Sources of Real Exchange Rate Movements in Saudi Arabia

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Abstract

The paper investigates the sources of real exchange rate movements in Saudi Arabia by decomposing real exchange rate movements into those attributable to real and nominal shocks. Using a popular structural VAR model and assuming long-run neutrality of nominal shocks, we find that real shocks play a significant role in explaining real exchange rate movements in Saudi Arabia. Using a more disaggregated model, we also find that oil production shocks rather than real oil price shocks are responsible for real exchange rate movements. In order to stabilize the real exchange rate, Saudi Arabia should focus on stabilizing oil production. (*JEL* F3, C5)

Introduction

It is well known that a stable real exchange rate plays a central role in economic stability, development, and growth. Real exchange rate stability is crucial to developing countries since it affects capital inflows, foreign direct investment, and trade according to comparative advantage. Caballero and Corbo (1988) study the conditions under which increases in the degree of uncertainty about the real exchange rate depress exports and find a clear and strong negative effect of real exchange rate uncertainty on export performance in several least developed countries. Goldberg and Klein (1997) found that foreign direct investment into some less developed countries is significantly affected by bilateral real exchange rates. There is a general agreement among economists that a severe macroeconomic disequilibrium will evolve as a result of sustained real exchange rate misalignment.

A great deal of interest in real exchange rate stability emerged after the collapse of the Bretton Wood System. Since many countries have switched to flexible exchange rates, which are associated with high variability of real exchange rates, real exchange rates became the central focus of theoretical and empirical work. Many argue that the choice of the exchange rate regime affects real exchange rate variability since fixed exchange rate regimes limit discretionary monetary policy. Stockman (1988) argues that the behavior of real exchange rates after the collapse of the Bretton Woods System could be attributed to real shocks. Lastrapes (1992) and

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Enders and Lee (1997) decompose real exchange rate movements and conclude that movements in real exchange rates in the post-Bretton Woods period are largely attributable to real shocks. Accordingly, knowing the sources of the shocks that drive real exchange rate movements is an important factor that may help policymakers adopt optimal policies.

Although there are ample studies investigating sources of real exchange rate movements in developed countries, scant attention has been paid to real exchange rate movements in resource-based economies such as Saudi Arabia. Saudi Arabia has important characteristics that merit study. First, Saudi Arabia is one of the major players in the world oil market and has a significant role in the OPEC cartel. Second, its fiscal and monetary policy is endogenous with respect to the oil policy. Hence large disturbances that alter equilibrium real exchange rates in Saudi Arabia may prompt adjustments in oil production, which can influence the world economy significantly.

Since the real exchange rate is the relative price of domestic goods in terms of foreign goods, it is important to know to what extent it is influenced by real shocks versus nominal shocks. Using a structural VAR model, we investigate the effects and relative importance of real and nominal shocks to the real exchange rate. We then develop a model that sheds some light on the sources of the real and nominal shocks. Using monthly data from 1980:02 to 2000:02 and a bivariate VAR of the price level and the real exchange rate, we constrain nominal shocks to have no long-run effect on the real exchange rate. We then estimate the inflation and real exchange rate variability due to real and nominal shocks.

The following section presents an overview of the Saudi Arabian exchange rate and oil policy. The third section describes the data and methodology. The fourth section reports the estimation results, while the last contains some concluding remarks.

An Overview of the Saudi Arabian Exchange Rate and Oil Policy

Historically, the Saudi Arabia Monetary Agency (SAMA) preferred to maintain a predictable *riyal* exchange rate. This fostered economic development and growth, kept prices stable, and promoted international trade. To achieve this goal, the monetary authority adopted a policy of a fixed exchange rate regime. After the collapse of the Bretton Woods System, it became difficult to maintain a stable *riyal* exchange rate against the U.S. dollar due to the erratic movements in the value of the U.S. dollar. SAMA switched to the International Monetary Fund's Special Drawing Rights (SDR) unit in 1975 at an exchange rate of 4.28 Saudi Riyal (SR) per SDR with a margin of $2^1/_4$ to $7^1/_4$ (Looney 1990). On July 22, 1981, SAMA suspended pegging the *riyal* to SDR; the U.S. dollar became the pegging currency with a range of SR 3.74 to SR 3.75 per dollar (Table 1).

TABLE 1. EXCHANGE RATE POLICY IN SAUDI ARABIA

Year	Regime	Exchange Rate
1950-70	Fixed exchange rate against the U.S. dollar	4.50
1970-72		4.15
1973-75		3.56
1975- 81	Fixed exchange rate against SDR	3.40
1981-present	Fixed exchange rate against the U.S. dollar	3.75

It is well known that fixed exchange rates where foreign exchange reserves play a major role in money supply fluctuations are conducive to the transmission of foreign disturbances into the domestic economy. A small open economy like that of Saudi Arabia (where there is one dominant export sector) can be subject to severe exogenous shocks. It is important to evaluate the extent these oil price shocks transmit to the real exchange rate.

Another potential source of fluctuation in the real exchange rate in Saudi Arabia is oil production. Decisions regarding oil production have important consequences for oil revenues, government spending, and foreign exchange reserves. These, in turn, affect the exchange rate through the supply of foreign exchange as well as the demand for foreign exchange. What is the basis for oil production decisions in Saudi Arabia? Since oil is a depletable natural resource, oil production decisions can be based on economic motives. Dynamic oil production models based on intertemporal optimization have been known since Hotelling (1931). These models assume that the decision maker would choose a production plan over time so as to maximize the net present value (over an infinite planning horizon) of the return from sale of the resource.[1] Although intertemporal models are intuitively appealing, they have several drawbacks. As emphasized in the literature, these models are sensitive to assumptions about the future price and availability of substitutes and the discount rates of decision makers (Powell 1990; Sickles and Hartley 2001). Similarly, optimization models have been unable to explain oil market behavior over the last several decades, when disequilibrium seemed to dominate equilibrium in the global oil market (Powell 1990). Finally, there is evidence that oil decisions, OPEC decisions in particular, have objectives other than simple revenue or profit maximization. For example, Sickles and Hartley (2001) find that Saudi oil production decisions depart substantially from profit maximizing levels and perhaps are best explained by political considerations.

It should be pointed out that domestic factors influence oil policy as well. Barkley and Sheehan (1995) argue that Saudi oil policy, driven by internal factors, influences world inflation. Moreover, Saudi oil policy influences world inflation through its oil policy, and world inflation transmits to the Saudi economy since the country depends on imports. A critical venue for the adjustment is the real exchange rate. In the following section, we try to evaluate the sources of real exchange rate adjustments.

Methodology

An Illustrative Empirical Model of the Real Exchange Rate

To determine empirically the sources of fluctuations in the real exchange rates, consider two types of shocks that are the sources of movements in domestic prices, p_t, and the real exchange rate, q_t: a real shock, $\varepsilon_{rt,}$ (e.g., changes in endowment, productivity, real expenditures) and a nominal shock, ε_{nt}, (e.g., money supply or devaluation of the exchange rate). Theoretically, real shocks can cause permanent changes in the real exchange rate, but nominal shocks can cause only temporary movements in the real exchange rate (Lastrapes 1992; Enders and Lee 1997). If the vector $\Delta y_t = [\Delta q_t \; \Delta p_t]$ is stationary, then the bivariate moving average model in the structural shocks has the form

$$\begin{bmatrix} \Delta q_t \\ \Delta p \end{bmatrix} = \begin{bmatrix} C_{11}(L) & C_{12}(L) \\ C_{21}(L) & C_{22}(L) \end{bmatrix} \begin{bmatrix} \varepsilon_{rt} \\ \varepsilon_{nt} \end{bmatrix} \tag{1}$$

[1] Powell (1990) discusses alternative oil decision making models including those based on intertemporal optimization.

where ε_{rt} and ε_{nt} are mutually uncorrelated real and nominal shocks with zero means and $\boldsymbol{C}_{ij}(L)$ are polynomials in the lag operator, L. The shocks can be identified by imposing the restriction that nominal shocks have no long-run effect on the real exchange rate (Blanchard and Quah 1989). This assumption can be represented by the restriction that the coefficients in $\boldsymbol{C}_{12}(L)$ sum to zero; thus, if $\boldsymbol{C}_{ij}(k)$ is the kth coefficient in $\boldsymbol{C}_{ij}(L)$, the restriction is equivalent to

$$\sum_{k=0}^{\infty} C_{12}(k) = 0. \tag{2}$$

The restriction in (2) conveys that the cumulative effect of ε_{nt} on Δq_t is zero.

Data

Seasonally unadjusted monthly data on the price level, the real exchange rate, oil production, and real oil price run from 1980:01 to 2000:02. The data set is taken from the CD-ROM edition of the *International Financial Statistics* database. The variables used in this study and their definitions are given in notes to Table 2.

In order to properly specify the VARs, we perform unit root and stationarity tests. Table 2 presents the results of Augmented Dickey-Fuller (ADF) and KPSS tests. The lag lengths in the ADF test are obtained using the Akaike Information Criterion (AIC). ADF test statistics in Table 2 indicate that a unit root for all the variables in levels cannot be rejected at conventional significance levels. However, ADF test statistics reject the presence of unit roots in all variables in the first differences. The KPSS test statistics for stationarity against the alternative of a unit root confirm the results of the ADF tests. These tests indicate that stationarity can be rejected for all variables in levels but not in the first differences. In what follows, we model the variables in first differences.

TABLE 2. UNIT ROOT AND STATIONARITY TESTS

	q	p	y	h	Δq	Δp	Δy	Δh
ADF τ_μ statistic	-1.25	-0.81	-2.13	-1.76	-7.39	-10.29	-3.73	-6.52
Lags	3	1	12	1	2	1	11	1
KPSS η_μ statistic	4.14	2.61	1.45	2.77	0.31	0.16	0.13	0.09

Notes: p_t = log consumer price index, q_t = log real effective exchange rate, y_t = log oil production index, h_t = log crude oil price converted to domestic prices using nominal exchange rate and deflated by domestic prices. The ADF critical values for 236 observations are -2.89 (5 percent) and -3.51 (1 percent). The KPSS critical values are 0.463 (5 percent) and 0.739 (1 percent). The lag truncation in the KPSS test is set at 4.

Empirical Results

Since a unit root in p_t and q_t cannot be rejected, a VAR in first differences is appropriate. Starting with a maximum lag of 12, likelihood ratio tests indicate that the VAR can be pared down to four lags. We then estimate the VAR with four lags and impose the restriction in equation 2. The dynamic effects of real and nominal shocks on real exchange rate can be analyzed by variance decompositions (VDC) and impulse response functions (IRF) typical of VAR methods.

Figures 1 and 2 present the IRF for the levels of real exchange rate and prices. The plots display the dynamic response of the real exchange rate or the price level to the real shock (ε_{rt}) or the nominal shock (ε_{nt}). The figures also present 90 percent confidence intervals for the IRFs based on a simulation. Recall that the theoretical framework presupposes that real shocks can cause permanent changes in the real exchange but nominal shocks can cause only temporary changes. Figure 1 shows that a real shock causes an immediate increase in real exchange rate. The real exchange rate reaches its long-run level in about five months. In response to the real shock, the price level increases by a smaller amount. Note that the confidence intervals indicate that the response of both the price level and the real exchange rate is significant. The responses to the nominal shock are given in Figure 2. In response to the nominal shock, the real exchange rate

FIGURE 1. RESPONSES TO A REAL SHOCK

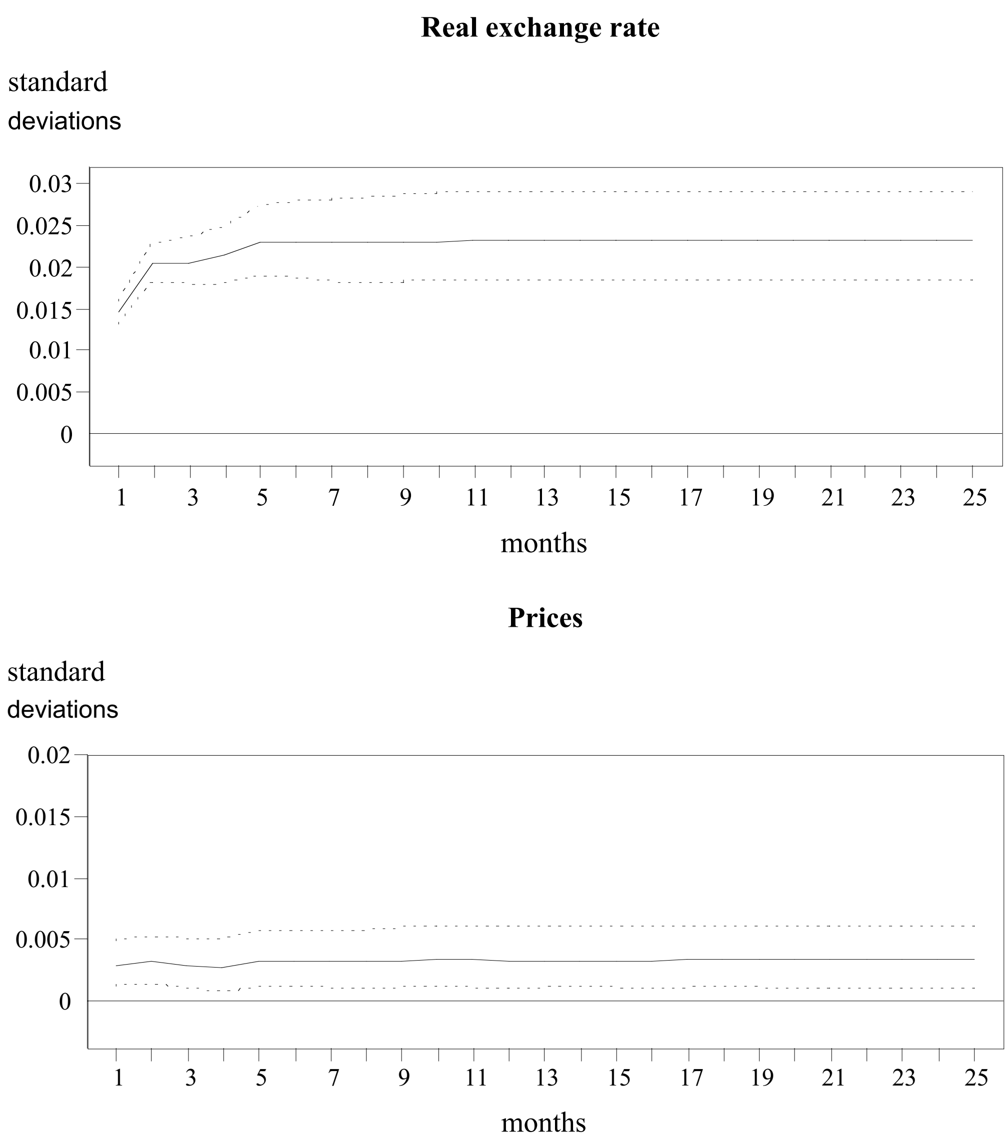
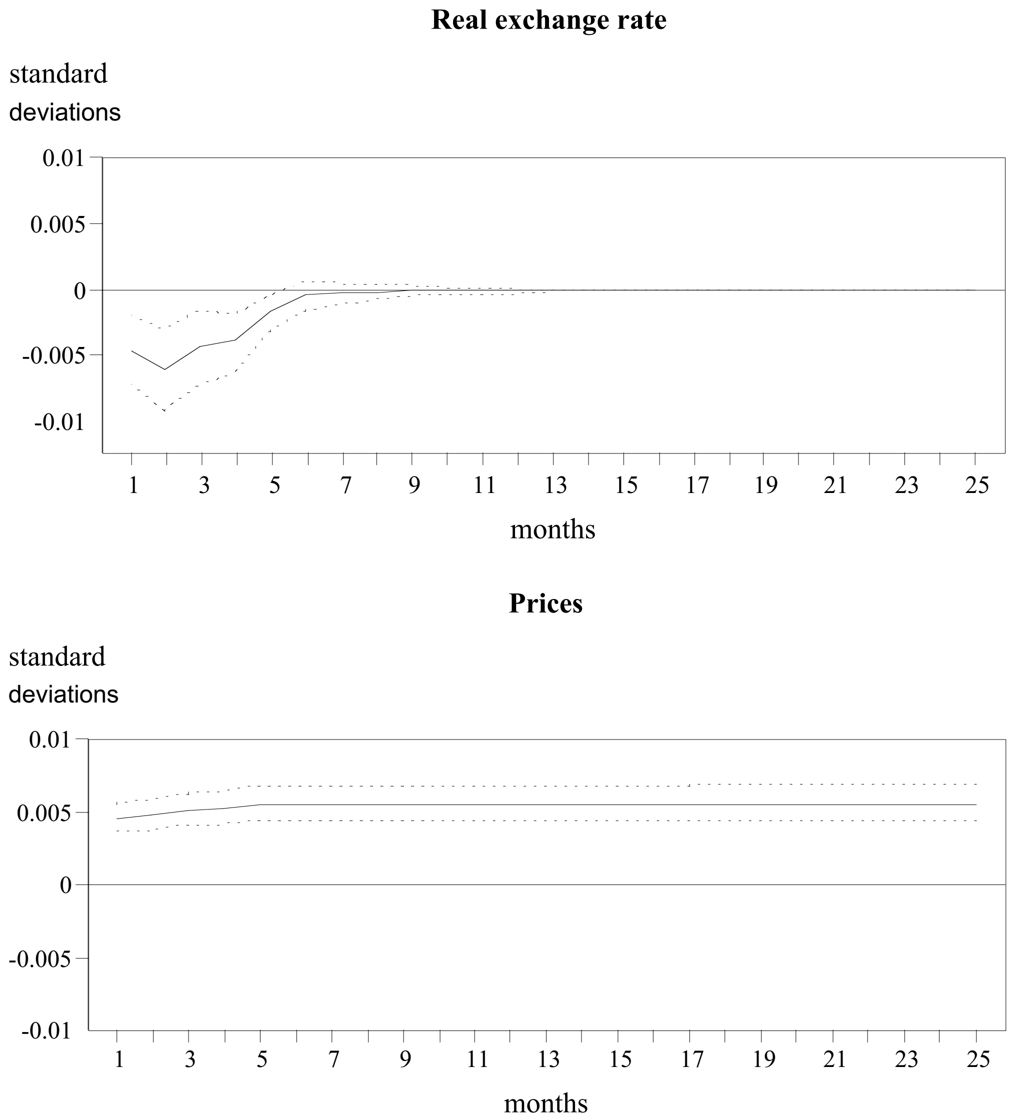


FIGURE 2. RESPONSES TO A NOMINAL SHOCK



depreciates and reverts to its long-run level in five months. As expected, the price level increases in response to the nominal shock. Overall, the IRFs indicate that responses to the shocks are significant and conform to theoretical predictions.

Table 3 presents the VDC results for the real exchange rate and prices. VDCs show that nominal shocks explain about 10 percent of real exchange rate movements in the short run; however, the effects falls to about less than 2 percent after one year. It is evident that real shocks appear to be the main driving force of real exchange rate movements. On the other hand, nominal shocks play a larger role in price level movements than real shocks. The results show that after one month, more than 70 percent of the price level variability can be attributed to nominal shocks. Nominal shocks continue to play a major role in price level movements in the long run.

TABLE 3. VARIANCE DECOMPOSITION OF THE REAL EXCHANGE RATE AND THE PRICE LEVEL

	Real Exchange Rate		Prices	
Month	Real Shocks	Nominal Shocks	Real Shocks	Nominal Shocks
1	89.8	10.2	30.9	69.1
3	93.4	6.6	27.7	72.3
6	96.5	3.5	27.3	72.7
9	97.7	2.3	27.4	72.6
12	98.3	1.7	27.4	72.6
24	99.2	0.8	27.5	72.5
36	99.4	0.6	27.5	72.5
Long Run	100.0	0.0	27.6	72.8

The Role of the Real Oil Price and Oil Production

Our results indicate that real shocks are an important factor behind real exchange rate movements in Saudi Arabia. These results are consistent with Lastrapes (1992) and Enders and Lee (1996), who use data from industrial countries. For example, Enders and Lee (1997) contend that a major source of real shocks in the United States is government spending shocks. What are the sources of the real shocks in an oil-based economy such as Saudi Arabia? One may conjecture that real shocks stem from the oil market. In order to evaluate the source of the real shocks, we consider real oil prices and oil production. Real oil price may alter the terms of trade and affect the real exchange rate.[2] On the other hand, oil production can have supply side as well as demand side effects. For example, oil production affects government revenue and domestic spending.

In order to evaluate the sources of real shocks and nominal shocks, we need a more disaggregated structure. A simple aggregate supply, aggregate demand model can serve as a reference in identifying a broader set of shocks. In order to motivate the restrictions embedded in the structural VAR model, consider the following aggregate supply, aggregate demand model:

Evolution of the real oil price:	$h_t = h_{t-1} + \varepsilon_t^h$	(3)
Aggregate supply:	$y_t^s = \breve{y}_t + \theta h_t$	(4)
Autonomous oil production:	$\breve{y}_t = \breve{y}_{t-1} + \varepsilon_t^s$	(5)
Aggregate demand/IS:	$y_t^d = d_t + \beta\, q_t$	(6)
Evolution of autonomous aggregate demand:	$d_t = d_{t-1} + \varepsilon_t^d$	(7)
Money demand:	$m_t^d = p_t + k\, y_t$	(8)
Money supply:	$m_t^s = m^s_{t-1} + \varepsilon_t^m$	(9)
Goods market equilibrium:	$y_t^s = y_t^d = y_t$	(10)
Money market equilibrium:	$m_t^s = m_t^d$	(11)

where h = real oil price, y = real GDP proxied by oil production, $\breve{y}$ = capacity output, p = domestic price level, m = money stock, d = autonomous aggregate demand, all variables are in logarithms, and all parameters are assumed positive.

[2] For the link between the terms of trade and the real exchange rate, see De Gregorio and Wolf (1994).

The observed movements in the variables are due to four mutually uncorrelated "structural" shocks with finite variances. These are real oil price shocks, ε_t^h, oil production shocks, ε_t^s, aggregate demand shocks, ε_t^d, and money supply shocks, ε_t^m.

Equation 3 is the evolution of the world oil price, which is assumed to be exogenous. Equation 4 is an aggregate supply equation, where aggregate supply consists of autonomous oil production and a price sensitive component, which is a function of the relative price of crude oil. For simplicity, autonomous oil production is assumed to follow a random walk process in equation 5.

Equation 6 is a simple aggregate demand (IS) equation where aggregate spending depends on the real exchange rate. The autonomous portion of aggregate demand, d_t, is assumed to follow a random walk in equation 7. Equation 8 is a money demand equation based on transactions demand for money. Equation 9 is the evolution of money supply, which, for simplicity, is assumed to follow a random walk.[3] Finally we close the model by postulating goods and money market equilibrium relationships (equations 10 and 11).

It can be shown that the long run impact of the structural shocks on the endogenous variables has a peculiar triangular structure. In order to show the long-run impact of the four structural shocks $\boldsymbol{\varepsilon_t} = [\varepsilon_t^h\ \varepsilon_t^s\ \varepsilon_t^d\ \varepsilon_t^m]$ on the system of endogenous variables $\mathbf{X_t} = [h_t\ y_t\ q_t\ p_t]'$, we express the solution to the model in first differences:

$$\Delta h_t = \varepsilon_t^h \quad (12)$$
$$\Delta y_t = \theta\ \varepsilon_t^h + \varepsilon_t^s \quad (13)$$
$$\Delta q_t = 1/\beta\ (\theta\ \varepsilon_t^h + \varepsilon_t^s - \varepsilon_t^d) \quad (14)$$
$$\Delta p_t = \varepsilon_t^m - k\ (\theta\ \varepsilon_t^h + \varepsilon_t^s) \quad (15)$$

Note that although all endogenous variables have unit roots, they are difference stationary. The long-run impact of the structural shocks on the endogenous variables is triangular. Specifically, all shocks except oil price shocks have no long-run effect on the real oil price. Aggregate demand and monetary shocks have no long-run impact on oil output, and monetary shocks have no long-run impact on the real exchange rate.

In order to assess the sources of real and nominal shocks, we let $\mathbf{X_t} = [\Delta h_t\ \Delta y_t\ \Delta q_t\ \Delta p_t]'$ and estimate the VAR with 12 lags. Likelihood ratio test statistics indicate that the VAR cannot be pared down. In order to identify the shocks, we impose the triangular long-run structure implied by the aggregate supply aggregate demand model in equations 12-15. The resulting decomposition is presented in Table 4.

Table 4 indicates that monetary shocks explain about 10 percent of real exchange rate movements in the short run, and these conform to the results of the bivariate model in Table 3. It is evident from Table 4 that oil price shocks have negligible effect on the real exchange rate in the short run. On the other hand, oil production shocks account for more than 48 percent of the forecast error variance of the real exchange rate at a one-month forecasting horizon. The effect of the oil production shocks reaches its peak around a six-month horizon, explaining 53 percent of real exchange rate movements. Even in the long run, oil production shocks account for a moderate proportion of real exchange rate movements in Saudi Arabia. Although real oil price shocks have some moderate effect on the real exchange rate in the long run, these are dominated by oil production shocks at all horizons. Evidently, in an oil-based economy such as that of Saudi Arabia, oil production and oil revenues influence government revenue as well as the money supply as discussed above. These in turn stimulate aggregate demand and alter the real exchange rate.

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[3] The specification of a random walk for the exogenous processes is for illustrative purposes. In the empirical model, these will be specified as autoregressive processes with the number of lags specified by lag selection criteria.

TABLE 4. VARIANCE DECOMPOSITION OF THE REAL EXCHANGE RATE: THE ROLE OF OIL PRODUCTION VERSUS OIL PRICES

Month	*Percent of forecast error variance attributable to*			
	Real Oil Price Shocks	Oil Production Shocks	Aggregate Demand Shocks	Monetary Shocks
1	0.0	48.4	42.3	9.3
3	0.1	52.6	40.2	7.2
6	0.1	53.0	42.0	4.9
9	1.4	50.0	44.7	3.9
12	3.4	44.8	48.1	3.7
24	6.2	32.9	59.0	1.9
36	8.6	26.6	63.5	1.3
Long Run	13.1	14.9	72.0	0.0

Concluding Discussion

This paper has used time series methods to investigate the sources of real exchange rate movements in Saudi Arabia. Saudi Arabia follows a fixed exchange rate policy, so nominal exchange rate flexibility combined with price rigidity is not a source of real exchange rate variability. Still, under fixed exchange rates, increases in reserves and the money supply can stimulate aggregate demand and increase real exchange rate variability. Since real exchange rate is the relative price of domestic goods in terms of foreign goods, it is important to know to what extent it is influenced by real shocks versus nominal shocks. Our results show that real shocks dominate nominal shocks in explaining real exchange rate movements at all horizons in Saudi Arabia. However, nominal shocks play a major role in explaining price level movements. These results are consistent with those reported for low inflation countries by Lastrapes (1992) and Enders and Lee (1997) in that real exchange rate variability can be attributed to real shocks.

In order to address the question of the source of the real shocks, we consider real oil prices and domestic oil production. The former seems to play a modest role, whereas the latter seems to have a sizable effect on the real exchange rate. Although the Saudi economy has moved from being heavily dependent on oil revenue of more than 90 percent in 1980 to about 56 percent in 1998, oil policy still has a major role in economic activity. In fact, oil policy influences fiscal and monetary policy. Since oil production shocks are a major source of real exchange rate variability, it is important to develop a stable oil policy to stabilize the real exchange rate. Moreover, it is imperative that authorities in Saudi Arabia continue to diversify the domestic production and export base to reduce the vulnerability of the economy to the oil sector.

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