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THE RISE AND FALL OF STERLING: TESTING ALTERNATIVE MODELS OF EXCHANGE  
RATE DETERMINATION

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of Exchange Rate Determination

I. Introduction

The purpose of this paper is threefold. Firstly, to model short run fluctuations and analyse the long run tendencies of the dollar-pound exchange rate over the current floating period.<sup>1/</sup> Secondly, to point out a number of shortcomings of existing models which have been proposed to describe the behaviour of exchange rates (particularly Frankel (1979, 1983)<sup>2/</sup> but also Frenkel (1976), Bilson (1978), Dornbusch (1976)). Thirdly, to apply the econometric method of starting from a general model and testing for simplifications as advocated by Hendry-Mizon (1978) and Davidson et al (1978). One salient feature of this econometric approach when modelling the exchange rate is that the hypothesis that the long-run tendency of the exchange rate is towards Purchasing Power Parity, henceforth PPP, can be tested. This test relates to the restrictions on the estimated coefficients and is described in detail in section III.

The first model considered in section II is a general or "augmented" monetary model.<sup>3/</sup> Its special attributes are that it relaxes the assumption of fully flexible prices of the monetary model in the short run by incorporating dynamics.<sup>4/</sup> To be consistent with much of the recent literature on exchange rate determination we single out Frankel (1979), a variant of Dornbusch's model of "overshooting", and Frankel (1983) "synthesis" model (of monetary and portfolio-balance models). Both of Frankel's models embed other models. Some of the restrictions

used to derive these other models are noted. Furthermore, both models are shown to be special cases of the augmented monetary model. Two restrictions are emphasised (i) the sign on the short term interest rate differential and (ii) the dynamic properties--especially the overshooting and monotonic adjustment mechanisms--portrayed in Frankel's models.

In Section IV the econometric results are discussed. In general, the results tend to support the generalised 'traditional' monetary model. The short term interest rate differential coefficient is positive in all the specifications considered, (i.e.,  $\partial e/\partial(i - i') > 0$ , where  $i, i'$  are the U.S. and U.K. nominal interest rates respectively. Furthermore, the dynamics do not tend to indicate overshooting. Lastly, PPP does not appear to hold in a strict sense, although prices and the exchange rate are found to move proportionally in the long run.

## II. Alternative Models of Exchange Rate Determination

The first model considered here is based on the traditional monetary model as developed by Bilson (1978) and Frenkel (1976). It is assumed that there are no barriers (such as transactions costs or capital controls) restricting capital markets and that domestic and foreign bonds are perfect substitutes in investors' demand functions. The analogous assumption of no barriers in the goods market is relaxed (hence PPP does not hold at all points in time). The common assumption of homogenous demand for money function with respect to prices is also relaxed (at least in the short run). It is, of course, a matter of debate how far the monetary model can be adapted before it loses its essential features. This general monetary model is the dynamic form of the

traditionally static monetary model. Its components are similar, uncovered interest rate parity is implicitly assumed, and in the reduced form exchange rate equation the nominal interest rate differential is positively related to the exchange rate. Therefore, we argue that the model described here is monetary as opposed to monetarist since it retains, in the long run, the characteristics of the traditional monetary model.<sup>5/</sup>

The fundamental equation in the monetary approach is a money demand function, such as:

$$(1) \quad m = p + \phi y - \lambda i + \sigma w$$

where  $m$  = log of the domestic money supply

$p$  = log of domestic price level

$i$  = the domestic short term interest rate

$\phi$  = money demand elasticity with respect to income

$\lambda$  = money demand semi-elasticity with respect to the interest rate

$\sigma$  = money demand elasticity with respect to wealth

which is derived from the stationary state relationship that  $\frac{M}{P} = KY^\phi W^\sigma \exp(-\lambda i)$ , a Cagan-type money demand. This type of steady state relationship also forms the basis of the generalised monetary model. In the generalised model, however, it is assumed that there are both costs of adjustments and time lags. Thus the conventional static money demand equation (1) is generalised to include dynamics.

$$(2) \quad \Delta(m - p)_t = \alpha_{10} + \sum_{k=0}^n \alpha_{1ik} \Delta x_{it-k} + \beta_{1i} x_{it-1} + \beta_{16}(L)m$$

where  $x_i = (y, w, i, b, p_{-1})$

L = lag operator

n = lag length

b = inflation rate (an argument added to equation 1)

( $\Delta$ ) = first difference operator

The wealth term here represents total personal wealth and is included to explain the allocation of wealth to money holdings. The long-term interest rate, b, is used to proxy the inflation rate.

A similar money demand function for the foreign country is assumed:

$$(3) \quad \Delta(m' - p')_t = \alpha_{20} + \sum_{k=0}^n \alpha_{2ik} \Delta k'_i + \beta_{2i} x'_i + \beta_{26} (L)m'$$

where  $x'_i = (y', w', i', b', p'_{-1})$

(') denotes foreign country

The formulation of these functions allow us to test for homogeneity between money and prices; we need not assume (or impose) it. These money demand functions are meant to be general. It has been argued that they are more an econometric specification than an economic formulation. However, this criticism can equally be applied to partial adjustment type generalisations as well.

The purchasing power parity equation is embodied in (4)

$$(4) \quad \Delta e_t = \alpha_{30} + \sum_{k=0}^n \alpha_{3ik} \Delta y_{it-k} + \alpha_{3i} y_{it-1} + \alpha_{33}^{\Omega} + \beta_{33} (L)e$$

where  $y_i = (p, p')$

$e$  = log of exchange rate (home currency/foreign currency)

$\Omega$  = explanatory variable (captures deviations from PPP)

This equation differs from the traditional monetary model only insofar as it does not assume that prices adjust immediately to PPP similar to Dornbusch (1976). The way (4) is written it is implicit that the expected signs on the coefficients for  $p'$  are negative. The exchange rate may exhibit the tendency towards PPP, this is observed when  $\beta_{33} = -\beta_{31} = \beta_{32}$ . The variable  $\Omega$  is introduced to explain deviations from PPP in the short run (or are transitory factors). If  $\Omega$  is included in the long run solution it also indicates that the exchange rate does not converge to PPP.<sup>6/</sup> Thus, PPP is not assumed to hold in the short run due to sticky prices and imperfect substitutability of goods. Whether PPP holds in the long run can be determined by analyzing the econometrics results, i.e., it is not assumed or imposed.

Combining equations (2), (3), (4), and solving for current prices the reduced form exchange rate equation is obtained.

$$(5) \quad \Delta e_t = \gamma_0 + \sum_{k=0}^n \delta_{ik} \Delta z_{it-k} + \gamma_i z_{it-1} + \gamma_{14} (L)e.$$

where  $z_i = (y, y', w, w', i, i', b, b', m, m', \Omega, p_{-1}, p'_{-1})$

Equation (5) says that the exchange rate, as the relative price of two currencies, is determined by the supply and demand for money. The  $\delta$ 's and  $\gamma$ 's are reduced-form coefficients. The general dynamic structure in

(5) needs to be stressed. The difference between (4) and (5) is the presence of additional factors that explain short-run fluctuations in the exchange rate, but which supposedly do not influence the long run exchange rate. The lag structure can be justified in terms of costs of adjustment or by time lags.

An important feature of this model is as in the traditional (Bilson-Frenkel) monetary model that the expected sign on the short-term interest rate differential is positive, i.e.  $\delta_5 > 0$ ,  $\delta_6 < 0$ . This corresponds to the original negative coefficient in the money demand equation. Thus, sterling appreciates when the interest rate differential increases in favour of the U.S. In the next model the opposite result holds. The difference stems from whether real interest rates are considered constant or not. In the traditional model they are assumed to be constant when nominal interest rates rise--due to higher price expectations--the exchange moves with the interest rates. In the overshooting model, real interest are variable with nominal interest rates reflecting monetary policy.

The second model considered is the sticky price or "overshooting" monetary model as described in Frankel (1979, 1983). The reduced form equation of this model is a special case of equation (5). As in the first model the assumption PPP is relaxed in the short run. An important feature of this model is the distinction between the short and long run and the role of expectations. Two distinguishing features of this model are short-term nominal interest rate differentials are negatively related to the exchange rate and that after a monetary shock there is monotonic adjustment of the current exchange rate back to the long-run exchange rate. Both of these features can be used to distinguish this model from the first one. The long run predictions of this model and the

traditional model are the same hence we argue that the nomenclature monetary remains applicable for this model as well.<sup>7/</sup>

The overshooting model retains the money demand function as in (1) for both countries:

$$(1) \quad m - p = \phi y - \lambda i + \sigma w$$

$$(6) \quad m' - p' = \phi' y' - \lambda' i' + \sigma' w'$$

In the overshooting model domestic and foreign bonds are considered as perfect substitutes as in the previous model. Portfolio shares are infinitely sensitive to expected rates of return. This one-bond assumption gives us the uncovered open interest rate parity condition

$$(7) \quad i - i^* = E(\Delta e)$$

where  $E(\Delta e)$  = the expected depreciation of domestic currency.

Unlike the first model this model assumes that the long-run exchange rate will always equalise long run relative prices (PPP):

$$(8) \quad \bar{e} = \bar{p} - \bar{p}'$$

where bars over variables signify long run.

Relative prices are obtained by subtracting equation (1) from (6) and solving for  $p - p'$ .

$$(9) \quad p - p' = m - m' - \phi y + \phi' y' + \lambda i - \lambda' i' - \sigma w + \sigma' w'$$



Note that symmetry on the coefficients is not assumed. Letting  $\lambda = \lambda'$  and assuming as Frankel does that the nominal interest rate differential is equal to the inflation differential in equilibrium,  $i - i' = \pi - \pi'$ , then equation (9) can be rewritten to define the long run exchange rate.

$$(10) \quad \bar{e} = \bar{m} - \bar{m}' - \phi\bar{y} + \phi'\bar{y}' + \sigma\bar{w} + \sigma'\bar{w}' + \lambda(\pi - \pi')$$

This equation illustrates the traditional monetary model of exchange rate determination. The exchange rate is determined by the relative demand for the two currencies. The money market is always in equilibrium. A given increase in money supply leads to an equiproportionate rise in the exchange rate. Note the positive relationship between interest rates, the long-term inflation rates in equilibrium, and the exchange rate.

To derive the final short run exchange rate equation we assume as Frankel does that the expected exchange rate change is a function of the gap between the current spot rate and the long-run equilibrium rate, plus the expected rate of change in the long run inflation differential between the domestic and foreign countries.

$$(11) \quad E(\Delta e) = -\theta(e - \bar{e}) + \pi - \pi^*$$

The parameter  $\theta$  represents the speed of adjustment. Equation (11) is combined with equation (7) to give

$$(12) \quad e = \bar{e} - \frac{1}{\theta}[(i - \pi) - (i^* - \pi')]$$

The gap between the exchange rate and its equilibria value is proportional to the real interest rate differential-the term inside the brackets. Substituting equation (10) in for the definition of  $\bar{e}$  yields

$$(13) \quad e = \bar{m} - \bar{m}' - \phi \bar{y} + \phi' \bar{y}' + \sigma \bar{w} + \sigma' \bar{w}' - \frac{1}{\theta}(i - i') + \left(\frac{1}{\theta} + \lambda\right)(\pi + \pi')$$

This is the final equation for the overshooting model which corresponds to Frankel (1979). Note the negative coefficient on the nominal interest rate differential term is a distinguishing characteristic of this model. Frankel (1983) extends this model by relaxing the assumption that bonds are perfect substitutes. In this case the model is no longer said to be strictly monetary; it is instead said to be a synthesis of the monetary and portfolio models. In this model he assumes that there is only one aspect in which domestic and foreign currency bonds differ - their currency of denomination. The uncovered interest rate parity equation (7) is modified to include a risk premium which is assumed to be a function of net supplies of bonds.<sup>8/</sup>

$$(14) \quad i = i' = E(\Delta e) + \psi$$

here  $\psi$  is a risk premium and according to Frankel (1983)  $\psi = \psi(B, F)$  where B, F are net supplies of bonds (domestic and foreign currency denominated respectively).

With this additional assumption equation (13) can be rewritten to synthesize many different versions of asset-market models, monetary as well as portfolio.

$$(15) \quad e = \bar{m} - \bar{m}' - \phi\bar{y} + \phi\bar{y}' + \sigma\bar{w} + \sigma\bar{w}' - \frac{1}{\theta} (i - i') + \left(\frac{1}{\theta} + \lambda\right)(\pi + \pi') + \frac{1}{\theta}(\psi)$$

Equation (15) represents the final version of the second model--a synthesis of the overshooting and the monetary model.<sup>9/</sup> In many ways it is used as a punching bag. It is useful in so far as it contains individual competing models as special cases, for example:

- i) If  $\sigma = \sigma' = 0$  and  $\psi = 0$ , then we obtain Frankel (1979).
- ii) If  $\sigma = \sigma' = \psi = 0$  and  $\left(\frac{1}{\theta} + \lambda\right) = 0$ , then we obtain a Dornbusch model.
- iii) If  $\sigma = \sigma' = \psi = 0$  and  $\frac{1}{\theta} = 0$ , then we have a typical monetary model.
- iv) If all the regressors on the right hand side are dropped except for  $\frac{1}{\theta} \psi$  then we have the portfolio model.

When empirically implemented as in Frankel (1983) it suffers from several drawbacks. Before turning to some of these drawbacks, two points must be made. In the empirical work Frankel uses estimates for supply of bonds by assuming that a good measure of net outside wealth is the stock of government issued liabilities held by the public sector. We, however, approach the risk term from a slightly different perspective (and perhaps from a more naive one) by using a different set of variables  $\psi$ . These

variables include actual current account, spot price of oil, stock prices and unexpected current account. This set of variables, or a subset of them, are thought to be useful in explaining risk and ultimately movements in the exchange rate. Hooper and Morton (1982) in a model similar to (15) have used current account and intervention figures to account for risk. Note that the same set of variables used to model the risk premium,  $\psi$ , is also used in equation (5) to model deviations from PPP,  $\Omega$ .

Note that model 1, equation (5), is more general than even Frankel's synthesis model under the assumption that the same set of variables are used to explain  $\psi$  and  $\Omega$ . Equation (15) can be derived from (5) by applying the following restrictions

- i)  $\Delta e = 0$
- ii)  $\delta_i = 0$  for  $i = 1, 13$
- iii)  $\gamma_{12} = \gamma_{13} = 0$
- iv)  $n = 1$
- v)  $\gamma_{10} = -\gamma_{11} = 1$
- vi)  $-\gamma_5 = \gamma_6$
- vii)  $\gamma_7 = -\gamma_8$

These restrictions are quite numerous. The first four restrictions relate to removing all the dynamics, it is assumed that the dependent variable becomes the level of the exchange rate. The latter three restrictions relate to symmetry. This leads us to point out some of the drawbacks of both the Frankel models and the technique he has employed to test them. These criticisms, outlined briefly, are as follows:

- (i) Since Frankel only uses contemporaneous variables this increases the possibility of biased coefficient estimates.

Using longer lags may induce inefficient estimates but this is a small sacrifice as compared to inconsistent estimates obtained when truncating the lags.<sup>10/</sup>

(ii) Imposing symmetry on the coefficients, if invalid, also biases coefficient estimates.<sup>11/</sup>

(iii) Interest rates are endogenous in the overshooting model, yet they are treated as though they were exogenous especially when the model is estimated.<sup>12/</sup>

(iv) The use of long term bonds as a proxy of inflation may be incorrect introducing further error.<sup>13/</sup>

(v) It must be noted that the assumptions used to derive Frankel's final model, such as the money supply process and the way expectations are formed are restrictive, changing them changes the final reduced form equation.<sup>14/</sup>

### III. Testing for PPP

The long run assumption of purchasing power parity can be analysed from (5). Setting  $e^* = e_{t-k}$  and  $z_i^* = z_{i,t-k}$  for all  $k$  and  $i = 1, 13$  and solving for  $e^*$  the econometric results can be compared with the original theory. In the case of the exchange rate this is

$$(16) \quad E = K \frac{P}{\bar{P}}$$

Three conditions are important in testing PPP. They are: (i) proportionality between relative prices and the exchange rate (ii) symmetry between the domestic and foreign country and (iii) the requirement that  $K$  is a constant (but not necessarily unity). Following these conditions three tests are considered corresponding to when condition (i) holds, condition (i) and (ii) hold and when all three

conditions hold. According to much of the literature on PPP (Officer(1976)) the last test is really the only true test of PPP. In our experience the last test is rather stringent since most equations fail this test. Consequently, we offer three tests of varying degrees of stringency to be used when testing for PPP.

The tests stated below all refer to the reduced form coefficients, the  $\gamma$ 's in particular, from equation (5). The tests are:

WEAK FORM TEST: This corresponds to the first condition holding - prices and exchange rates are proportional to each other,  $\gamma_{12} = -\gamma_{13} = \gamma_{14}$ .

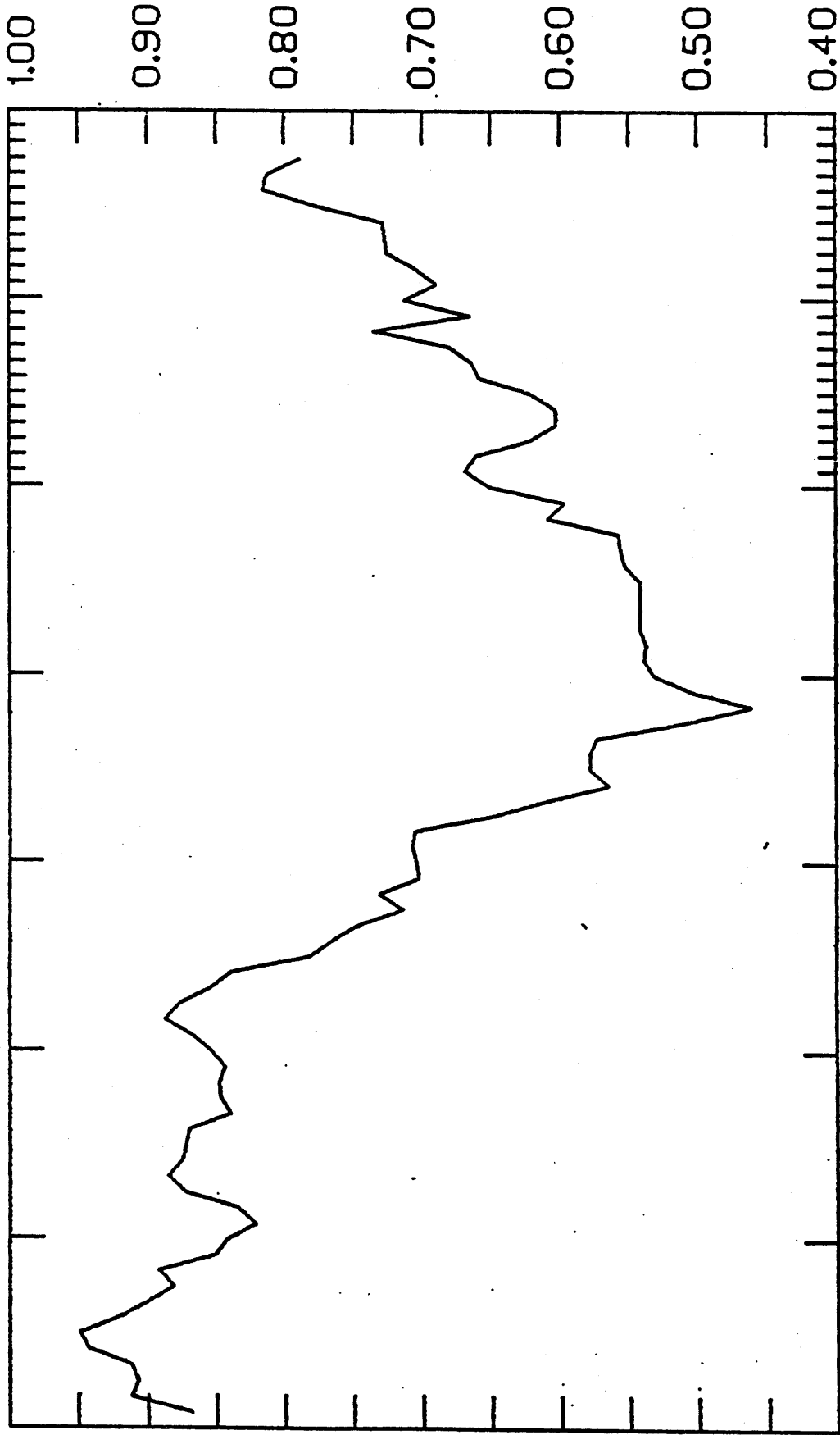
SEMI-STRONG TEST: The weak test must hold and each country must exert the same influence on the exchange rate. The conditions on the other gammas are as follows:  
 $\gamma_1 = -\gamma_2, \gamma_3 = -\gamma_4, \gamma_5 = -\gamma_6, \gamma_7 = -\gamma_8, \gamma_9 = -\gamma_{10}$ .

STRONG TEST: The semi strong test must hold however all the gammas on all the variables excluding prices and exchange rate must now equal zero i.e.  $\gamma_i = 0$  for  $i = 1, 11$ . Only relative prices should exert influence on the long run exchange rate.

#### IV. Empirical Results:

The main concern of this section is to model the monthly changes and to analyse the long run tendency of the dollar/pound exchange rate from January 1973 to September 1979. In Graph 1 the log of the exchange rate is plotted over the entire period. The large decline in the

GRAPH 1  
LOG OF DOLLAR/POUND EXCHANGE RATE



1973 1974 1975 1976 1977 1978 1979  
RANGE: JANUARY 1973 TO SEPTEMBER 1979

exchange rate in 1976 is due to the sterling crisis, the upward trend - an appreciation of the pound - occurring after the implementation of the IMF package.

A simple exchange rate equation, a univariate time series model, is examined first to monitor the success and to detect misspecification of the economic model. Two key statistics are used to monitor the results: (i) the residual sum of squares (RSS) and (ii) the sum of squared forecast errors ( $\sum fe^2$ ). The objective is to test whether the economic model fits and forecasts the data using realised predetermined variables better than the time series model.<sup>15/</sup> The results from this simple time-series estimation are:<sup>16/</sup>

$$\begin{aligned} \Delta e_t &= \underset{(.003)}{-.0024} + \underset{(.125)}{.097} \Delta e_{t-1} \\ (17) \quad \text{NOBS}=69 \quad R^2 &= .009 \quad \text{RSS}=.0507 \\ Z_3(6) &= 2.67 \quad Z_4 = 7.75 \quad Z_5 = .848 \quad \sum fe^2 = .0059 \end{aligned}$$

where

$Z_3$  The Lagrange Multiplier Test of (n)<sup>th</sup> order autocorrelation

$Z_4$  The Chi-Square Prediction Test

$Z_5$  Chow Test of Parameter Stability

$\sum fe^2$  Sum of squared forecast errors.

The first economic model that is estimated is referred to as the "risk" model, the case where  $\psi = \Omega$  and corresponds to the general model, equation (5). Two further models also starting with a general model with



modifications are considered. The first of these two models sets  $\Omega=0$  and is referred to as monetary-portfolio model while the second model sets  $\Omega=0$  and  $\beta_{12}=\beta_{22}=0$  and is referred to as the simple monetary model. Before concluding estimates of a model based on equation (15) which is the dollar/pound equivalent to Frankel's mark/dollar model are presented.

In Table 1, coefficient estimates are reported for equation 5, the general model.<sup>17/</sup> This model represents the maintained hypothesis. All subsequent models can be nested within this model where restrictions on the coefficients can be explicitly tested. In Table 2 the final results of restricting the 'general risk' model are reported.<sup>18/</sup> The dependent variable in this ( and subsequent) models is the change in the log exchange rate( $\$/\pounds$ ). The first row includes all variables that are proposed to measure risk. None of them turn out to be significant or with the expected sign.

The third row is the final specification of the general risk model where the risk variables have been deleted except for changes in spot price of oil. This variable is reported as it has been commonly argued that sterling had become a haven of petrodollars- as the price of oil goes up so does the demand for sterling. The sign reported in Table 2, however, show results which are not consistent with this argument.<sup>19/</sup>

The coefficient on the sum of changes in money supply is .327, significantly less than one. A one percent change in relative money supply ceteris paribus leads to a .3 percent change in the exchange rate. This result appears unfavourable to the overshooting model, The change in wealth, which is actually modelled as the share of money wealth, for statistical reasons, must also be considered in this

Table 1 Generalised Model, Equation (5), Coefficient Estimates

	0	1	2
e	-	.341 (.214)	.013 (.209)
p	-	.530 (1.87)	1.30 (1.85)
p'	-	-.727 (.81)	-.587 (.68)
m	-.204 (.78)	.818 (.95)	-.205 (.797)
y	-.984 (1.11)	.044 (1.36)	-.95 (1.16)
w	.25 (.40)	-.01 (.41)	.52 (.36)
i	1.35 (.69)	.89 (.73)	-.53 (.83)
b	.45 (3.10)	-3.15 (4.31)	5.12 (3.75)
m'	-.43 (.44)	-.63 (.50)	1.20 (.48)
y'	-.60 (.20)	.03 (.32)	-.57 (.46)
w'	-.23 (.29)	.037 (.30)	-.20 (.23)
b'	-.51 (.34)	.004 (.38)	.545 (.43)
OIL	-.027 (.035)	-	-
CA'	4.2E-07 (1.9E-06)	-	-
CA <sup>1</sup>	-7.9E-06 (9.9E-06)	-	-
CAE'	-.001 (1.004)	-	-
CAE <sup>1</sup>	-.05 (1.04)	-	-
NYSE	.242 (.18)	-	-
FTSE	-.04 (.066)	-	-

RSS = .00103

NOBS = 69



calculation. In general the signs on all the coefficients seem somewhat low.

It is the sign on the short term interest rate differential which is crucial in distinguishing between the overshooting and the more traditional monetary model. In all models in Table 2, the sign turns out to be positive. This suggests the model conforms to the traditional monetary description, a result not altogether uncommon. However from casual empiricism one tends to associate an appreciation of the exchange rate (a rise in the \$/£ rate) with a fall in interest rate differential (a larger rise in UK interest rates). In examining the results more closely it was found that a negative relationship is at times exhibited. There is in fact a definite negative relationship between current changes in the exchange rate and in lagged changes in the interest rate differential. This result suggests there might be a problem of simultaneity. To allow for this, the model was reestimated using an Instrumental Variable Estimator. The results are reported in the fourth row in Table 2. The size and sign of the coefficients remain much the same, but the standard errors increase. The change in estimation technique does not yield further insights on the problem.

In Table 3 the long run stationary state estimates are reported. These results are derived as described in section III by setting  $e^* = e_{t-j}^*$ , and  $z_i^* = z_{it-j}$  and solving for  $e^*$ . A unit elasticity of prices with respect to exchange rate is observed as predicted by the PPP hypothesis, hence the weak condition is met. In addition to prices there are other economic variables which influence the long run exchange rate. Three of these additional variables--income, interest rates and wealth--indicate

Table 3 LONG-RUN RESULTS

RISK	$e = 16.2 + (p - p') - 1.75y + 7.76(b - b') + 2.17i$
WEALTH	$e = 18.08 + (p - p') - 1.98y + 8.64(b - b') + 2.82i'$ $+ 1.94w - .376w'$
SIMPLE	$e = 5.52 - 1.48(m = m') + 4.91(b - b')$

LONG INTEREST-RATE ELASTICITIES

	b	b'	i'
RISK	.757	1.48	.378
WEALTH	.844	1.617	.492
SIMPLE	.479	.918	-



that the long run exchange rate is influenced by different factors asymmetrically. Hence PPP, rigorously defined, is rejected since only the weak criteria is fulfilled.

On the whole, the model captures turning points well, though not all of the magnitudes are correct. The forecasting performance of the 'risk' model using actual values for predetermined variables, however, is not as good as the univariate time series (i.e. .0085 to .0059). In two months, May and June of 1979, the general model performed poorly, these months correspond to period of political and economic turmoil in the UK.<sup>20/</sup>

Two alternative models of exchange rate similar to the general model but imposing some initial exclusion restriction are now considered. Again following the search procedure the final specifications for the model where  $\psi=0$  are reported in Table 4. It turns out that there are only two restrictions to the previous model. The results and interpretation of coefficients are similar as before: a) interest rate differential is positive, b) non-monotonic adjustment and c) PPP does not hold in the long run (as reported in Table 3). We also note more change in the coefficients as well as standard errors when using an IV estimator.

The results of the simple model, reported in Table 5 vary somewhat from the previous models: i) the coefficient on U.S. income is higher ii) a lagged money velocity term is included and iii) the rate of change of inflation is substituted for the change in inflation. However, as in the other two models there is a positive coefficient on nominal interest rate differential as well as a long run unit elasticity between prices and the exchange rate. The other variables which influence the long run exchange rate, money supply and bond rates, have identical coefficients for both

TABLE 5 SIMPLE MONETARY MODEL

	$\Delta y$	$\Delta m + \Delta m_t - \Delta y_{t-1}$	$\Delta i - \Delta i_t$	$\Delta b - \Delta b_t$	$\Delta b - \Delta b_{t-1}$	$b_{t-1}$	$m_{t-1}$	$(p - p - e)_{t-1}$	INMI	CNST	NBS	RSS	$R^2$	$Z_3(6)$	$Z_5$	$Z_4(9)$	$\Sigma e^2$
OLS	-1.96 (.398)	.248 (.12)	.514 (.123)	.528 (.238)	1.02 (.22)	-246 (.09)	.139 (.05)	-	.915 (.31)	69	.0256	.50	8.5	1.57	15.88		
OLS	-1.74 (.395)	.259 (.115)	.478 (.120)	.55 (.23)	1.03 (.21)	-.31 (.09)	.212 (.06)	-.02 (.009)	1.16 (.31)	69	.023	.54	6.6	1.55	15.2	(.0059)	
IV	-2.16 (.54)	.173 (.17)	.697 (.33)	.53 (.25)	1.08 (.244)	-.299 (.126)	.161 (.06)	-	-	69	.026	-	-	1.52	1.72	(.0075)	

For definitions of symbols, see Note below Table 2.



Table 6: The Overshooting and Synthesis Models  
January 1973 - September 1979

Dependent Variable: Log of the Dollar/Pound Exchange Rate

	y	y	m	m	f	f	b	b	w	w	CA	CA	CAE	CAE	NYSE	FTCE	OIL	CNST	R	RSS
OLS	-1.23	.139	.165	-.101	1.97	-.44	.25	-.91	-1.07	.205	0	0	-.01	.05	-.53	.09	.011	11.17	.94	.068
	1.64	(.354)	(.365)	(.27)	(.59)	(.31)	(2.62)	(.95)	(.37)	(.14)	(.00)	(.0)	(.006)	(.044)	(.17)	(.087)	(.036)	(4.10)		
OLS	-2.77	.21	-.42	.15	3.06	-.10	3.14	2.29	-.001	.08	-	-	-	-	-	-	-	21.01	.92	.104
	(.57)	(.38)	(.39)	(.29)	(.59)	(.33)	(2.70)	(.78)	(.206)	(.10)	-	-	-	-	-	-	-	(3.45)		

For definition of symbols, see note below Table 2

countries. This result is slightly more favourable to PPP but does not meet the criteria of the strong test.

An inclusion of a dummy variable for the sterling crisis of 1976 enhances this model. In fact, the forecasting results are as good as the univariate model.<sup>21/</sup> This happens to be an uncommon result in many studies.<sup>22/</sup> Still it does seem as though there is some tradeoff between complex models and more parsimonious models -- simpler models do better especially during turbulent times because there are fewer explanatory variables which can cause these models to break down.

Lastly we report two equations in Table 6 similar to Frankel's models corresponding to equations (15) and (13) respectively. Comparing the results of equations with the results of the general model, we can see that the exclusion restriction on the dynamics leads us to reject equation 15 since the joint F test is 121. However, it is interesting to note that estimating this model, ala Frankel, also leads to the positive sign on nominal interest rates. The second row in Table 6 corresponds to equation 13; it too can be rejected by the more general models. Both equations are econometrically misspecified.

## V. Conclusion

The purpose of this paper is to analyse the fluctuations in the dollar/pound exchange rate and to assess the long-run tendencies of the exchange rate. Three asset market models of exchange-rate determination--the augmented-monetary model, Frankel (1979) overshooting model, and Frankel (1983), synthesis model--are outlined in section II. The augmented-monetary model is a generalised version of the traditional (Bilson-Frenkel) monetary model and econometrically encompasses the other models considered. All of the models relax the assumption of perfectly

flexible prices in the short run and the tendency of the exchange rate towards PPP is tested. In the synthesis model the assumption of bonds being perfect substitutes is relaxed. Two restrictions which distinguish between the models are monitored: i) the coefficient on the short-run nominal interest rate differential and ii) the adjustment mechanism.

The main conclusion that emerges from the econometric investigation is that the data supports the augmented monetary model. All evidence point to the exchange rate and interest rates moving together. Moreover, the adjustment mechanism is not monotonic and it seems to be more complex than that described in the overshooting model.

The other general conclusion that emerges from this study is that the long-run exchange rate does not support the PPP hypotheses. In the first two economic models considered other factors influences the long-run exchange rate and these factors have different weights assigned for each country. In the simple monetary model, on the other hand, exhibits a "semi-strong" tendency towards PPP, however, none of the results met the rigorous requirements of PPP. This suggests a non-constant real exchange rate and that goods are not perfect substitutes. No firm conclusion can be made about bonds substitutability here since this is not tested explicitly.

Lastly, a few words about the overall success of the economic models. All three economic models explain the in-sample exchange rate better than the univariate time series model. Furthermore, the simple monetary model with a dummy for the 1976 sterling crises predicts over the post-sample period using actual values for the predetermined variables equally as well as the time-series model. This result we find encouraging for exchange rate modellers. The method of starting with a general model and testing for simplifications seems to work well.

## Footnotes

\*This paper is a revised version of Edison (1981a) and chapter 4 of my dissertation. I would like to thank my colleagues at the LSE and in particular my advisors; Meghnad Desai, David Hendry, and Stephen Nickell. I would also like to thank my colleagues at the Fed, Richard Haas and Peter Hooper, for helpful comments while revising this paper. This paper represents the view of the author and should not be interpreted as representing the views of the Board of Governors of the Federal Reserve System.

1/ From the definition of the exchange rates quoted as the dollar/pound rate, a rise in the exchange rate implies an appreciation of the pound (or a depreciation of the dollar). Since both countries typically quote the exchange rate in this form, we treat the U.K. as the "foreign" country. Therefore, when we talk about, for example, a positive sign on the interest rate differential with respect to the exchange rate we mean,  $\partial e / \partial (i - i') > 0$  or that the equation conforms to the traditional monetary model.

2/ We single out Frankel's models as alternative models since they incorporate other models that are considered in the literature.

3/ A distinguishing feature of this model is that the added dynamics are not derived by assuming rational expectations.

4/ In the first model, the risk term is in the model to explain why there may not be goods arbitrage (goods substitutability) while in the second model it is used to explain why assets are not perfect substitutes. However, in the reduced form exchange rate equation, we do not distinguish between these two assumptions.

5/ The three characteristics which highlight the model are:  
a) PPP-goods are perfect substitutes  
b) assets are perfect substitutes  
c) real interest rates are constant

6/ Throughout this paper, we distinguish between short and long run. By short run we mean transitory factors that may or may not effect the outcome in the long-run equilibrium state. Hooper and Morton (1982) assume in their paper that the long-run exchange rate is not constant and that cumulated current account explains long-run deviations from PPP.

7/ Once again this model's long-run conditions embody most of the important monetary model main characteristics a) PPP, b) asset substitutability.

8/ In the estimation, the two terms,  $\psi$  and  $\Omega$ , are treated identically. This enables us to use equation (5) as the general model with its monetary attributes while equation (15) takes on portfolio balance type characteristics.

9/ Equation (15) is identical to Frankel's equation (27), except that in (15) we have not spelled out what  $\psi$  is, therefore, the structural coefficients at this point differ.

10/ This is explained in more detail in Edison (1981) and Mizon (1977).

11/ Haynes and Stone (1981) have pointed out this problem of imposing the linear constraint of symmetry on variables. This is not a problem related to Frankel alone, but also symptomatic of many studies in the literature.

12/ Driskill and Sheffrin (1981) have also argued that the nominal interest differential are endogenous.

13/ The use of long term bond rates is wide spread, but it is not altogether clear whether it is the best way to model inflation.

14/ As described in Mussa (1976).

15/ These tests are suggested in Hendry (1980).

16/ All of the equations estimated in this paper were done by using David Hendry's computer program--G.I.V.E.--Generalised Instrumental Variables Estimates.

17/ The number of lags is truncated at 2 when estimating the general model in log levels. The reason for doing this is due to both data and computational limitations (i.e., the number of degrees of freedom and the dimensions of the computer package). The decision here had to be made between truncating the lag or imposing untested restrictions on the polynomial lag structure. Since both involve restrictions which can lag to inconsistent estimates, the former method was followed as suggested in Mizon (1977).

18/ The general model reported in Table 1 is in log levels. However, it can be easily estimated with the dependent variable in difference form where the regressors are in both levels and first differences.

19/ Haache and Townend (1981) discuss various ways North Sea oil may effect the exchange rate. Their results were quite positive when using index of Saudi marker of crude. This is contrary to our result, however, consist with their statement, pg. 225, "It is unlikely that the direct and indirect effects of these changes can be easily captured empirically.

20/ Three additional tests were carried out to test for misspecification. They were a) a dummy for 1976 sterling crises, b) seasonal dummies, and c) for structural break. The first test was considered because it was thought that the relationship changed, no statistical evidence for the "risk" model substantiated this hypothesis. The results showed that the seasonal dummies were jointly insignificant. The third test was considered to determine whether the data generating process was completely different in the earlier and later periods. Other

studies such as Frankel discussed how results changed when new observations were added. When dividing our sample at various points in time, we rejected the hypothesis that the periods were different by using a Chow Test.

21/ In assessing the property of his demand for money functions, Goldfeldt (1973) also found that excluding wealth improved his models prediction capabilities.

22/ In Rogoff and Meese (1982) none of the economic models were found to consistently out forecast using realised values for the predetermined variables the simple univariate time series model. Our results are not inconsistent with these findings since most of the models we explicitly examine do worse. We are more optimistic than Meese and Rogoff and for that matter, Haache and Townend who claim that they have not found a stable empirical relationship that can be used in forecasting. The reason for this optimism is that the econometric methodology used here helps in testing well-specified models. Thus, if we, as economist's, can describe the exchange rate market more closely we may be able to find a model that consistently out-performs a univariate time-series model.

## APPENDIX I

### THE DATA:

Notation	(SCB)	Survey of Current Business (USA)
of	(FRB)	Federal Reserve Bulletin (USA)
Sources	(OECD/O)	Biannual Economic Outlook of OECD
	(OECD)	Historical Data of OECD
	(MD)	Monthly Digest of CSO (UK)
	(ET)	Economic Trends (CSO-UK)
	(FS)	Financial Statistics (CSO-UK)
	(BE)	Bank of England Quarterly Bulletin

(all data are monthly and seasonally unadjusted unless otherwise noted)

- 1) Exchange Rate: defined as the \$/£ rate. Reported for the last working day of the month--the middle rate (average of bid/ask spread) (BEQ)
  
- 2) Prices: U.S.: Consumer Price Index (CPI) general base year rescaled 1973 = 100 (SCB)  
U.K.: Retail Price Index (RPI) general--all items base year rescaled 1973 = 100 (MD)
  
- 3) Money: U.S.: M1 in billions of dollars (FRB) average daily  
M2 in billions of dollars (FRB) figures  
U.K.: M1 in billions of pounds sterling (BE)  
TM3 in billions of pounds (BE) (total M3)  
OCA: other currency in accounts in billions of pounds (BE)  
SM3: defined as: TM3-OCA.
  
- 4) Income: U.S.: Income: Gross National Product in constant 1972 prices in billions of dollars--seasonally adjusted (SCB) (QUARTERLY). Industrial Production Index--monthly seasonally adjusted (SCB). Retail Sales: monthly: seasonally adjusted in billions of dollars (SCB).  
  
Income: U.K.: Gross domestic income at factor costs (at 1975 prices) seasonally adjusted quarterly data (ET). Industrial Production: based 1975 = 100 monthly seasonally adjusted (ET). Value Retail Sales Index: monthly 1971 = 100 seasonally adjusted.

- 5) Interest U.S.: Eurodollar Rates: 3 month rate quoted in London at end of month (BE) (percent per annum).  
Bond Rate: (Long-Term Rate) Average of daily figures for bonds maturing or callable in 10 years or more U.S. Government (FRB).
- U.K.: Euro-sterling Rates: 3 month rates end of month percent per annum (BE).  
Bond Rate: Long term bond rates (10 years or more) on U.K. government stocks (BE).
- 6) Wealth U.S.: Quarterly Outstanding of Net Personal Sector Financial Assets (Fed Flow of Funds).  
U.K.: Net Wealth of Personal Sector: published by the C.S.O. Studies in Official Statistics No. 35 (1965-75) and (FT-Feb 1978).
- 7) Stock Market Prices: New York Stock Exchange: Dow Jones Industrial Averages 30 Stocks (SCB).  
Financial Times Share Index: Index of Industrial ordinary shares 1 July 1985 - 100. (FS).
- 8) Current Account Data: U.S.: Quarterly data on U.S. current account in millions of dollars (FRB).  
Trade balance: monthly trade balance based on averages in millions of \$ (OECD) exports--imports.  
Forecast of current account: biannually produced by the OECD (OECD/Outlook) in billions of \$.
- U.K.: current account: U.K. based in million of £ (MD).  
trade balance: monthly averages in millions of £ (exports-imports)  
Forecast of current account: As for the U.S. biannually produced by the OECD six months in advance--billions of \$ (OECD/outlook).
- 9) Oil Price: Arabian crude 34<sup>0</sup> light spot market price in the Rotterdam Market: Petroleum Intelligence Weekly.



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