depicted in Figure 1 may emerge due to any one of three reasons. The negative relationship between output and the real exchange rate may be a spurious correlation emerging from the opposite responses of the real exchange rate and output to some external factor; it may be due to the causality running from output to the real exchange rate, or it may reflect the causality running from the real exchange rate to output. The possible reasons and the related theoretical explanations of these three sources will be presented.

### A. *Spurious Correlation*

Devaluations are, in general, responses to unfavorable external and internal developments. First, investors attack official reserves and the value of local currency is devalued when it is not sustained at its present value in relation to the interest rate level and financial market conditions. Attacks from investors usually come with the realization of an adverse external shock, such as a deterioration in terms of trade, an increase in world interest rates, or a decline in capital flow; or the attacks are reactions to major deviations from sustainable equilibrium levels in domestic variables, like appreciated local currency, huge current account deficits, and/or balance of payments deficits. These factors may lead to declines in output contemporaneously or in the subsequent periods. There may also be some instances in which declines in output due to these unfavorable effects may be observed earlier than the devaluations. The spurious correlation between exchange rates and output is supported by empirical evidence provided by Kamin (1988) and Edwards (1989). The co-movement of the real exchange rate and output in opposite directions as depicted in Figure 1 may be considered as a response of these variables to some exogenous shocks. Recently, prior to the exchange rate regime switch and the instability in the nominal exchange rates in February of 2001, the Turkish economy had begun to suffer important output losses starting with the November 2000 banking and resulting liquidity crisis. Thus, in an empirical study, external variables should be controlled to analyze the negative relationship clearly.

### B. *Causality Running from Output to the Real Exchange Rate*

In exchange-rate-based stabilization programs, there are, especially in the initial phases, strong output growth periods, which indicate that the causality between output and the real exchange rate runs from the former to the latter. In this kind of stabilization program, domestic demand is pushed with the implementation of the program, which will increase the price of non-tradable goods where the price of tradable goods is fixed or exhibits less increase than non-tradables due to the pegged exchange rate regime; thus, the real exchange rate appreciates. There are various explanations for why strong output performance is observed with the implementation of exchange-rate-based stabilization programs (Kiguel and Liviatan 1992; Calvo and Végh 1993; Roldos 1995; Uribe 1995; and Mendoza and Uribe 1996). Such a situation indicates that the causality is directed from output to the real exchange rate. In the Turkish case, such a development of output was seen with the implementation of the Year 2000 Disinflation Program. Output expanded by 6.2 per cent in 2000 and the real exchange rate appreciated by 8 per cent. This hypothesis about the causality from output to the real exchange rate may explain a longer-term co-movement between the variables, especially when the nominal exchange rate is fixed or predetermined. Nevertheless, there is no observation in recent Turkish history that large depreciations of the real exchange rate are caused by large declines in the prices of non-tradable goods. Real exchange rate devaluations or large depreciations in real terms result from large nominal exchange rate devaluations or depreciations like the 1994 and 2001 crises.

### C. *Causality from the Real Exchange Rate to Output*

From the viewpoint of the classical model, the devaluation of the real exchange rate has expansionary effects on output if the Marshall-Lerner condition is satisfied. In other words, if the sum of the price elasticity of exports and imports exceeds unity, the devaluation will lead to an improvement in the current account. Hence, devaluations lead to an increase in aggregate demand. However, in the short run, contractionary effects of devaluation on the non-tradable sector may balance or even be larger than these effects; thus, devaluation may depress the economy in the short run. The various channels that explain the contractionary effect of devaluations are as follows:

a. *Nominal rigidities in the economy*. If all the prices in the economy are inflexible, after a devaluation there will be a real decrease in nominal wages, money supply, and related credit magnitudes relative to the value of traded goods. The decline in these variables may weaken domestic demand, resulting in a decline in the level of output.

b. *External debt and foreign-currency-denominated liabilities*. When devaluation occurs, external debt increases proportionately and so does the domestic value of the foreign-exchange-denominated liabilities of the firms and households. This is especially important for countries where dollarization has taken place to some extent. Banks, firms, or households with liabilities indexed or denominated in foreign currency incur significant losses after devaluation. Thus, they have to make adjustments in their balance sheets or budgets and possibly reduce their expenditures. Banks that suffer big losses from the devaluation will not extend credit to the real sector and may even call in credit before the maturation date. This produces a serious negative effect on the firms and may lead to significant declines in output.

c. *Weakening confidence*. After a devaluation, prices do not adjust their long-run value instantly, and this may raise the expected level of inflation as well as the expected level of depreciation of the nominal exchange rate. All of these are negative signals and weaken the confidence of economic agents, which may cause a decline in output.

d. *Capital account problems*. Devaluations are generally coupled with capital outflows. Before or at the time of devaluation, large amounts of foreign capital go abroad, and in the initial stages of devaluation, no large amounts of foreign capital come back. This may limit the growth of the economy and cause the level of output to decrease.

e. *Redistribution of income after devaluation*. Devaluations generally affect income distribution. If income is redistributed after a devaluation from groups with a high marginal propensity to consume to groups with a low marginal propensity to consume, this could lead to a decline in output.

f. *Associated economic policies*. Governments may implement contractionary policies to contain the inflationary effects of devaluation; hence, a decline in output may be the result.

g. *Supply-side-related problems*. If the country's real sector uses significant amounts of imported inputs in their production, increases in costs will follow after a devaluation takes place. This will lead to an upward shift in the supply curve leading to a decrease in the level of output. Another explanation of the contractionary devaluation hypothesis was proposed by Lai (1990). He showed that devaluation would definitely depress domestic output in the presence of the efficiency wage consideration.

In the next section, empirical studies on the effects of the real exchange rate on output will be discussed.

## III. PREVIOUS EMPIRICAL STUDIES

Least squares analysis, panel data studies, macro model simulations, and VAR models have been used previously to investigate empirically the effects of the real exchange rate on output. The empirical literature on the issue has focused generally on developing countries, but there are some studies investigating developed country cases, such as Kamin and Klau (1998).

Edwards (1985) formed a reduced-form equation for twelve developing countries by using annual data for 1965–80 in which real output is regressed to money growth surprises, government expenditure, terms of trade, and the real exchange rate. The empirical findings of this analysis suggest that the initial contractionary effects of a real devaluation are reversed after one year and devaluation is neutral in the long run. Edwards (1989) found that devaluations reduce output in developing countries in a pooled time-series/cross-country analysis where the real GDP is explained by the real exchange rate, government spending, terms of trade, and money growth. Agénor (1991) distinguished anticipated and unanticipated devaluations and found that unanticipated devaluations increase the level of output, whereas anticipated devaluations decrease the level of output. Morley (1992) regressed capacity utilization to the real exchange rate, measures of fiscal and monetary policy, terms of trade, export growth, and import growth in a pooled time-series/cross-country analysis and found that real devaluations tended to reduce output and it took at least two years for the full effects to show. In a similar analysis, Domaç (1997), based on Turkish data for the 1960–90 period using nonlinear three-stage least squares, showed that unanticipated devaluations have positive effects on output but anticipated devaluations do not exert any significant effect on output.

By using a panel data analysis, Kamin and Klau (1998) found that after controlling possible external variables having an effect on output, real exchange rate devaluations have negative effects on output in the short run but are neutral in the long run. In their study, Mills and Pentecost (2000) used a conditional error correction model for four European Accession countries: Hungary, Poland, Slovakia, and the Czech Republic. They found that real exchange rate depreciations had positive effects in Poland, no significant effect in Hungary and the Czech Republic, and negative effects in Slovakia. In a macro model simulation aiming at showing the inflationary effects of real exchange rate targeting, Erol and van Wijnbergen (1997) found the real exchange rate appreciations to be contractionary for Turkey.

By using a VAR model for Mexico with four variables—output, government expenditures, inflation, and money growth—, Rogers and Wang (1995) found that most of the output variation is attributable to its own shocks, but the response of output to devaluation is negative. Copelman and Werner (1996), by using a VAR model for Mexico with five variables—output, the real exchange rate, rate of depreciation of the nominal exchange rate, the real interest rate, and a measure for real money balances—showed that declines in output are observed after a devaluation. Kamin and Rogers (2000) examined Mexican data by a VAR model with four endogenous variables where they employed the U.S. interest rate, the real exchange rate, inflation, and output for 1981–95 period on a quarterly basis and found that although the variation of output is explained mostly by its own innovations, the response of output to a permanent depreciation is permanent and negative.

In addition to direct analysis of the contractionary devaluation hypothesis in the above VAR models, there are VAR models that basically investigate output response in exchange-rate-based disinflation programs; that is, the relationship between output and a reduction in the rate of nominal exchange rate increase. For example, in their study, Santaella and Vela (1996) showed that by using a two-variable VAR model for Mexico, a reduction in the rate of nominal exchange rate depreciation raised output initially, but the rise was reversed after the twelfth quarter. Hoffmaister and Végh (1996) estimated a VAR model for Uruguay with output, inflation, nominal exchange rate depreciation, and money growth and found that a permanent reduction in exchange rate depreciation led to a long-lasting positive effect on output.

The majority of the studies discussed above found that devaluations are contractionary; however, this is not generally supported as there are studies showing that devaluations are expansionary. Thus, the contractionary devaluations hypothesis is a controversial issue for the world in general and for Turkey in particular.

This study uses the VAR method as employed in Kamin and Rogers (2000) for the case of Mexico. Another method would be to employ structural models, which generally have a theoretical foundation. However, choosing the structural form is often difficult and may lead to arbitrary identifying restrictions. VAR models may not have the strong theoretical foundations that structural models have, but they do provide dynamic interaction among variables of interest and have high predictive power. In addition, Kamin and Rogers (2000) provide the theoretical framework of the core model, on which we base our findings. The theoretical framework is reported in the Appendix of Kamin and Rogers (2000).

## IV. DATA AND HISTORICAL ANALYSIS OF EXCHANGE RATE MOVEMENTS IN TURKEY

To analyze the interrelationships among inflation, output, and the real exchange rate in Turkey, we have used the real exchange rate, the real GDP, inflation, and the nominal U.S. interest rate in the core model. The real exchange rate is computed by the nominal exchange rate basket, which is chosen in line with the official definition of the exchange rate basket adopted in the sample period and which is deflated by the inflation used in this study. Thus, the exchange rate basket used in here consists of 1 U.S. dollar and 1.5 deutsche mark. The inflation rate that has been used is the logarithmic first difference of the wholesale price index (WPI). In alternative models, we have also added some other variables, such as balance of payments items, current account, capital account plus official reserves, money supply (M1), and the government purchases item of GDP. The sample period covers quarterly data from 1987:I to 2001:III. The data are quarterly due to the quarterly GDP data releases. All data, except U.S. nominal interest rates, are available on the website of the CBRT (http://tcmbf40.tcmb.gov.tr/cbt.html). The data for U.S. nominal interest rates are available on the website of the Federal Reserve Bank of St. Louis (http://research.stlouisfed.org/fred2/data).

The level of output exhibits a very apparent seasonality in Turkey; hence we use the seasonally adjusted real GDP. The real GDP and M1 are used in logarithmic levels. For variables of balance of payments items and government size, we use the ratio of the variables to the nominal GDP. We have used the three-month U.S. treasury bill interest rate as the nominal U.S. interest rate.

The course of developments in the exchange rate have been relatively stable during the sample period but with substantial exceptions during the crisis periods. Turkey applied to the IMF for the full convertibility of the Turkish lira in 1989. From then until January 2 of 2000, Turkey's exchange rate regime was that of an intermediate exchange rate with a financial crisis and devaluation in 1994. In other words, the exchange rate was not fixed or priorly announced, but the CBRT monitored the exchange rate movements and did not allow excessive real exchange rate fluctuations in most of the sample period. From January 2 of 2000 to February 22 of 2001, the CBRT publicly announced the daily quotations of the nominal exchange rates every morning and committed itself to intervene in the exchange rate market, i.e., buy or sell foreign exchange at these announced rates. The markets carefully followed these quotations and the level of the nominal exchange rate in the markets did not deviate much from the CBRT's quotations except in the 1994 crisis period. The CBRT used the nominal exchange rate as a policy variable throughout most of the sample period. The nominal exchange rate was determined in consideration of inflation and current account sustainability issues, as stated by Gazi Erçel—CBRT governor.

> The Central Bank's exchange rate policy is affected by two factors. These are the sustainability of the current account balance and inflation. A rapid increase in exchange rates could encourage inflation, while increasing the sustainability of current account balance. The contrary effect of the exchange rate on these two variables oblige the Central Bank to steer its exchange rate policy between these two constraints to maintain equilibrium in the economy. In periods when the fight against inflation has priority in economic policymaking, exchange rate policy is pursued with by its inflationary effects in view. But when the fight against inflation recedes, exchange rate policy is redirected to strengthen the current account balance. (Erçel 1998)

The CBRT considered current account sustainability and the inflationary effects of exchange rate movements in order to achieve stability in the financial markets in the sense that a comprehensive program and effort for disinflation was lacking. The Turkish economy has had high, chronic, and variable inflation since the mid-1970s and the economy was characterized by rising budget deficits and a rising stock of domestic debt in the sample period. In such an environment, the objective of the CBRT was achieving stability in financial markets, and it was successful in achieving this objective. Except for the 1994 crisis, the financial markets were stable until November 2000. Stability was achieved to some extent in the financial markets even in the presence of negative external shocks like the Persian Gulf crisis in 1991, the Asian crisis in 1997, and Russian crisis in 1998.

In 1989 the capital account was fully liberalized. The initial effects of this liberalization was a rapid capital inflow into the Turkish economy, coming in the form of borrowing from international markets by the banking sector and rising portfolio investments on the Istanbul Stock Exchange (Emir, Karasoy, and Kunter 2000). The real exchange rate appreciated about 9.7 per cent in 1990. The Persian Gulf crisis created uncertainties about the exchange rate, and the CBRT aimed at keeping these uncertainties to minimum levels. However, the real exchange rate depreciated 8.3 per cent in 1991. In 1992, the exchange rate policy was quite different from the 1989–90 period, and the CBRT did not allow the exchange rate to appreciate in real terms. The exchange rate basket (1 U.S. dollar + 1.5 deutsche mark) depreciated by 1.4 per cent in 1992. In 1993, the real exchange rate did not appreciate much and stayed approximately around the same level during the year, but at the end of 1993 there was a 19 per cent appreciation of Turkish lira stemming from the 1989–90 period. In 1994, because of domestic imbalances and growing budget deficits, the CBRT encountered a serious attack on its reserves. Following the erosion of reserves, the financial crisis and frequent but small devaluations, the Turkish government devalued the lira by 20 per cent on April 5, 1994. While the nominal exchange rate stabilized towards the end of the year, the real exchange rate depreciated by 12 per cent in 1994. In 1995, the real exchange rate appreciated to some degree, but by the end of the year it was more depreciated than it had been in 1993.

The political uncertainties after the November 1995 elections, the continuation of coalition governments, and the lack of disinflation efforts, and related prudent fiscal measures caused the CBRT to describe its primary objective as the achievement of stability in the financial markets. The CBRT also aimed to decrease inflation, but this was of secondary importance because of the previously noted reasons. To keep the financial markets stable, the CBRT used the nominal exchange rate as its policy tool. The CBRT pursued an implicit competitive real exchange rate policy which basically limited the deviation of the percentage change of the nominal exchange rate from the expected inflation rate. Another consideration in the stability of the real exchange rate was the balance of payments issue. In the 1995–99 period, the monthly nominal exchange rate basket depreciation was around the monthly inflation rate figure, so in this period the real exchange rate gained stability. Additionally, the intra-month volatility of the exchange rate was limited in general. This strategy was successful in handling the big negative external shocks, like the 1997 Asian crisis and the 1998 Russian crisis. During those periods, there was some erosion of the CBRT reserves, but there were no big turbulences that could be considered "financial crises."

With the Year 2000 Disinflation Program, a crawling peg regime in the exchange rate policy was adopted starting on January 2, 2000. The Year 2000 Disinflation Program was an exchange-rate-based disinflation strategy with prudent fiscal measures and an ambitious structural reform agenda. The CBRT announced every three months the path of the nominal exchange rate basket (1 U.S. dollar + 0.77 euros) which followed a sliding twelve-month scale. The definition of the exchange rate basket was switched from 1 U.S. dollar + 1.5 deutsche mark to 1 U.S. dollar + 0.77 euros because the euro had become the currency unit used in accounts in international financial markets as the official European currency from 1999 on. It was announced that the nominal exchange rate basket would depreciate by 20 per cent, the targeted WPI inflation rate for 2000. Like in other disinflation programs, the inflation rate converged to the exchange rate basket depreciation two to three months after the beginning of the program. The inflation rate was 33 per cent in the WPI for 2000, above the exchange rate basket depreciation; but it was the lowest figure for the previous fourteen years. However, the crawling peg policy was abandoned and a floating exchange rate policy was adopted on February 22 of 2001 after the huge attack on CBRT reserves. On that day, the value of the U.S. dollar against the Turkish lira increased by 40 per cent. After switching to the floating exchange rate regime, the nominal exchange rate further rose until November 2001, and the real exchange rate depreciated by 11.9 per cent in 2001.

## V. BIVARIATE DATA ANALYSIS

As seen in Figure 1, there seems to be a tight negative relationship between the real exchange rate and output. To analyze this negative correlation, we first perform the cross correlations between the real exchange rate and output. We repeat the cross correlation analysis with different transformations. Then, to analyze the direction of causality, the Granger causality test statistics will be presented. The causality tests have been performed in the full sample and in the subsamples.

In Table I, we show the cross correlations between the quarterly seasonally adjusted real GDP and the real exchange rate after various transformations. The data are from the sample period between 1987:I and 2001:III. We have evaluated the cross correlations up to four periods. The lag number indicates the number of quarters by which the real exchange rate is lagged relative to the seasonally adjusted real GDP. Negative values for periods indicate that the real exchange rate is lagged relative to the seasonally adjusted real GDP and positive values for periods indicate that the seasonally adjusted real GDP is lagged relative to the real exchange rate. We have seasonally adjusted the real GDP because it displays an apparent seasonality. We use different transformations, namely, logarithmic form, first difference of logarithmic form, deviation from a linear trend, deviation from a quadratic trend, deviation from a cubic trend, trend obtained by HP filter, and deviation from the trend obtained by HP filter, because there is no general agreement about equilibrium values of the variables, and we want to see whether the co-movements of the real ex-

TABLE I

CROSS CORRELATIONS BETWEEN THE REAL EXCHANGE RATE AND THE SEASONALLY ADJUSTED REAL GDP

| | Logarithmic Form | First Difference of Logarithmic Form | Deviation from a Linear Trend | Deviation from a Quadratic Trend | Deviation from a Cubic Trend | HP Filtered | Deviation from the HP Filter Trend |
|---|---|---|---|---|---|---|---|
| –4 | –0.07 | 0.36** | 0.26** | 0.05 | 0.01 | –0.26** | 0.36** |
| –3 | –0.15 | 0.06 | 0.16 | –0.06 | –0.10 | –0.34** | 0.06 |
| –2 | –0.25* | –0.02 | –0.01 | –0.22** | –0.24** | –0.43** | –0.02 |
| –1 | –0.34** | –0.35** | –0.24* | –0.39** | –0.38** | –0.52** | –0.35** |
| 0 | –0.43** | –0.62** | –0.42** | –0.54** | –0.51** | –0.62** | –0.62** |
| 1 | –0.43** | –0.46** | –0.26** | –0.40** | –0.30** | –0.61** | –0.46** |
| 2 | –0.42** | –0.29** | –0.11 | –0.27** | –0.29** | –0.60** | –0.29** |
| 3 | –0.38** | –0.13 | –0.01 | –0.19 | –0.22** | –0.58** | –0.13 |
| 4 | –0.33** | 0.18 | 0.05 | –0.15 | –0.20 | –0.57** | 0.04 |

* Significance at the 10 per cent level.

** Significance at the 5 per cent level.

change rate and output in opposite directions are valid under different assumptions of equilibrium variables for the real exchange rate and output. The transformations were made to both the real exchange and the output.

Consistent with the tight negative relationship between output and the real exchange rate in Turkey (shown in Figure 1), almost all of the cross correlations exhibited in Table I are negatively correlated. However, a positive correlation seems to exist at the four-period lag; for five filters used in the analysis, this situation exists but three of them are statistically significant. At the three-period lag, the situation is mixed; for three of the filters (deviation from a linear trend, deviation from the trend obtained by the HP filter, and the first difference of the variables) used in the analysis, there exists a positive relationship between output and the real exchange rate but none of them is statistically significant. For the remaining four filters, the relationship between the variables is negative and only one of them is statistically significant. Likewise, at the four-period lead, there exists a positive cross correlation for the same filters that indicate a positive relation at the three-period lag, and the other filters indicate a negative correlation. However, observations that indicate positive correlation are not statistically significant, and the two observations that indicate negative correlation are statistically significant.

The magnitude of the cross correlation varies among the filters, but all filters show that the magnitude of the correlation between the variables is at their highest in the contemporaneous period. In addition, all observations for the contemporaneous period, one-period lag, and one-period lead are statistically significant. The magnitude of the correlation coefficient is highest for the HP-filtered data and lowest for the filtered deviation from the linear trend. Hence, the cross correlations show that devaluations are associated with depressed output and appreciations are associated with increased levels of output.

From the cross correlations presented in Table I, it is evident that there is a negative correlation between the real exchange rate and output. The direction of the causality seems to be from the seasonally adjusted real GDP to the real exchange rate as the magnitudes of the cross correlations are greater in lead periods than in lag periods. To examine the direction of causality more precisely and control the effects of other lagged forms of these two variables, we test the relationship between the real exchange rate and output in a VAR setting and compute the relevant $F$-statistics to perform the causality test in Granger's sense (hereafter, Granger causality). The Granger causality tests will indicate whether a set of lagged variables has explanatory power on the other variables. If the computed $F$-statistics are significant, then we can safely claim that one variable does Granger cause the other variable. The transformations of the above cross correlation analysis are repeated in these Granger causality tests, the results of which are presented in Table II. The VAR model that is used in computing the Granger causality tests is a two endogenous variable model with four lags, a constant term, and seasonal dummies for the first three quarters.

TABLE II

GRANGER CAUSALITY TESTS ($F$-statistics and Significance)

| | Logarithmic Form | First Difference of Logarithmic Form | Deviation from a Linear Trend | Deviation from a Quadratic Trend | Deviation from a Cubic Trend | HP Filtered | Deviation from the HP Filter Trend |
|---|---|---|---|---|---|---|---|
| Full sample: | | | | | | | |
| Real GDP → Real exchange rate | 0.31 (0.87) | 3.38 (0.02) | 1.15 (0.35) | 0.39 (0.82) | 0.33 (0.86) | 0.00 (1.00) | 2.04 (0.11) |
| Real exchange rate → Real GDP | 0.68 (0.61) | 0.51 (0.73) | 0.42 (0.79) | 0.56 (0.69) | 0.45 (0.77) | 0.00 (1.00) | 0.49 (0.74) |
| Subsample 1 (1987:I–1994:I): | | | | | | | |
| Real GDP → Real exchange rate | 1.10 (0.39) | 2.19 (0.12) | 3.11 (0.05) | 1.54 (0.24) | 1.21 (0.35) | 0.00 (1.00) | 2.53 (0.08) |
| Real exchange rate → Real GDP | 0.70 (0.60) | 0.48 (0.75) | 0.62 (0.66) | 0.82 (0.53) | 0.76 (0.57) | 0.00 (1.00) | 0.69 (0.61) |
| Subsample 2 (1995:III–1999:IV): | | | | | | | |
| Real GDP → Real exchange rate | 2.21 (0.20) | 0.28 (0.88) | 0.56 (0.71) | 0.26 (0.90) | 0.23 (0.91) | 0.00 (1.00) | 0.65 (0.65) |
| Real exchange rate → Real GDP | 0.78 (0.58) | 0.24 (0.90) | 0.59 (0.69) | 0.71 (0.62) | 0.77 (0.59) | 0.00 (1.00) | 1.22 (0.41) |
| Subsample 3 (1995:III–2000:IV): | | | | | | | |
| Real GDP → Real exchange rate | 1.25 (0.36) | 0.89 (0.51) | 1.22 (0.37) | 1.43 (0.30) | 1.42 (0.30) | 0.00 (1.00) | 1.23 (0.37) |
| Real exchange rate → Real GDP | 3.26 (0.07) | 1.01 (0.45) | 2.19 (0.15) | 3.10 (0.07) | 3.40 (0.06) | 0.00 (1.00) | 1.49 (0.29) |
| Subsample 4 (1995:III–2001:III): | | | | | | | |
| Real GDP → Real exchange rate | 3.39 (0.05) | 1.35 (0.31) | 1.98 (0.16) | 1.74 (0.21) | 1.72 (0.21) | 0.00 (1.00) | 1.35 (0.31) |
| Real exchange rate → Real GDP | 3.89 (0.03) | 1.07 (0.42) | 6.67 (0.01) | 7.43 (0.00) | 7.70 (0.00) | 0.00 (1.00) | 3.64 (0.04) |

Note: $p$-values are reported next to $F$-statistics, in parentheses.

We first computed the relevant $F$-statistic values for the whole sample. The results of the full sample Granger causality test state that neither of the variables is helpful in explaining the movements of the other. The null hypothesis that the real exchange rate does not Granger cause real output, and the null hypothesis that real output does not Granger cause the real exchange rate cannot be rejected even in lower levels of significance. However, for the transformation of the first difference of the logarithms of the variables, the null hypothesis that the real GDP does not Granger cause the real exchange rate is rejected at the 2 per cent level of significance. In all other transformations, there seems to be no causality between these two variables. There are at least two different ways to explain this failure of the Granger causality test in the full sample. The first is that the fifteen-year sample period is a long horizon when different characteristics of economic activity, monetary policy, and related policy tools are considered. There may be periods when the interaction between the real exchange rate and output changes. For example, for the years between 1995 and 1999, the CBRT's objective was primarily to achieve market stability. The CBRT tried to influence exchange rate movements under this constraint and for the year 2000, the exchange rate tool was used in the disinflation strategy. These counter developments may offset the possible negative effects between the variables.

We re-performed the analysis for different subsamples. The 1994 devaluation was very detrimental on economic activity, and high levels of depreciation were seen in this period. Therefore, it was thought that dividing the full sample into subsamples before and after the 1994 crisis would be suitable. Thus, the first subsample is chosen to be the period from 1987:I, the beginning period of our full sample, to 1994:I, the last period before the crisis and devaluation of 1994. We have excluded the crisis and subsequent recession and the "V type" of the recovery period because of the extreme behavior of the nominal exchange rates during this period. For the post-1994 subsample, we consider three different and overlapping subsamples. Our second subsample is the period between 1995:III and 1999:IV. The last quarter of 1999 is the last quarter of the managed float regime before the implementation of the crawling peg regime of the Year 2000 Disinflation Program. We also repeated the analysis to assess whether any different relationship could be detected when the period of crawling peg regime is included; hence, we extended the data span in the third subsample to 2000:III, the last quarter before the November 2000 banking and related liquidity crisis. In the same manner, we extended the analysis to include the crisis in February 2001 and the following recession. Neither the 2000 Disinflation Program's crawling peg regime nor the period of the floating exchange rate regime of 2001 can be analyzed alone, due to the shortness of each time span.

The results of these subsample analyses of Granger causality tests give mixed results. First of all, there is no transformation that gives a statistically significant causal relationship between the real exchange rate and output in any of the subsamples considered. In the first subsample, the transformation of deviation from a linear trend and deviation from HP filtered reveal that output Granger causes the real exchange rate at the 5 per cent and the 8 per cent levels of significance, respectively. There is no statistically significant causality relationship in either direction in the second subsample presented in Table II. In the subsample between 1995:III and 2000:IV, in three of the transformations—namely, logarithmic form of the variables, deviation from a quadratic trend, and deviation from a cubic trend—the null hypothesis that the real exchange rate does not Granger-cause real output is rejected at the 7 per cent level of significance. Finally, when the last subsample is considered in the majority of the transformations, it is evident that the real exchange rate Granger causes real output. In the logarithmic form, where the real exchange rate Granger causes output, output also Granger causes the real exchange rate. In the other cases, the hypothesis that output Granger causes the real exchange rate is rejected

The results of the subsample Granger causality tests are mixed but they at least give an indication and an expected result for the last subsample. In the last subsample, we have considered all the periods between 1995:III and 2001:III. During this period, there are times when the real exchange rate appreciated and output increased contemporaneously or with lags, like in 2000. In 2001 as well, there is a period when the nominal and real exchange rate depreciated and recession occurred. Thus, the last subsample is sufficiently large to incorporate significant variation in the endogenous variables. Hence, it is large enough to deduce significant relationships between variables. However, it cannot be said that the causality from the real exchange rate to real output is homogeneous in different transformations. Thus, we cannot safely conclude that the real exchange rate Granger causes real output in the last subsample.

The second possible explanation for the failure of the Granger causality tests is that we cannot remove the possible effects of exogenous variables from the considered endogenous variables in this test. In other words, it is clear that other economic variables (interest rates, inflation, capital account movements, etc.) may have possible effects on both variables, and their effects may limit the usefulness of the Granger causality analysis. In the next section, the statistical properties of the data will be analyzed.

## VI. STATISTICAL PROPERTIES OF THE DATA

In this section, we will analyze the stationary properties of the variables of interest, namely, the real exchange rate, inflation, and output, and a set of control variables. These control variables are government size, current account, capital account, and M1. In addition, we analyzed whether any long-term relationship among the real exchange rate, output, and inflation exists even when some of the control variables are added into the system. Unit root tests of the variables are given in the first subsection. In the second subsection cointegration tests that explore the possible long-term relationships among these variables will be analyzed.

## A. *Unit Root Tests*

In this subsection, we analyze the unit root tests of the variables of the real exchange rate, inflation, output, the U.S. interest rates, government size, M1, current account, and capital account. In all VAR models, we use the real exchange rate, inflation, and output. In addition, we use the variables of the U.S. interest rates, government size (fraction of the government purchases item in the nominal GDP), M1, current account (ratio of the current account to the nominal GDP), and capital account (ratio of the capital account, excluding official reserves to the nominal GDP). All the variables enter the analysis in logarithms except variables in rates. Table III gives the unit root tests of these variables.

We use both the augmented Dickey-Fuller (ADF) test and the Phillips-Perron test for unit root tests. Both tests reveal that for output, U.S. interest rates, and M1, we cannot reject the presence of unit root, while for variables of inflation, current account, and capital account we can reject the presence of unit root. In addition, while the ADF test states that the real exchange does not contain a unit root, the Phillips-Perron test states the reverse. The Phillips-Perron test states that government size is stationary while the ADF test states the opposite. This suggests that the order of the variables of interests are mixed. In addition, for the first differences of output and M1, we can reject the presence of unit root. However, for the first difference of U.S.

TABLE III

UNIT ROOT TESTS

| | Level | | First Difference | |
|---|---|---|---|---|
| | ADF Test | Phillips-Perron Test | ADF Test | Phillips-Perron Test |
| Real exchange rate | –2.63** | –2.39 | –3.55** | –5.26*** |
| Inflation | –2.88* | –6.65*** | –4.59*** | –14.00*** |
| Output | –1.11 | –1.63 | –4.11*** | –8.35*** |
| U.S. interest rates | –1.70 | –1.57 | –2.49 | –3.42** |
| Government size | –1.82 | –4.30*** | –3.16** | –12.80*** |
| M1 | 0.93 | 0.76 | –3.77*** | –11.56*** |
| Current account | –4.94*** | –4.54*** | –4.26*** | –9.76*** |
| Capital account | –4.38*** | –5.90*** | –3.99*** | –12.52*** |

Note: In both of the tests, we use four-lag orders.

* denotes the rejection of the hypothesis that the variable does not contain unit root at the 10 per cent level of significance.

** denotes the rejection of the hypothesis that the variable does not contain unit root at the 5 per cent level of significance.

*** denotes the rejection of the hypothesis that the variable does not contain unit root at the 1 per cent level of significance.

nominal interest, we can reject the presence of unit root only with the Phillips-Perron test.

## B. *Cointegration Tests*

In this paper, we want to assess the effects of a real depreciation on output and inflation. To this end, we first want to analyze whether there exists any long-run relationship among variables of the real exchange rate, inflation, and output. Hence, we perform Johansen cointegration tests and compute the λ-trace and λ-max eigenvalue test statistics for various settings.[1] First of all, we want to assess a long-run relationship among the variables for a minimum number of variables. Hence, the first setting explores for a long-run relationship among the real exchange rate, inflation, and output when seasonal factors and external factors, which are captured by U.S. interest rates, are kept exogenous.

As Table IV suggests, after controlling for seasonal factors and U.S. interest rates, there exists a long-run relationship among the real exchange rate, inflation, and output. The λ-trace and λ-max test statistics also show that there is only one cointegrating vector in this setting. Then, we look at whether a long-run relationship exists in other specifications, which will be elaborated on later in the text for observing the robustness of our findings. These models include M1 monetary aggregate, government size, current account, and capital account in different specifications. The findings of Johansen cointegration tests of these alternative settings state that there exists at least one long-run relationship in each of the alternative settings.[2]

As elaborated in Sims, Stock, and Watson (1990), when the variables are cointegrated, using a VAR model in levels is consistent. Hence, we have estimated VAR models parallel to Kamin and Rogers (2000) so that the negative correlations and dynamic relation between the variables of interest can be analyzed for the core

TABLE IV

COINTEGRATION TEST FOR THE REAL EXCHANGE RATE, INFLATION, AND OUTPUT

| Hypothesized No. of Cointegrating Vector(s) | Eigenvalues | λ-Trace Statistics | λ-Max Statistics |
|---|---|---|---|
| None | 0.35 | 40.21* | 22.82* |
| At most 1 | 0.25 | 17.38 | 15.55 |
| At most 2 | 0.03 | 1.83 | 1.83 |

* refers to rejection of zero cointegrating vector at 5 per cent level of significance.

[1] In order to perform Johansen cointegration tests, not all variables should be $I(1)$ but some of the variables might be $I(0)$ while other variables are $I(1)$ (see Hansen and Juselius 1995).

[2] The results of these tests are presented in Appendix Table.

model and also for the alternative settings explained above for a set of robustness checks.

## VII. VAR MODEL AND EMPIRICAL ANALYSIS

In this section, the core model and alternative models that our econometric analyses are based on are described first. In the second subsection, the forecast error variance decomposition analyses are explained, and the impulse responses obtained from the models are explained in the last subsection.

### A. *The Model*

In the bivariate analysis, it was shown that there exists a negative correlation between the real exchange rate and output; however, the direction of causality could not be shown due to the reasons mentioned. In the statistical analysis section, findings show that some of the variables have a unit root when the others do not; however, it was found that a long-run relationship exists among the real exchange rate, inflation, and output. In addition, we also found that when other variables like government size, M1, capital account, and current account are included there is a cointegration relation. Relying on the result of Sims, Stock, and Watson (1990), VAR models in level are derived to study the negative correlation between output and the real exchange rate more precisely and to see whether this negative relationship emerges from a spurious correlation. Another way of studying this negative relationship might be the use of structural equations which are based on economic theory. However, choice of structural form is difficult and may lead to arbitrary identifying restrictions. VAR models, on the other hand, treat the variables symmetrically and provide dynamic interaction among the variables of interest. In addition, VAR models have high predictive power. Hence, we use the VAR models, which also enable us to the observe impulse response functions and the forecast error variance decomposition analyses from which our findings are gathered. These VAR models also capture the sources of important external shocks.

Our core VAR model is formed by three-endogenous variables with the particular order of the real exchange rate, the inflation and the seasonally adjusted real output where U.S. nominal interest rate is used as exogenous. The order of the variables is the same as those in Kamin and Rogers.[3] The U.S. nominal interest rate is taken as exogenous because Turkish economic variables like inflation, the real GDP, and the real exchange rate are not expected to have any effect on U.S. interest rates. The U.S. interest rate captures the external developments that may have significant effects on the real exchange rate, inflation, and the real GDP in Turkey. In alternative models, we add other variables like government size, balance of payments items,

[3] For further reference, see the Appendix of Kamin and Rogers (2000).

and M1 monetary aggregate. Given that we use quarterly data, our VAR models have four lags and use constant terms and seasonal dummies for the first three quarters.[4] In the first alternative model, we include government size as an additional variable in the core model setting. Government size is included in the core model because government purchases and public sector prices are influential in the GDP and inflation, and it may also have an effect on the level of the real exchange. In the second alternative model, we augment the M1 monetary aggregate variable to the core model. M1 is included to capture the monetary channel to the formation of the real exchange rate, inflation, and output. The third alternative model uses the added variable of the current account. As a balance of payments item, the current account is expected to have effects on the real exchange rate. Moreover, the current account affects the GDP directly and it influences inflation and output via indirect channels. The size of capital flows affects the nominal exchange rate directly by changing the supply and demand in the exchange rate market, and thus the real exchange rate. It also has indirect effects on inflation and output. Thus, the fourth alternative model incorporates the capital account variable in the core model. In the last alternative model, the exogenous variable of U.S. interest rate is excluded, and the capital account and government size are included with the variables of the real exchange rate, inflation, and output because we want to see the dynamic interrelationship among the domestic variables in a setting that assumes the weaknesses of international links.

## B. *Forecast Error Variance Decompositions*

In Table V, we present the forecast error variance decompositions of the variables used in the core VAR model. These are fractions of the forecast error variances of the variables attributed to their own innovations or the innovations of the other variables. The forecast error variances of the variables will give information about shocks that have explanatory power to forecast variables. After obtaining the model estimates, in order to calculate the standard errors, we have used the bootstrap procedure, and the number of bootstrap draws was chosen to be three thousand.

We have reported the forecast error variance decompositions at the 4, 8, 12, 16, and 24 periods. The variables in the rows are the ones whose forecast error variance decompositions are in question, and the variables in the columns are those whose innovations constitute the fraction of the variables in the column. For example, 0.88 is the fraction of the forecast error variance in the real exchange rate that is attributed to its own innovation at the four-quarter forecast horizon, and the associated standard error for this fraction is 0.05. We have reported the forecast error variances of the real exchange rate, inflation, and the output.

[4] We have tried shorter lag lengths and the findings from these models are parallel to our core model findings.

TABLE V

FORECAST ERROR VARIANCE DECOMPOSITION OF VARIABLES IN THE CORE MODEL

| | Real Exchange Rate | | | | | Inflation | | | | | Output | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 8 | 12 | 16 | 24 | 4 | 8 | 12 | 16 | 24 | 4 | 8 | 12 | 16 | 24 |
| Real exchange rate | 0.88 (0.05) | 0.82 (0.07) | 0.80 (0.08) | 0.79 (0.08) | 0.77 (0.09) | 0.07 (0.09) | 0.11 (0.11) | 0.12 (0.11) | 0.12 (0.11) | 0.12 (0.12) | 0.03 (0.05) | 0.05 (0.07) | 0.05 (0.07) | 0.06 (0.08) | 0.07 (0.09) |
| Inflation | 0.32 (0.10) | 0.33 (0.10) | 0.34 (0.10) | 0.34 (0.10) | 0.34 (0.10) | 0.62 (0.09) | 0.59 (0.09) | 0.58 (0.09) | 0.58 (0.09) | 0.58 (0.09) | 0.05 (0.05) | 0.06 (0.05) | 0.07 (0.05) | 0.07 (0.05) | 0.07 (0.05) |
| Output | 0.50 (0.13) | 0.41 (0.14) | 0.38 (0.15) | 0.37 (0.16) | 0.35 (0.16) | 0.18 (0.12) | 0.24 (0.14) | 0.25 (0.15) | 0.25 (0.15) | 0.25 (0.16) | 0.28 (0.14) | 0.31 (0.14) | 0.32 (0.15) | 0.33 (0.15) | 0.34 (0.16) |

Note: Standard errors are reported in parentheses under fractions of forecast errors estimated.

Table V shows that the most important source of variation in the real exchange rate forecast error is its own innovations, which account for 77–88 per cent of the variance of its forecast. As seen in Table V, innovations in inflation account for 7–12 per cent and innovations in output account for only 3–7 per cent of the forecast error variance of the real exchange rate. These findings show that innovations in the other variables have little power to explain the variation in the real exchange rate; thus, it can be argued that the real exchange rate is exogenous. These findings may also suggest that the CBRT might be using this variable as a policy tool in the sample period. The findings are statistically significant for the real exchange rate innovations for all the periods.[5]

Similar to the real exchange rate, inflation's own innovations account for the highest fraction of its forecast error variance. It accounts for 58–62 per cent of the forecast error variance. The second important source of forecast error variance of inflation is the innovations in the real exchange rate. It explains 32–34 per cent of the forecast error variance of inflation. These show that real exchange rate movements are important in the variability of the forecast error of inflation. The weakest source of the forecast error variance of inflation is output. It accounts for only 5–7 per cent of the forecast error variance of inflation. Observations for inflation and real exchange rate innovations are statistically significant throughout the twenty-four-quarter forecast horizon in explaining the forecast error variance of inflation.

There exists an interesting case for forecast error variance of output. In contrast to the real exchange rate and inflation, the innovations of output are not the most important source in explaining the forecast error variance of output. Innovations in the real exchange rate account for 35–50 per cent and innovations in output explain 28–34 per cent of the forecast error variance of output. These two are the most important factors in explaining the variance of output. Innovations in inflation are the third most important source of the forecast error variance of output and they explain 18–25 per cent of the forecast error variance of output. All findings, except those for innovations in inflation for the fourth and twenty-fourth forecast period, are statistically significant.

The findings in the above forecast error variance decompositions reveal that real exchange rate movements influence the level of the real GDP and inflation but are not influenced by any endogenous variable in the model. Likewise, inflationary shocks explain the movements in output, but shocks to output do not explain any of the variables in the system.

After obtaining the forecast error variances of the endogenous variables in the core model, we have computed the forecast error variances of the variables in the alternative models to assess the robustness of the results that have been arrived at in the forecast error variance decomposition analysis of the core model. We have de-

[5] The level of significance is at the 10 per cent level unless otherwise mentioned.

veloped five other VAR models with four lags and a variable is added in each of the models. We include government size as an additional variable in the first alternative model with the particular order of government size, the real exchange rate, inflation, and output. In the second alternative model, we augment the M1 monetary aggregate variable and use the particular order of the real exchange rate, M1, inflation, and output. The third alternative model uses the added variable of the current account with the particular order of current account, the real exchange rate, inflation, and output. The fourth alternative model incorporates the capital account variable and the particular order of the model is the capital account, the real exchange rate, inflation, and output. All of these models use the U.S. interest rate as exogenous, while in the last alternative model, the U.S. interest rate is excluded and the capital account and government size are included with the variables of interest. We want to see the dynamic interrelationship between the domestic variables in a setting that assumes the weaknesses of international links. The particular order of the last alternative model is capital account, government size, the real exchange rate, inflation, and output. In Table VI, as in Table V, the variables in the columns are the variables whose innovations constitute the forecast error variance, and the variables in the rows are the variables whose forecast error variance is in question, namely, the real exchange rate, inflation, and output. The variables in the columns are presented correspondingly to their order in the VAR models.

From the forecast error variance decomposition analysis of the core model, we have arrived at the conclusion that the movements of output and inflation do not influence real exchange movements. From the alternative models, it is evident that the balance of payments items—the current account and the capital account—are helpful in explaining the forecast error variance of the real exchange rate. From the alternative models, this may suggest that the main balance of payments items are effective in explaining the forecast error variance of the real exchange rate. This may mean that the CBRT aligned its exchange rate policy by observing these variables in the sample period that we consider. However, other endogenous variables of interest—inflation and output—are not useful in explaining the forecast error variance of the real exchange rate. Innovations in inflation account for 4–14 per cent and innovations in output 3–10 per cent of the forecast error variance of the real exchange in the alternative models. Thus, parallel to the conclusion that was drawn from the forecast error variances of the core model, inflation and output do not influence the real exchange rate.

The innovations in the real exchange rate are helpful in the forecast error variance of inflation in the core model. As seen in Table VI, innovations in the real exchange rate are helpful in explaining the forecast error variance of inflation in all of the alternative models. Innovations in the real exchange rate account for 19–28 per cent of the forecast error variance of inflation in the alternative models. However, from the alternative models that include the balance of payments items, we reach the conclu-

TABLE VI

FORECAST ERROR VARIANCE DECOMPOSITIONS OF ALTERNATIVE MODELS

A. First Alternative Model

| | Government Size | | | | | Real Exchange Rate | | | | | Inflation | | | | | Output | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 8 | 12 | 16 | 24 | 4 | 8 | 12 | 16 | 24 | 4 | 8 | 12 | 16 | 24 | 4 | 8 | 12 | 16 | 24 |
| Real exchange rate | 0.13 | 0.14 | 0.14 | 0.14 | 0.14 | 0.72 | 0.62 | 0.60 | 0.58 | 0.56 | 0.05 | 0.08 | 0.09 | 0.09 | 0.10 | 0.03 | 0.06 | 0.08 | 0.09 | 0.09 |
| | (0.13) | (0.13) | (0.13) | (0.13) | (0.14) | (0.10) | (0.12) | (0.12) | (0.13) | (0.13) | (0.09) | (0.11) | (0.11) | (0.11) | (0.12) | (0.06) | (0.10) | (0.11) | (0.13) | (0.14) |
| Inflation | 0.14 | 0.15 | 0.15 | 0.16 | 0.16 | 0.28 | 0.27 | 0.28 | 0.28 | 0.28 | 0.49 | 0.47 | 0.45 | 0.44 | 0.44 | 0.06 | 0.08 | 0.08 | 0.08 | 0.09 |
| | (0.08) | (0.08) | (0.08) | (0.08) | (0.08) | (0.11) | (0.11) | (0.11) | (0.10) | (0.10) | (0.09) | (0.09) | (0.09) | (0.09) | (0.09) | (0.04) | (0.05) | (0.05) | (0.05) | (0.05) |
| Output | 0.11 | 0.14 | 0.13 | 0.14 | 0.14 | 0.53 | 0.47 | 0.47 | 0.46 | 0.45 | 0.13 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 |
| | (0.11) | (0.12) | (0.12) | (0.12) | (0.12) | (0.12) | (0.12) | (0.13) | (0.13) | (0.13) | (0.12) | (0.14) | (0.14) | (0.14) | (0.14) | (0.08) | (0.08) | (0.10) | (0.10) | (0.12) |

B. Second Alternative Model

| | Real Exchange Rate | | | | | M1 | | | | | Inflation | | | | | Output | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 8 | 12 | 16 | 24 | 4 | 8 | 12 | 16 | 24 | 4 | 8 | 12 | 16 | 24 | 4 | 8 | 12 | 16 | 24 |
| Real exchange rate | 0.70 | 0.64 | 0.62 | 0.61 | 0.61 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.08 | 0.12 | 0.13 | 0.14 | 0.14 | 0.03 | 0.06 | 0.07 | 0.07 | 0.07 |
| | (0.10) | (0.11) | (0.11) | (0.11) | (0.11) | (0.11) | (0.10) | (0.10) | (0.09) | (0.10) | (0.10) | (0.11) | (0.11) | (0.11) | (0.11) | (0.05) | (0.07) | (0.07 | (0.07) | (0.07) |
| Inflation | 0.28 | 0.29 | 0.29 | 0.29 | 0.29 | 0.18 | 0.19 | 0.19 | 0.19 | 0.19 | 0.46 | 0.42 | 0.41 | 0.41 | 0.41 | 0.05 | 0.07 | 0.08 | 0.08 | 0.08 |
| | (0.09) | (0.08) | (0.08) | (0.08) | (0.09) | (0.07) | (0.07) | (0.07) | (0.07) | (0.07) | (0.09) | (0.09) | (0.09) | (0.09) | (0.09) | (0.04) | (0.05) | (0.05) | (0.05) | (0.05) |
| Output | 0.37 | 0.40 | 0.39 | 0.39 | 0.39 | 0.16 | 0.14 | 0.14 | 0.14 | 0.15 | 0.21 | 0.23 | 0.23 | 0.23 | 0.23 | 0.19 | 0.18 | 0.18 | 0.17 | 0.17 |
| | (0.12) | (0.12) | (0.12) | (0.12) | (0.12) | (0.11) | (0.10) | (0.09) | (0.10) | (0.10) | (0.13) | (0.13) | (0.13) | (0.13) | (0.13) | (0.09) | (0.09) | (0.09) | (0.09) | (0.09) |

TABLE VI (Continued)

C. Third Alternative Model

| | Current Account | | | | | Real Exchange Rate | | | | | Inflation | | | | | Output | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 8 | 12 | 16 | 24 | 4 | 8 | 12 | 16 | 24 | 4 | 8 | 12 | 16 | 24 | 4 | 8 | 12 | 16 | 24 |
| Real exchange rate | 0.31 | 0.35 | 0.35 | 0.35 | 0.35 | 0.51 | 0.45 | 0.43 | 0.42 | 0.41 | 0.07 | 0.10 | 0.11 | 0.11 | 0.11 | 0.05 | 0.06 | 0.06 | 0.06 | 0.07 |
| | (0.12) | (0.12) | (0.12) | (0.13) | (0.13) | (0.12) | (0.12) | (0.12) | (0.12) | (0.13) | (0.09) | (0.09) | (0.09) | (0.09) | (0.09) | (0.06) | (0.06) | (0.06) | (0.06) | (0.06) |
| Inflation | 0.26 | 0.27 | 0.28 | 0.29 | 0.29 | 0.20 | 0.21 | 0.21 | 0.21 | 0.21 | 0.46 | 0.43 | 0.42 | 0.41 | 0.41 | 0.05 | 0.06 | 0.06 | 0.06 | 0.06 |
| | (0.10) | (0.10) | (0.10) | (0.09) | (0.10) | (0.08) | (0.08) | (0.08) | (0.08) | (0.08) | (0.10) | (0.09) | (0.09) | (0.09) | (0.09) | (0.04) | (0.04) | (0.04) | (0.04) | (0.04) |
| Output | 0.26 | 0.24 | 0.24 | 0.23 | 0.22 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.21 | 0.25 | 0.25 | 0.25 | 0.25 | 0.27 | 0.25 | 0.25 | 0.26 | 0.26 |
| | (0.12) | (0.11) | (0.11) | (0.11) | (0.11) | (0.11) | (0.11) | (0.12) | (0.12) | (0.13) | (0.14) | (0.14) | (0.14) | (0.15) | (0.16) | (0.11) | (0.11) | (0.11) | (0.12) | (0.12) |

D. Fourth Alternative Model

| | Capital Account | | | | | Real Exchange Rate | | | | | Inflation | | | | | Output | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 8 | 12 | 16 | 24 | 4 | 8 | 12 | 16 | 24 | 4 | 8 | 12 | 16 | 24 | 4 | 8 | 12 | 16 | 24 |
| Real exchange rate | 0.22 | 0.32 | 0.32 | 0.32 | 0.32 | 0.61 | 0.47 | 0.44 | 0.42 | 0.40 | 0.06 | 0.09 | 0.10 | 0.11 | 0.12 | 0.06 | 0.07 | 0.09 | 0.09 | 0.10 |
| | (0.10) | (0.11) | (0.11) | (0.11) | (0.11) | (0.10) | (0.12) | (0.12) | (0.12) | (0.12) | (0.08) | (0.08) | (0.09) | (0.09) | (0.10) | (0.07) | (0.06) | (0.07) | (0.08) | (0.09) |
| Inflation | 0.20 | 0.23 | 0.25 | 0.25 | 0.26 | 0.24 | 0.24 | 0.23 | 0.23 | 0.23 | 0.48 | 0.44 | 0.42 | 0.41 | 0.40 | 0.05 | 0.07 | 0.07 | 0.07 | 0.08 |
| | (0.08) | (0.08) | (0.08) | (0.08) | (0.09) | (0.08) | (0.08) | (0.08) | (0.08) | (0.08) | (0.09) | (0.08) | (0.08) | (0.08) | (0.08) | (0.04) | (0.04) | (0.04) | (0.04) | (0.04) |
| Output | 0.16 | 0.19 | 0.18 | 0.17 | 0.16 | 0.33 | 0.27 | 0.25 | 0.24 | 0.23 | 0.16 | 0.21 | 0.22 | 0.23 | 0.23 | 0.29 | 0.24 | 0.26 | 0.25 | 0.26 |
| | (0.09) | (0.12) | (0.11) | (0.12) | (0.12) | (0.13) | (0.13) | (0.15) | (0.16) | (0.18) | (0.13) | (0.14) | (0.15) | (0.15) | (0.16) | (0.11) | (0.13) | (0.14) | (0.16) | (0.17) |

TABLE VI (Continued)

E. Fifth Alternative Model

| | Capital Account | | | | | Government Size | | | | | Real Exchange Rate | | | | | Inflation | | | | | Output | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 8 | 12 | 16 | 24 | 4 | 8 | 12 | 16 | 24 | 4 | 8 | 12 | 16 | 24 | 4 | 8 | 12 | 16 | 24 | 4 | 8 | 12 | 16 | 24 |
| Real exchange rate | 0.10 | 0.18 | 0.20 | 0.20 | 0.21 | 0.05 | 0.08 | 0.09 | 0.10 | 0.10 | 0.70 | 0.55 | 0.49 | 0.47 | 0.46 | 0.04 | 0.06 | 0.08 | 0.08 | 0.09 | 0.03 | 0.06 | 0.08 | 0.08 | 0.08 |
| | (0.09) | (0.10) | (0.10) | (0.10) | (0.10) | (0.07) | (0.06) | (0.06) | (0.06) | (0.07) | (0.08) | (0.11) | (0.11) | (0.12) | (0.12) | (0.06) | (0.07) | (0.07) | (0.07) | (0.07) | (0.05) | (0.06) | (0.06) | (0.07) | (0.07) |
| Inflation | 0.15 | 0.16 | 0.18 | 0.18 | 0.19 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.19 | 0.21 | 0.20 | 0.20 | 0.21 | 0.37 | 0.33 | 0.31 | 0.30 | 0.29 | 0.08 | 0.09 | 0.10 | 0.10 | 0.11 |
| | (0.08) | (0.07) | (0.07) | (0.07) | (0.07) | (0.08) | (0.07) | (0.07) | (0.07) | (0.07) | (0.08) | (0.07) | (0.07) | (0.07) | (0.07) | (0.09) | (0.08) | (0.08) | (0.08) | (0.08) | (0.05) | (0.05) | (0.05) | (0.05) | (0.05) |
| Output | 0.10 | 0.11 | 0.11 | 0.11 | 0.11 | 0.07 | 0.09 | 0.08 | 0.09 | 0.08 | 0.34 | 0.28 | 0.29 | 0.27 | 0.27 | 0.15 | 0.20 | 0.21 | 0.22 | 0.23 | 0.25 | 0.21 | 0.21 | 0.19 | 0.19 |
| | (0.08) | (0.08) | (0.08) | (0.08) | (0.08) | (0.08) | (0.09) | (0.09) | (0.10) | (0.09) | (0.14) | (0.13) | (0.16) | (0.16) | (0.17) | (0.10) | (0.13) | (0.13) | (0.14) | (0.15) | (0.11) | (0.10) | (0.11) | (0.12) | (0.13) |

Note: Standard errors are reported in parentheses under fractions of forecast errors estimated.

sion that apart from the real exchange rate, external factors are also influential in the level of inflation. The current account variable accounts for 26–29 per cent, and the capital account variable accounts for 15–26 per cent of the forecast error variance of inflation. Parallel to the core model forecast error variance analysis, innovations in output account for only a small fraction of the forecast error variance of inflation in the alternative models. As presented in Table VI, we conclude that innovations of other endogenous variables used in alternative models, such as government size and M1 monetary aggregate, are not as influential in forecast error variances of inflation as innovations of real exchange rate.

The innovations in the real exchange rate are important in explaining the forecast error variance of output in the core model. This result is also arrived at using alternative specifications. It is only in the third alternative model, when the current account is included in the core model, that real exchange innovations are not helpful in explaining the forecast error variances of output. Innovations in the real exchange rate explain 18–53 per cent of the forecast error variance of output and are the most important source of the forecast error variances of output in the alternative models, except for the third alternative model. Like the case for the real exchange rate, innovations in inflation account for an important fraction of the forecast error variance of output in the core model. This finding is seen in all of the alternative models. Innovations in inflation explain 13–25 per cent of the forecast error variance of output in alternative VAR settings. Among the other variables of alternative models, only the current account is significant in explaining the forecast error variance of output and innovations in this variable account for 22–26 per cent of the forecast error variance of output.

From the findings of forecast error variance decompositions of alternative settings, we arrive at the conclusion that the real exchange rate is not determined by the endogenous variables of inflation and output; and the real exchange rate is influential in determining the variables of interest, inflation and output. Likewise, one of the results of the forecast error variance of the core model, the one that states that innovations in inflation are significant in explaining the forecast errors of output, also holds in other model settings. Similarly, forecast error variance decomposition analysis of both the core model and the alternative models states that output is not influential in the variability of either the real exchange rate or inflation.

In the core model, we found that both inflation and output are not influential in explaining the forecast error variance of the real exchange rate. However, this finding is not robust to alternative specifications, which may be due to the fact that in the alternative models we have included the current account and the capital account. The finding that the capital account and the current account have explanatory power in explaining the level of inflation and output is consistent with economic theory.

## C. *Impulse Responses*

In Figure 2, the impulse responses of the core VAR model, which includes the real exchange rate, output, and inflation with four lags for twenty-four periods are presented. The impulse response functions are obtained by the above-mentioned bootstrap procedure, and we present the median responses and 10–90 per cent confidence intervals of impulse responses. The magnitude of the shocks is one standard deviation, and the responses are also normalized by one standard deviation. We have a core VAR model with three endogenous variables bringing about nine different impulse response functions. In Figure 2, we present the responses of inflation and output to the real exchange rate shocks and the response of the real exchange rate to output and inflation shocks.

A positive real exchange rate shock increases the inflation for the first three quarters, deflation occurs after the fourth quarter, and the magnitude is statistically significant in the first two periods and in the fourth period. The effect of the real exchange rate on output is negative and permanent. However, the magnitude is significant only in the first four periods. This is parallel to the findings of Kamin and Rogers (2000), which supports the contractionary devaluation hypothesis for Mexico.

It seems that one standard deviation shock to inflation appreciates the currency in real terms. One possible reason is that inflation increases the nominal exchange rate less than the change in prices due to the non-tradable component. However, the response of the real exchange rate to an inflation shock is not statistically significant. Moreover, a positive output shock depreciates the domestic currency in the first two periods and then causes it to depreciate. However, this observation is not statistically significant either.

After analyzing the responses of the variables in the core model, we evaluated the responses of the variables to shocks of endogenous variables in the alternative VAR specifications in order to check the robustness of the results that were presented for the core model.[6]

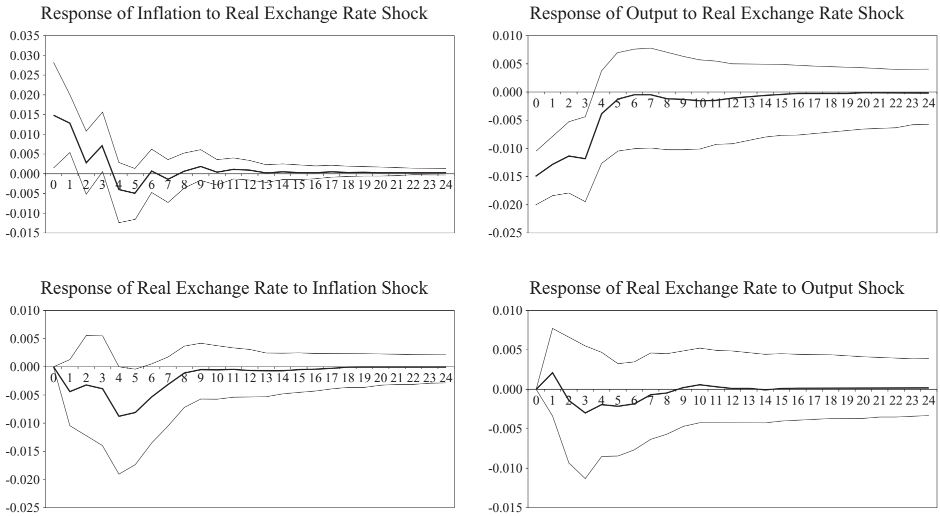
In line with the findings of the core model, a positive real exchange rate shock raises the inflation rate in all of the alternative models. The duration of the positive response of inflation varies from the second to fourth quarters among the models, and a self-correcting mechanism is seen after the positive response. The magnitude of the response is statistically significant in the first quarter and insignificant in all other periods in the alternative settings.

The response of output to a real exchange rate shock is negative in the core model. A similar conclusion can be made when alternative models are considered. The response of output is negative for all periods in the alternative models except the

[6] The impulse response functions of all the VAR specifications are also available from the authors upon request.

Fig. 2. Impulse Responses of the Models

A. Impulse Responses of the Core Model




Note: The two outer curves represent the lower and upper standard error bands for the 10 per cent level of significance and the middle curve represents the median response in Figures 2A–2F.

B. Impulse Responses of the 1st Alternative Model
(Government Size, Real Exchange Rate, Inflation, Output)

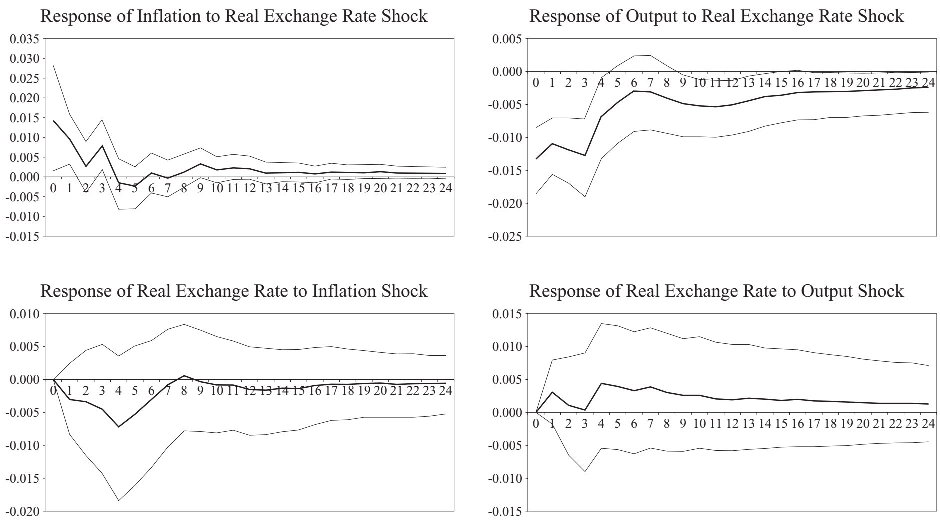
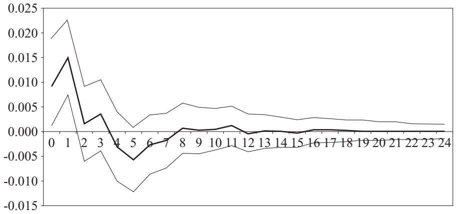


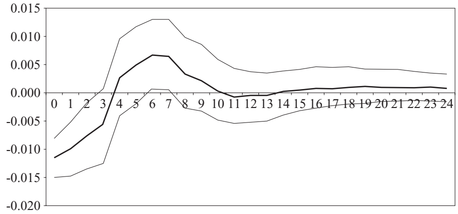
Fig. 2 (Continued)

C. Impulse Responses of the 2nd Alternative Model
(Real Exchange Rate, M1 Monetary Aggregate, Inflation, Output)

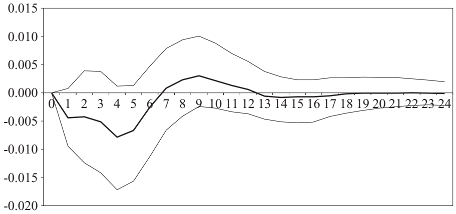
Response of Inflation to Real Exchange Rate Shock



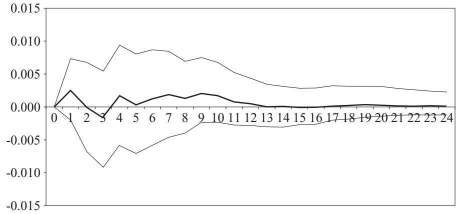

Response of Output to Real Exchange Rate Shock




Response of Real Exchange Rate to Inflation Shock

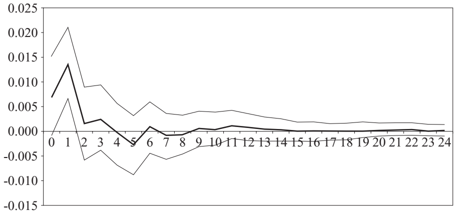



Response of Real Exchange Rate to Output Shock

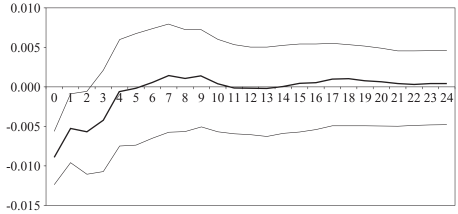



D. Impulse Responses of the 3rd Alternative Model
(Current Account, Real Exchange Rate, Inflation, Output)

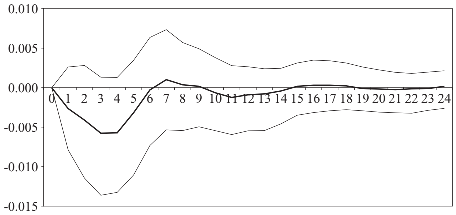
Response of Inflation to Real Exchange Rate Shock




Response of Output to Real Exchange Rate Shock




Response of Real Exchange Rate to Inflation Shock




Response of Real Exchange Rate to Output Shock

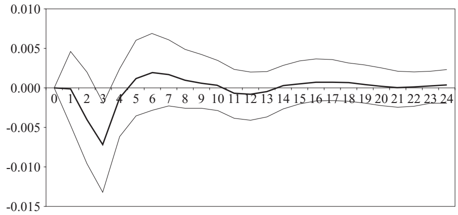
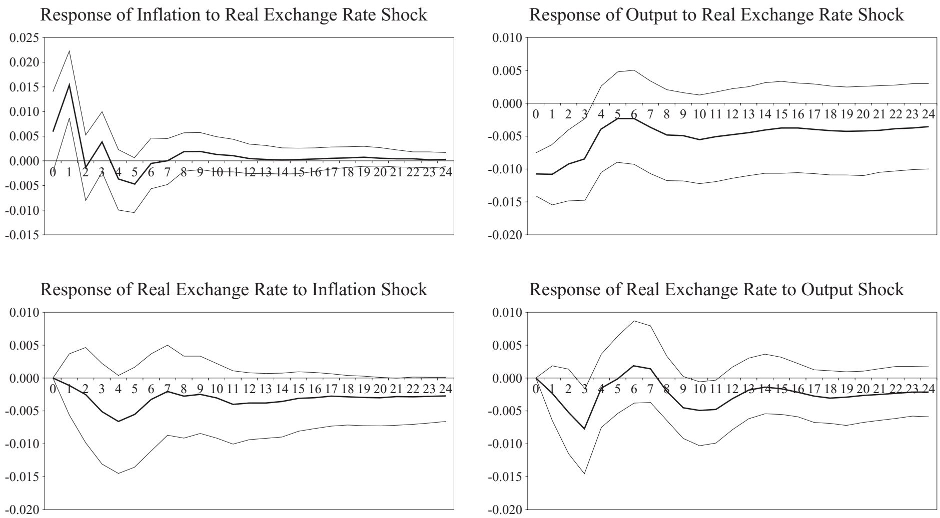
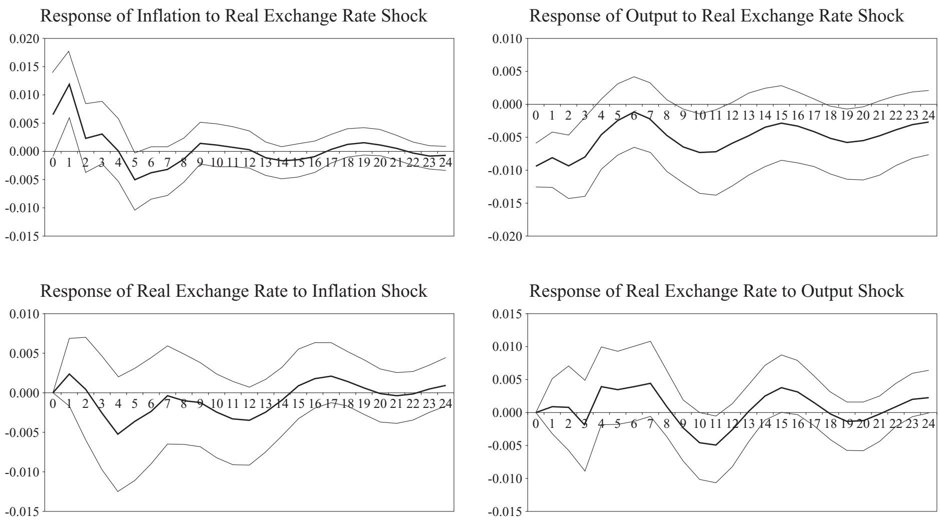


Fig. 2 (Continued)

E. Impulse Responses of the 4th Alternative Model
(Capital Account, Real Exchange Rate, Inflation, Output)




F. Impulse Responses of the 5th Alternative Model
(Capital Account, Government Size, Real Exchange Rate, Inflation, Output)



second and third models. In those alternative models, there are periods when the response is positive; however these periods constitute only a few fractions of the time horizon. The responses become positive after significant lags of the shock, and they are not statistically significant. The negative response of output to a real exchange rate shock is significant in the first two quarters for the second and third alternative models. For the remaining alternative models, the observations of the third quarter are also significant, and there are other periods like the one between the ninth and twenty-fourth quarters in the first alternative model, where the negative response is significant.

In the core model, we have found that a positive inflationary shock appreciates the real exchange rate. The alternative models, except the fifth one, support this finding. An inflationary shock depreciates the real exchange rate only in the last alternative model. The duration of the negative response of the real exchange rate varies between the sixth and twenty-fourth periods in the former alternative models. Similar to responses in the core model, most of the observations are statistically insignificant.

Like the response examined in the core model, the response of the real exchange rate to a positive output shock is positive in the short run in most of the alternative models considered. The response is negative in the third and fourth alternative models. The duration of the positive response varies between the second and twenty-fourth quarters in the first, second, and fifth alternative models, and the response of the real exchange rate exhibits an alternating pattern. However, all of the observations are statistically insignificant.

## VIII. SUMMARY AND CONCLUSION

In this study, we have investigated the negative relationship between the real exchange rate and output in Turkey. We first analyzed the bivariate relationship between the set of the variables of interest. We also analyzed whether a long-term relationship exists between the real exchange rate, inflation, and output. Then, several VAR models were estimated, and the forecast error variance decompositions and impulse responses obtained from the VAR models were examined.

In the bivariate analysis, for most of the transformations and lags, we found a negative correlation between output and the real exchange rate. However, from the Granger causality test, we did not find a significant causality between the variables, possibly due to the inability of the test to remove the effects of other exogenous variables. We also found that a long-run relationship exists among the real exchange rate, inflation and output, which led us to employ VAR models. After employing various VAR models for the sample period—including the variables of U.S. interest rate, the real exchange rate, government size, inflation, output, capital account, and current account—we found that real exchange rate movements are important in the variability of output. The response of output is negative and permanent after a real devaluation. These findings also hold in the alternative settings in which the possible effects of external variables are controlled. Moreover, devaluation is inflationary. These findings are parallel to what Kamin and Rogers (2000) found for Mexico.

These findings suggest that to limit the detrimental effects of devaluation, the overvaluation of a currency must be prevented, and there is no easy way to keep output costs at moderate levels after a devaluation. Our findings suggest that an overvalued domestic currency may initially result in increased output but may create the risk of a financial crisis, which, in turn, may cause exchange rate depreciation and subsequent output losses.

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APPENDIX TABLE

COINTEGRATION TESTS FOR ALTERNATIVE SPECIFICATIONS

| Hypothesized No. of Cointegrating Vector(s) | Eigenvalue | λ-Trace Statistics | λ-Max Statistics |
|---|---|---|---|
| A. Government Size, Real Exchange Rate, Inflation, and Output | | | |
| None | 0.52 | 64.58** | 38.79** |
| At most 1 | 0.26 | 25.79 | 16.12 |
| At most 2 | 0.10 | 9.67 | 5.72 |
| At most 3 | 0.07 | 3.95 | 3.95 |
| B. Real Exchange Rate, M1, Inflation, and Output | | | |
| None | 0.37 | 56.40* | 24.64 |
| At most 1 | 0.25 | 31.75 | 15.04 |
| At most 2 | 0.24 | 16.72 | 14.55 |
| At most 3 | 0.04 | 2.17 | 2.17 |
| C. Current Account, Real Exchange Rate, Inflation, and Output | | | |
| None | 0.50 | 80.69** | 36.99** |
| At most 1 | 0.37 | 43.70** | 24.46* |
| At most 2 | 0.28 | 19.24 | 17.51* |
| At most 3 | 0.03 | 1.73 | 1.73 |
| D. Capital Account, Real Exchange Rate, Inflation, and Output | | | |
| None | 0.52 | 72.42** | 38.43** |
| At most 1 | 0.30 | 33.99 | 19.15 |
| At most 2 | 0.23 | 14.84 | 13.98 |
| At most 3 | 0.02 | 0.86 | 0.86 |
| E. Capital Account, Government Size, Real Exchange Rate, Inflation, and Output | | | |
| None | 0.57 | 112.32** | 44.47** |
| At most 1 | 0.39 | 67.85** | 26.06 |
| At most 2 | 0.37 | 41.79** | 24.71* |
| At most 3 | 0.25 | 17.09 | 14.95 |
| At most 4 | 0.04 | 2.14 | 2.14 |

* refers to rejection of zero cointegrating vector at 5 per cent level of significance.
** refers to rejection of zero cointegrating vector at 1 per cent level of significance.