The Saudi Riyal/U.S. Dollar Exchange Rate: An Empirical Examination

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Introduction

Due to the important role the exchange rate policy usually plays in the performance of an open economy, it has to be allowed for in any realistic analysis of macroeconomic policies. It has also been stated that exchange rate economics is one of the most heavily researched areas. Yet, despite noticeable research efforts, there is still virtually no consensus on the determinants of exchange rates; moreover, little empirical research effort has been devoted to this issue with reference to a developing economy.

Most previous studies on the Saudi economy have focused especially on the problems of development or on specific macroeconomic policy issues. For instance, Al Moneef (1989) analysed the Saudi Arabian experience with respect to the Saudi Arabian riyal/SDR exchange rate and some of its policy implications. However, no attempt was made to empirically test the exchange rate determination in the Saudi Arabian context. We believe that for the Saudi economy, which is an open economy with important foreign links, and because of the policy implications that the external disturbances[1] may have, the issue of the Saudi riyal/U.S. dollar exchange rate determination remains an important empirical question which warrants further research.

Saudi Arabia accepted the obligations of Article VIII, Sections 2, 3, and 4 of the Fund Agreement, as from March 22, 1961. The Saudi Arabian riyal is linked to the U.S. dollar with a limited flexibility. The middle rate of the Saudi Arabian riyal for the U.S. dollar, the intervention currency, quoted by the Saudi Arabian Monetary Agency (SAMA), is determined on the basis of the International Monetary Fund daily calculation of the U.S. dollar-SDR rate. The rate was S.R. 4.50 for one U.S. dollar. Following the breakdown of the fixed exchange rate regime in 1971, and the fall of the U.S. dollar in the foreign exchange market, Saudi Arabiah adjusted the parity of its currency by raising its value by 8.57 percent. Two other consecutive changes followed thereafter. In 1975, the riyal ceased to be pegged to the U.S. dollar, but rather to the SDR, whereby one unit of SDR was equal ot S.R. 4.2855. The rate continued to fluctuate within the ± 7.25 percent limit until May 1981, when the value of one unit of SDR exceeded the lower bound and reached S.R. 3.9697. This led to the abandonment of the official SDR link and the adoption of the peg to the U.S. dollar which, in turn, induced an increase in the value of the Saudi Arabian riyal until it reached its upper limit in February 1985. But, the subsequent slide of the U.S. dollar in the foreign exchange has reversed this upward trend.

Since Saudi Arabia has adopted an exchange rate arrangement that de facto links the Saudi Arabian riyal to the U.S. dollar, the question of the riyal exchange rate determination is to be addressed in relation to the U.S. macroeconomic policies. The focus is on testing which of the competing models of exchange rate determination is supported by the Saudi Arabian data.

The study departs from a general exchange rate model which encompasses a number of models of exchange rate determination. In an attempt to test for the relevant model specifications, the Cochrane Orcutt estimation procedure is used and alternative parameter restrictions are imposed.

The outline of the present paper is as follows. Section 2 surveys the literature on exchange rate economics. The focus is particularly on the two dominant views of exchange rate determination, namely the monetary approach (in its flexible and sticky price formulation) and the portfolio balance approach. Section 3 introduces the stylized exchange rate model. Section 4 discusses the empirical results and their theoretical relevance. Section 5 concludes the paper.

2. A Brief Review of the Literature on the Exchange Rate Determination

The classical monetary approach based on two, often controversial, propositions (Purchasing Power Parity (PPP) and the Quantity Theory of Money), although limited in scope, has all the ingredients of the modern monetary approach. It has PPP as a long-run equilibrium condition; it has a stock adjustment process as a mechanism by which equilibrium is restored following an exogenous disturbance; and it has exchange rate overshooting, if some prices are not fully flexible in the short run. It is also limited in scope by not considering capital flows and exchange rate expectations.

Unlike the classical approach, the early Keynesian approach does not allow floating exchange rates to provide full insulation from foreign disturbances, even in the long run. Thus, exchange rate changes are real changes that are not neutral in their effects on the real economy. This suggests that floating exchange rates are less attractive to policy makers. Like the classical approach, the Keynesian approach ignores international capital movements and exchange rate expectations. This makes it less appropriate in the real world.

The Mundell-Fleming model (Fleming, 1962; Mundell, 1968) is an extension of the early Keynesian income-expenditure approach that incorporates international capital movements into the model. The model retains a fixed price assumption, so that exchange rate changes are changes in the real exchange rates rather than in nominal rate as in the modern monetary approach, and assumes perfect capital mobility so that uncovered interest parity holds. There are three variants of the Mundell-Fleming model which allow for some flexibility of the general price level in the long run. These are the sticky-price model (SPM hereafter) of Dornbush (1976a, 1976b), the core inflation model of Buiter and Miller (1981) and the model of Devereux and Purvis (1990) which, additionally, incorporates an aggregate supply equation in which a real exchange rate appreciation increases the supply of domestic output. The main limitation of this class of exchange rate models is the assumption of perfect capital mobility which does not permit trade balance to influence the path of the exchange rate or make the exchange rate susceptible to switches in asset preferences.

There is still no consensus among economists on exchange rate determination. The lack of consensus resides in whether monetary shocks cause exchange rate volatility because of sticky prices (Dornbush, 1976), temporarily fixed stocks of financial assets (Calvo-Rodriguez, 1977) or physical capital (Neary-Ourvis, 1983), small wealth effects in the demand of money (Branson-Halttunen-Masson, 1977), or not at all. It is recognized that relative prices matter. Yet, it is not clear whether to emphasize nontraded final goods, internationally-traded inputs; or both. Trade and current account balances are also closely related to exchange rate changes. However, whether this reflects anticipated changes in future wealth, misanticipated supply or demand shocks, or spurious correlation, is still being debated ((Dornbush and Fisher, 1980) (Sachs, (1981)).

The empirical validity of PPP as a long run equilibrium has not yet been settled, at least for the 1970s and the 1980s. Taylor and McMahon (1988) found evidence for PPP in the inter-war period (i.e., 1920s), but for the more recent period of floating exchange rates (i.e., 1970s and 1980s) strong support for PPP was not found. Using the Engle and Granger approach on monthly exchange rates (March 1973 to December 1983) for the UK, Japan, West Germany and Canada, Baillie and Selover (1987) report no evidence of long run PPP. Similarly, Corbae and Ouliaris (1988) rejected long run PPP. Similarly, Corbae and Ouliaris (1988) rejected long run PPP for the Canadian dollar, French franc, Deutsche mark, Italian lira, Japanese yen, and UK pound-US dollar spot exchange rates. Enders (1988) reports mixed results for PPP over both the Bretton Woods and subsequent floating exchange rate periods. Mark (1990) found little support for long-run PPP for eight OECD countries (monthly data from June 1973 to February 1988). This weakness, however, will also be a feature of the modern monetary approach; for some, like Smith and Wickens (1986), it is perhaps the main reason for the failure of the monetary models.

Currency substitution models are a special kind of monetary models. Direct currency substitution occurs when economic agents have an incentive to hold portfolio of non-interest bearing currencies and substitute between such currencies on a risk-return criterion. Indirect currency substitution, on the other hand, arises because of the substitutability of non-money assets. The interesting feature of this class of models is that they attempt to integrate the current and capital accounts of the balance of payments through wealth effects. McKinnon (1982) argues that indirect substitution is likely to be more important than direct substitution. For this reason, currency substitution models may be regarded as being of limited empirical validity. In particular, the econometric evidence for the existence of currency substitution is very weak.

The portfolio balance models (PBM hereafter) of exchange rate determination stem from the work on portfolio theory and the demand for money by Markowitz (1952) and Tobin (1958). The central feature of the

PBM is that because domestic and foreign non-monetary assets are assumed to be imperfect substitutes, rather than perfect substitutes as in the monetary and Mundell-Fleming approaches2, uncovered interest rate parity does not hold in this class of model.Although the PBM has been used in a classical framework by Dornbush and Fisher (1980), it has its origins in the Keynesian tradition of fixed prices (McKinnon and Oats, 1966; Branson, 1968). Unlike the monetary approach, the PBM has not been extensively tested.

Although the foregoing discussion is far from being exhaustive, it gives a fair overview of the main strands in the literature on exchange rate determination.

A Stylized Exchange Rate Model

Empirical research on exchange rate determination has evolved along two main directions: the structural approach (Bilson, (1978), Dornbush, (1980), Driskill, (1981), Edwards (1983)) and the time series approach (Burt et al, (1977), Logue and Sweeney, (1977) etc.).

The study departs from the well-known general exchange rate model that subsumes a number of special cases. A detailed derivation of the model is given in appendix A. The stylized reduced form equation can be expressed as:

et = a0 + a1et-1 + a2 (mt - m*t) + a3 (yt - y*t) _+ a4 (it - i*t) + a5 (?t - ?*t) + a 6 (?t - 1 - ?*t-1) + a8tbt - a9tb*t + et (1)

where

et: log of the nominal exchange rate (SDR hereafter), defined as the domestic price of one unit of U.S. currency, that is one dollar;

mt (m*t): log of the domestic (U.S.) nominal money stock as defined by M1;3

yt (y*t): log of the domestic (U.S.) real income level as measured by real GDP;

pt (p*t): log of the domestic (U.S.) price level as measured by the CPI (base = 1985);

it (i*t): log of the domestic (U.S.) interest rate;

?t (?*t): log of the domestic (U.S.) inflation expectation;

tbt (tb*t): the domestic (U.S.) trade balance as a ratio to domestic (U.S.) GDP; and et: the stochastic white noise error term.

By appropriate parameter restrictions, specific exchange rate models are derived from equation (1). The flexible price model (FPM hereafter) results if the parameters are restricted to be as a1 = a4 = a5 = a6 = a7 = a*7 = 0. The SPM results if the parameters are restricted to be as a1 = a5 = a6 = a7 = a*7 = 0. The dynamic stock flow model (Driskill, 1981) imposes a3 = a4 = a7 = a*7 = 0. The stock flow model (Hooper and Morton, 1982) constrains a1 = a5 = a6 = 0. The rational expectations monetary model (Hoffman and Schlagenhauf (1983) and Huang (1984)) is the same as the FPM, except for the imposing of uncovered interest rate parity and solving for the rational expectations solution after determining the stochastic processes generating the exogenous variables.

Further, it should be noted that the random walk model is also subsumed in the general specification (1). That model is given by considering the following parameter restrictions a0 = a2 = a3 = a4 = a5 = a6 = a7 = a8 = a9 = 0, and et = et - 1 + ?t, where ?t is a white noise process. Actually, the quasi reduced form model (1) can be thought of as a restricted version of the VAR (vector autoregression).

Several important econometric issues are worth mentioning. First, there is potential simultaneity problem which may cast doubt on the adequacy of the reduced form specification. Actually, intervention of the monetary authority in the foreign exchange market, if it is not sterilized, may cause a correlation between the relative money supply term and the error term; thus creating a simultaneous equation bias. A way to account for the possible simultaneity between et and (mt - m*t) involves constraining first degree homogeneity between the two terms. Second, in order to correct for possible serial correlation, the Cochrane-Orcutt procedure is applied. As asserted by Saidi (1983), when estimated in levels, as is the case, structural models typically yield serially correlated residuals. Non linearities in the demand for money function may also be a source for the serial correlation.

The Empirical Analysis

The data used in the analysis were obtained from various issues of the IFS (International Financial Statistics). They cover the period from 1961 until 1992. As shown in Table 1, the variance of the SDR during the pre floating period (1961-1971) was largely smaller than during the floating period (1972-1992). Likewise, the relative money supply, real income and prices, the domestic and foreign trade balances, all show the same pattern of volatility over the two subperiods.

Table 1. Descriptive Statistics*

Series	Mean	Stand-Deviation	Max	Min
et	1.5037 (1.280)	0.0009 (0.052)	1.504 (1.422)	1.501 (1.202)
(mt-m*t)	-4.66 (-2.38)	0.160 (0.713)	-4.493 (-1.768)	-4.967 (-4.227)
(yt-y*t)	-4.127 (-2.609)	0.182 (0.427)	-3.746 (-1.912)	-4.381 (-3.664)
(pt-p*t)	-0.018 (0.098)	0.049 (0.250)	0.030 (0.566)	-0.102 (-0.234)
tbt	0.366 (0.298)	0.065 (0.221)	0.444 (0.842)	0.270 (0.047)
tb*t	0.004 (-0.016)	0.004 (0.011)	0.010 (0.006)	-0.002 (-0.035)
(tbt - tb*t)	0.361 (0.314)	0.062 (0.212)	0.437 (0.846)	0.269 (0.080)

***The numbers in parentheses are for the 1972-1992 period, while those above them are for the 1961 - 1971 period.**

The estimated regression equation over the whole sample period is presented in Table 2.1, where the t-statistics appear in parentheses, R2 is the adjusted R-square, h is the Durbin-h, SEE is the standard error of the estimate, p is the first order autocorrelation coefficient. In order to cope with autocorrelation which is suggestive of model misspecification, a partial adjustment scheme for the SDR and a first-order autoregression for the error term are imposed.

Table 2.1

$$\underset{(5.04)}{et = 0.564} + \underset{(6.52)}{0.636et\text{-}1} + \underset{(3.35)}{0.032\,(mt\text{-}m^*t)} - \underset{(-2.022)}{0.027\,(yt\text{-}y^*t)}$$

$$\underset{(-5.66)}{-\,0.087}\,(pt - 1 - p^*t\text{-}1) + \underset{(2.49)}{0.067tbt\text{-}1} - \underset{(-2.57)}{1.23tb^*t} - \underset{(-13.97)}{0.129D}$$

$R^{-2} = 0.989$ See = 0.011 h = 5.68 F = 317 p = -0.428 (-1.95)

While all the estimated coefficients are statistically significant, two of them are wrongly signed (i.e., domestic and foreign trade balances). The lagged nominal exchange rate appears with a positive and statistically significant coefficient. The evidence of a strongly significant partial adjustment which seems to imply that the nominal exchange rate is influenced by autoregressive movements, though not approximating a pure random walk, is rather in line with the stock flow specification.

The coefficient on relative money supply is statistically significant and correctly signed. Monetary influences on the nominal exchange rate are rather contemporaneous. However, this result does not lend support to the assumption of first degree homogeneity of the SDR with respect to relative money supplies. In addition, the small size of the coefficient (0.032) reveals the absence of overshooting, which is definitely not consistent with the Dornbush approach to exchange rate determination, but perhaps supportive of the imperfect capital mobility version of the SPM.

The negative coefficient on relative real income is in line with the Dornbush version of the monetary approach, in which an increase in relative real income is likely to induce a positive impact on the money demand, which will ultimately lead to an exchange rate appreciation.

The coefficient on relative prices appears significant only when lagged one period. Its size is also small, but compared to those on relative money supply and relative real income, it is nearly three times larger. Its negative sign is in accordance with both the Dornbush and the stock flow models. In the Dornbush monetary model domestic currency must appreciate, as prices increase, to maintain asset market equilibrium. In the stock flow model, prices also affect the trade balance and the effects of the latter can outweight the asset effects.

Furthermore, neither the absolute PPP (purchasing power parity) nor the relative PPP seem to be validated by the data. Even as a long term phenomenon, the results do not lend support to the PPP. On theoretical grounds, there are many reasons why relative PPP may not hold. Officer (1976) mentions restrictions on trade and capital movements, expectation of different inflation at home and abroad, divergences in the real economies, and productivity bias among others as possible causes for the failure of the relative PPP.

The domestic trade balance variable has a positive and statistically significant coefficient, only when included with a one year lag. On the other hand, the concurrent foreign trade balance appears with a negative and statistically significant coefficient whose size exceeds unity.

To account for the switch in the exchange rate regime that occurred in 1971, a dummy variable is included. Its negative and statistically significant coefficient suggests that, during the floating period, the trend is more towards an appreciation of the domestic currency.

When the restriction that domestic and foreign trade variables affect the SDR with equal coefficients but opposite signs is imposed, the estimated regression equation becomes:

Table 2.2

$$
\begin{aligned}
et = {} & \underset{(5.82)}{0.692} + \underset{(5.13)}{0.534et\text{-}1} + \underset{(3.64)}{0.039\,(mt\text{-}m^*t)} - \underset{(-3.39)}{0.045(yt\text{-}y^*t)} \\
& - \underset{(-5.54)}{0.096\,(pt\text{-}1\text{-}p^*t\text{-}1)} + \underset{(0.735)}{0.016\,(tbt\text{-}1\text{-}tb^*t\text{-}1)} - \underset{(-11.85)}{0.119D71}
\end{aligned}
$$

$R^{-2} = 0.986$ SEE = 0.013 F = 287 p = -0.368 (-1.53)

While all the other variables retain their statistical properties, the relative trade balance in contrast is not only wrongly signed but also statistically insignificant; even when both the concurrent and the lagged relative trade balance variables are included together in the estimation, they appear with a statically insignificant coefficient. This may suggest that changes in the other exogenous factors virtually, explain most of the observed changes in the SDR.

Following Dornbush (1979) and Frankel (1979), an attempt to account for any simultaneity between et and (mt-m*t) and also capture any partial adjustment, is made. The resulting regression equation is given in Table 2.3 below.

Table 2.3

$$
\begin{aligned}
(et - (mt\text{-}m^*t)) = {} & \underset{(5.45)}{0.968} + \underset{(16.21)}{0.89\,(et\text{-}1\text{-}(mt\text{-}1\text{-}m^*t\text{-}1)} + \underset{(0.40)}{0.035\,(yt\text{-}y^*t)} \\
& \underset{(-1.29)}{-0.169\,(pt\text{-}p^*t)} - \underset{(-3.17)}{0.528\,(tbt\text{-}1\text{-}tb^*t\text{-}1)} - \underset{(-5.37)}{0.379D71}
\end{aligned}
$$

$R^{-2} = 0.997$ SEE 0.068 F = 1632 p = 0.407 (2.05)

If on the one hand, both the lagged relative trade balance and the lagged adjustment term are correctly signed and statistically significant on the other hand, the results are somewhat disappointing. Both relative real income and relative prices are insignificant and only the latter appears with the expected negative sign. However, when the lagged relative trade balance is replaced by the domestic holding of foreign reserves (see Table 2.4), the regression results improve significantly. All the coefficients are correctly signed and statistically significant; and an increase in their magnitude is also observed.

Table 2.4

(et - (mt-m*t)) =	2.87 +	0.59 (et-1 - (mt-1-m*t-1))	- 0.18 (yt-y*t)		
	(4.32)	(9.27)	(-2.76)		
	-0.225 (pt-p*t)	- 0.179frt-1	- 0.168D71		
	(-2.37)	(-3.12)	(-1.83)		
R^{-2} = 0.997	SEE 0.066	F = 1731	p = 0.159 (0.805)		

In ortder to further explore the behavior of the nominal exchange rate, so as to ascertain whether it is approximating a random walk process or not, alternative specifications have been experimented. Under the presumption that ^{e}t and (^{e}t - (^{m}t-$^{m^*}t$)) follow a random walk with a drift, the model subsumed in the general specification (1) is estimated and reported in Table 3.1.

Table 3.1 Random walk with a drift

et = 0.073 + 0.941 et-1 (1.21) (20.99)			
R-2 = 0.938	SEE = 0.028	h = 3.71	F = 441
(et - (mt-m*t)0 = 0.075 + 0.961 (et-1-(mt-1-m*t-1) (0.633) (37.86)			
R^{-2} = 0.98	SEE = 0.184	h = 4.27	F = 1433

The fact that the intercept term is not different from zero, in both specifications, suggests the absence of a drift. Thus, a pure random walk is more likely; and the regression results shown in Table 3.2 below, whereby the lagged dependent variable (i.e., ^{e}t-1 or (^{e}t-1 - (^{m}t-1-$^{m^*}t$-1))) coefficient is significantly different from zero and close to unity, are a clear evidence for a pure random walk process.

Table 3.2
Simple random walk

et = 0.995 r t-1 (261)
R^{-2} = 0.937 SEE = 0.028 h = 3.60
(et - (mt - m*t) = 0.976 (et - 1 - (mt-1-m*1)) (138)
R^{-2} = 0.98 SEE = 0.182 h = 4.22

Conclusion

The primary aim of this paper was to test the factors underlying the SDR movements and, thus, to identify the proper exchange rate model. For this purpose, the research departed from a general exchange rate model that subsumes a number of specific exchange rate models.

The estimation results do not lend support to the assumed first degree homogeneity of the SDR with respect to relative money supply, exchange rate overshooting and PPP hypothesis, even as a long-term phenomenon. They do, however, reveal that the nominal SDR seems to approximate a pure random walk process.

Although the empirical results do not offer a full scale picture of the factors underlying the SDR they, however, provide some insights into the type of model whcih best fits the SDR data over the considered period.

It is hoped that the study will elicit interest for further research in this subject. Further studies should explore the time series modeling of the SDR exchange rate using monthly data.

Appendix A
Derivation of the Semi Reduced Form Exchange Rate Model

The derivation of the reduced form exchange rate equation stems from the structural model which requires the five following equations:

$$^{e}t = {}^{p}t - {}^{p^*}t \qquad \text{A.1}$$

$$^{m}t - {}^{p}t = t + øyt - ßrt \qquad \text{A.2}$$

$$^{m}t - {}^{p^*}t = t^* + ø^*y^*t - ß^*r^*t \qquad \text{A.3}$$

$$^{r}t - {}^{r^*}t = {}^{f}t - {}^{e}t \qquad \text{A.4}$$

$$^{f}t = {}^{E}t\ {}^{e}t + 1 \qquad \text{A.5}$$

where et is the spot nominal exchange rate, ft is the forward exchange rate, yt is real income, pt is the price level, mt is the money supply; and all these variable sare in natural lograithms. The variable rt is nominal interest rates; and asterisks denote foreign quantities. Et is the expectation operator. Equation A.1 represents an assumption of short and long-run validities of PPP in its absolute form, so that no terms of trade effect exists and that the good market is in short-run equilibrium. Equations A.2 and A.3 are the conventional demand for money equations.

By assuming that the real income elasticities and semi-interest rate elasticities for money demand are identical in both countries, it follows that

$$^{e}t = -(t-t^*) + ({}^{m}t-{}^{m^*}t) - ø({}^{y}t-{}^{y^*}t) + ß({}^{r}t-{}^{r^*}t) \ \text{A.6}$$

This relationship may be modified by assuming non-instantaneous adjustment of the exchange rate according to the following partial adjustment mechanism

$$^{e}t - {}^{e}t - 1 = ø\ ({}^{e}t - {}^{e}t - 1) \ \text{A.7}$$

where et = pt - p*t.

Introducing the equilibrium exchange rate from (5) into this gives the quasi reduced form of the exchange rate monetary model

$$^{e}t = -ø(t-t^*) + ø({}^{m}t-{}^{m^*}t) - øø\ ({}^{y}t-{}^{y^*}t) + øß({}^{r}t-{}^{r^*}t) + (1-ø){}^{e}t-1 \ \text{A.8}$$

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The Saudi Riyal / U.S. Dollar Exchange Rate: An Empirical Examination

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Abstract. The paper attempts to inquire into the issue of exchange rate determination with reference to Saudi Arabia. It departs from a general exchange rate determination model which subsumes a number of competing models. The Cochrane Orcutt procedure of estimation is used, and alternative parameter restrictions are imposed to test for the appropriate model specification.

The empirical findings do not lend support to the assumed first degree homogeneity of exchange rate with respect to relative money supplies. They also, cast doubt on both exchange rate overshooting and PPP, even as a long phenomenon. They do however, reveal that the data on nominal exchange rate in the Saudi context approximate a pure random process.