

# An econometric model for foreign exchange rate forecasting\*

## INTRODUCTION

The object of this article is to postulate and test a foreign exchange rate model. South African companies are becoming increasingly involved in foreign exchange dealing, and it is therefore felt that research in the area is both relevant and necessary. In evaluating this, as well as any other econometric model, the limitations of the resulting forecasts must be kept in mind: the forecast is a statement of the future based purely on the momentum of past time series, and is useful and valid to the extent that the future is a reflection of the past.

## CHOICE OF INDEPENDENT VARIABLES

A fundamental requirement of any model is that a strong *a priori* relationship, based on general economic theory, exists between the dependent and independent variables used in the model.

The relationship between supply and demand is a focal point behind the choice of variables. The rate of exchange "fluctuates continuously with every variation in the relationship between the current supply of and demand for the currency, and all factors which go to make up and affect current supply and demand are, consequently, of the first importance in considering movements in rates of exchange".<sup>1</sup> Accordingly, the choice of variables used in the model will be motivated in terms of this relationship.

### 1 Balance of payments (BOP)

A country running a BOP deficit will find its exchange rate under pressure to adjust downwards, as supply of its currency increases relative to demand. Conversely, a surplus on the BOP will lead to an upward pressure on the rate, as demand for the currency increases relative to supply.

### 2 Gold and foreign exchange reserves (GER)

When a country's BOP is in deficit, the GER will often be used to finance the deficit. Therefore, the running-down of the GER will be associated with a downward pressure on the exchange rate. Conversely, the building-up of the GER as a consequence of a BOP surplus, will be associated with an upward pressure on the rate.

Under the present exchange rate system, central banks tend to intervene in foreign exchange markets in an attempt to limit the movements of their exchange rates. Such action, which will be reflected in the GER, will affect the balance of the supply and demand for the currency, and will accordingly produce an exchange rate different from what it would have been without official intervention.

### 3 Employment index (EI)

This variable was included in the model for the following reasons: Firstly, an EI gives some indication of the level of capacity utilisation and economic activity in a particular country. These factors influence a country's BOP and, hence, affect the exchange rate. Secondly, in the current economic and political environment, an EI is a measure of confidence in the stability and potential of an economy. This can have a profound effect on an exchange rate, as foreign exchange markets will respond to changes in confidence.

### 4 Interest rates

Holders of investment funds will often move their funds from country to country to take advantage of differences in interest rates. The buying and selling of different currencies will therefore occur, and exchange rates will change in response to adjustments in the amounts supplied and demanded. For the purposes of this model, two interest rates have been used: the bank rate (BR) and the call rate (CL). The BR was selected because it tends to influence the general structure of interest rates in a particular economy. The CL, being a shorter term rate, was chosen for its volatility, which tends to attract speculative dealings in foreign exchange, as investors move in and out of currencies attempting to take advantage of interest rate differentials.

### 5 Prices

Differences in domestic price levels from country to country affect the price competitiveness of exports and imports. These price differentials will affect the flows of international trade, if we assume that demand is price elastic, and will thereby lead to changes in exchange rates. Both consumer (CPI) and wholesale (WPI) price indices have been included in the model. This is to ensure that the model exposes the exchange rate to the broadest possible inflationary influence.

### 6 Money and near-money supply (MNM)

The inclusion of this variable is in response to the monetarist view that the money supply is one of the most important determinants of the rate of inflation. Therefore, the line of causation is that a change in the MNM leads to a change in the inflation rate, resulting in an adjustment to the exchange rate.

## METHODOLOGY AND TERMINOLOGY

- (a) The model was constructed using the currencies of five of South Africa's major trading partners,

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which float in terms of the rand. The currencies selected were the Japanese yen, French franc, British pound, German mark and Swiss franc. The U.S. dollar had to be excluded from the analysis in view of the fixed but adjustable exchange rate maintained between the rand and the dollar.

- (b) Monthly data covering the period January 1973 to March 1977 were collected for the variables used in the model. The data for the Japanese yen covering the period January 1973 to December 1976, the French franc, January 1973 to August 1976, the British pound, German mark and Swiss franc, January 1973 to November 1976, were initially run through the Multiple Regression sub-programme of the Statistical Package for the Social Sciences. It was felt that these data covered a sufficiently long time period to be used as a basis for the model.<sup>2</sup>

Successive runs using various time lags were undertaken. For example, a two month lag is one in which the values of the independent variables at the end of month one are used to predict the value of the dependent variable, the exchange rate, at the end of month three.

The lag yielding the highest multiple correlation coefficient (R) was selected for use in the model. This criterion was used, as R<sup>2</sup> measures the proportion of the variability in the dependent variable that is attributable to the combined linear influence of the independent variables.

- (c) The sub-programme generated an equation which best fitted the dependent and independent variables used in the model. The general form of the multiple regression equation is:

$$Y^1 = A + B_1 X_1 + B_2 X_2 + B_3 X_3 \dots + B_k X_k$$

where Y<sup>1</sup> represents the estimated value of the dependent variable;

A is the intercept on the Y-axis;

B<sub>1</sub> are the regression coefficients;

X<sub>1</sub> are the independent variables.

- (d) For a model to be of maximum benefit to a company, it should be continually updated as soon as new data become available. This is a simple procedure which merely involves adding an extra set of variables to the existing data base, and then recalculating the relationship between the dependent and independent variables. The updating process unavoidably leads to changes in the regression coefficients, the multiple correlation coefficient and the intercept on the Y-axis. Nevertheless, this process is vital if the model is to remain valid over time. This follows from the fact that firstly, the more recent the data, the greater the confidence levels of the projections made by the model, and secondly, this process tests the stability of the relationships between the variables over time.

The updating process was tested for the Japanese yen, forecasts covering the period January 1977 to March 1977, the French franc, September 1976

to November 1976, the British pound, German mark and Swiss franc, December 1976 to February 1977.<sup>3</sup>

- (e) The estimated values of the exchange rate (Y<sup>1</sup>) were calculated using the equations generated by the sub-programme.

The differences between Y<sup>1</sup> and the actual exchange rate (Y) is the residual (RL). RL gives an indication of the absolute error of the prediction. The percentage residual (%RL) was also calculated:

$$\%RL = \frac{RL \cdot 100}{Y}$$

The %RL provides a relative measure of the error of prediction.

- (f) Y<sup>1</sup> and Y were plotted graphically on a monthly basis from 1973 onwards.

## RESULTS OF THE MODEL

### 1 Japanese yen

*Optimal time lag:* Three months

*Basic run:* Exchange rate =

$$\begin{aligned} & -520,17546 + 8,12138 EI + 7,59478 CL \\ & + 0,00316 GER - 2,31868 WPI + 9,63381 BR \\ & + 1,81115 CPI - 0,00470 BOP \end{aligned}$$

$$R = 0,94105; R^2 = 0,88557$$

*Update run 1:* Exchange rate =

$$\begin{aligned} & -520,53096 + 8,11831 EI + 7,53879 CL \\ & + 0,00318 GER - 2,31292 WPI + 9,71188 BR \\ & + 1,80855 CPI - 0,00443 BOP \end{aligned}$$

$$R = 0,94371; R^2 = 0,89059$$

*Update run 2:* Exchange rate =

$$\begin{aligned} & -515,72641 + 8,08182 EI + 7,61331 CL \\ & + 0,00316 GER - 2,30473 WPI + 9,59088 BR \\ & + 1,79523 CPI - 0,00463 BOP \end{aligned}$$

$$R = 0,94638; R^2 = 0,89563$$

*Update run 3:* Exchange rate =

$$\begin{aligned} & -452,34073 + 7,59234 EI + 6,78869 CL \\ & + 0,00307 GER - 2,13640 WPI + 10,47441 BR \\ & + 1,76249 CPI - 0,00031 MNM \end{aligned}$$

$$R = 0,94870; R^2 = 0,90004$$

Average RL = -1,7021

Standard deviation of RL = 13,9160

Average %RL = -0,5929

Standard deviation of %RL = 3,7526

### 2 French franc

*Optimal time lag:* One month

*Basic run:* Exchange rate =

$$\begin{aligned} & 1,50544 + 0,10868 EI - 0,00026 GER \\ & - 0,06664 CPI - 0,00539 MNM + 0,01871 WPI \\ & + 0,03689 BOP - 0,03083 BR - 0,00054 CL \end{aligned}$$

$$R = 0,96173; R^2 = 0,92492$$

*Update run 1:* Exchange rate =  
 $1,72241 + 0,10461 \text{ EI} - 0,00025 \text{ GER}$   
 $- 0,06560 \text{ CPI} + 0,00502 \text{ MNM} + 0,01973 \text{ WPI}$   
 $+ 0,03713 \text{ BOP} - 0,02939 \text{ BR} - 0,00057 \text{ CL}$   
 $R = 0,96156; R^2 = 0,92460$

*Update run 2:* Exchange rate =  
 $1,23972 + 0,10959 \text{ EI} - 0,00025 \text{ GER}$   
 $- 0,06468 \text{ CPI} + 0,00501 \text{ MNM} + 0,01894 \text{ WPI}$   
 $+ 0,03264 \text{ BOP} - 0,02990 \text{ BR} - 0,00060 \text{ CL}$   
 $R = 0,96210; R^2 = 0,92563$

*Update run 3:* Exchange rate =  
 $0,43201 + 0,11824 \text{ EI} - 0,00026 \text{ GER}$   
 $+ 0,00572 \text{ CPI} + 0,00477 \text{ MNM} + 0,01172 \text{ WPI}$   
 $- 0,00088 \text{ CL} - 0,00408 \text{ BOP} - 0,01141 \text{ BR}$   
 $R = 0,96148; R^2 = 0,92445$   
 Average RL =  $-0,0049$   
 Standard deviation of RL =  $0,1925$   
 Average %RL =  $-0,1574$   
 Standard deviation of %RL =  $3,2511$

### 3 British pound

*Optimal time lag:* Three months

*Basic run:* Exchange rate =  
 $4,18753 - 0,04246 \text{ EI} + 0,00004 \text{ GER}$   
 $+ 0,00787 \text{ BR} - 0,00186 \text{ WPI} + 0,00002 \text{ MNM}$   
 $+ 0,01303 \text{ CL} + 0,00067 \text{ CPI} + 0,00001 \text{ BOP}$   
 $R = 0,78102; R^2 = 0,60999$

*Update run 1:* Exchange rate =  
 $3,92340 - 0,03975 \text{ EI} + 0,00004 \text{ GER}$   
 $+ 0,00779 \text{ BR} - 0,00193 \text{ WPI} + 0,00002 \text{ MNM}$   
 $+ 0,01197 \text{ CL} + 0,00082 \text{ CPI} + 0,00002 \text{ BOP}$   
 $R = 0,78638; R^2 = 0,61839$

*Update run 2:* Exchange rate =  
 $3,56649 - 0,03656 \text{ EI} + 0,00004 \text{ GER}$   
 $+ 0,00592 \text{ BR} - 0,00205 \text{ WPI} + 0,00002 \text{ MNM}$   
 $+ 0,01283 \text{ CL} + 0,00126 \text{ CPI} + 0,00002 \text{ BOP}$   
 $R = 0,77596; R^2 = 0,60211$

*Update run 3:* Exchange rate =  
 $2,86476 - 0,02775 \text{ EI} + 0,00004 \text{ GER}$   
 $+ 0,00763 \text{ BR} - 0,00166 \text{ WPI} + 0,00002 \text{ MNM}$   
 $- 0,00002 \text{ BOP} + 0,00081 \text{ CPI} + 0,00246 \text{ CL}$   
 $R = 0,75129; R^2 = 0,56444$   
 Average RL =  $0,0361$   
 Standard deviation of RL =  $0,0341$   
 Average %RL =  $5,7609$   
 Standard deviation of %RL =  $5,1719$

### 4 German mark

*Optimal time lag:* Three months

*Basic run:* Exchange rate =  
 $7,57321 + 0,01913 \text{ EI} + 0,00001 \text{ GER}$   
 $+ 0,02026 \text{ BR} - 0,09494 \text{ CPI} + 0,03584$   
 $+ 0,00271 \text{ MNM} - 0,01809 \text{ BOP} - 0,00046 \text{ CL}$   
 $R = 0,92804; R^2 = 0,86125$

*Update run 1:* Exchange rate =  
 $9,97332 - 0,00180 \text{ EI} - 0,00069 \text{ BOP}$   
 $+ 0,00172 \text{ MNM} + 0,04136 \text{ BR} - 0,08864 \text{ CPI}$   
 $+ 0,02915 \text{ WPI} - 0,00046 \text{ CL}$   
 $R = 0,93106; R^2 = 0,86688$

*Update run 2:* Exchange rate =  
 $11,97617 - 0,01745 \text{ EI} + 0,00135 \text{ MNM}$   
 $+ 0,06391 \text{ BR} - 0,09133 \text{ CPI} + 0,02854 \text{ WPI}$   
 $- 0,01048 \text{ BOP} - 0,00051 \text{ CL}$   
 $R = 0,93445; R^2 = 0,87320$

*Update run 3:* Exchange rate =  
 $12,34597 + 0,00108 \text{ MNM} + 0,06862 \text{ BR}$   
 $- 0,08961 \text{ CPI} + 0,02757 \text{ WPI} - 0,02111 \text{ EI}$   
 $- 0,01040 \text{ BOP} - 0,00050 \text{ CL}$   
 $R = 0,93750; R^2 = 0,87891$   
 Average RL =  $-0,1219$   
 Standard deviation of RL =  $0,1498$   
 Average %RL =  $-3,7851$   
 Standard deviation of %RL =  $4,5516$

### 5 Swiss franc

*Optimal time lag:* Three months

*Basic run:* Exchange rate =  
 $13,55610 - 0,01494 \text{ MNM} - 0,00052 \text{ BOP}$   
 $- 0,02673 \text{ CPI} + 0,32837 \text{ CL} - 0,03453 \text{ WPI}$   
 $+ 0,00002 \text{ GER} - 0,02052 \text{ EI}$   
 $R = 0,95441; R^2 = 0,91090$

*Update run 1:* Exchange rate =  
 $13,80933 - 0,01492 \text{ MNM} - 0,00048 \text{ BOP}$   
 $- 0,02876 \text{ CPI} + 0,34503 \text{ CL} - 0,03439 \text{ WPI}$   
 $- 0,02129 \text{ EI} + 0,00002 \text{ GER}$   
 $R = 0,95621; R^2 = 0,91434$

*Update run 2:* Exchange rate =  
 $13,75786 - 0,01483 \text{ MNM} - 0,00048 \text{ BOP}$   
 $- 0,02861 \text{ CPI} + 0,34259 \text{ CL} - 0,03432 \text{ WPI}$   
 $- 0,02106 \text{ EI} + 0,00002 \text{ GER}$   
 $R = 0,95802; R^2 = 0,91781$

*Update run 3:* Exchange rate =  
 $11,70469 + 0,00006 \text{ MNM} - 0,00038 \text{ BOP}$   
 $- 0,03278 \text{ CPI} + 0,25586 \text{ CL} - 0,03464 \text{ WPI}$   
 $+ 0,08625 \text{ BR} + 0,00001 \text{ GER} - 0,01245 \text{ EI}$   
 $R = 0,95588; R^2 = 0,91370$   
 Average RL =  $-0,0012$   
 Standard deviation of RL =  $0,2010$   
 Average %RL =  $-0,5081$   
 Standard deviation of %RL =  $5,2549$

## An econometric model for foreign exchange rate forecasting

Figure 1. Graph illustrating the actual and predicted exchange rates for the Japanese yen.

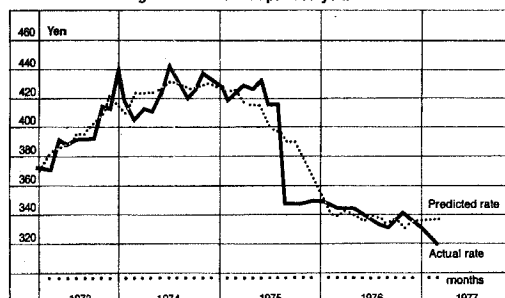


Figure 2. Graph illustrating the actual and predicted exchange rates for the French franc.

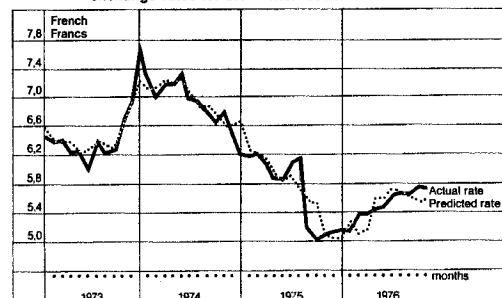


Figure 3. Graph illustrating the actual and predicted exchange rates for the British pound.

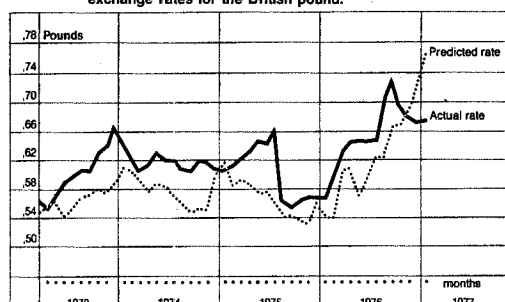


Figure 4. Graph illustrating the actual and predicted exchange rates for the German mark.

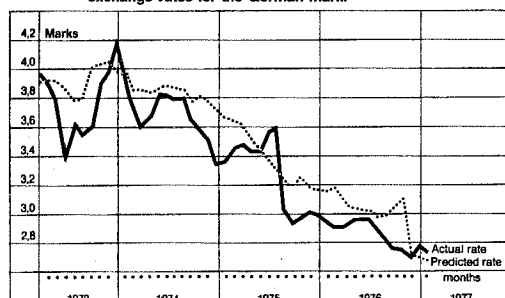
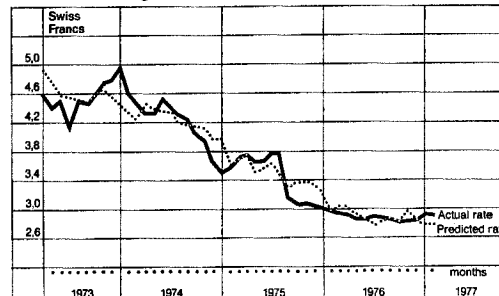


Figure 5. Graph illustrating the actual and predicted exchange rates for the Swiss franc.



### EVALUATION OF THE MODEL

The empirical testing of the model has shown that it provides useful forecasting information. It will be noted that the multiple correlation coefficients varied from one currency to another. This obviously makes the model more accurate and therefore more relevant to certain currencies. Although the pound has statistically acceptable correlation coefficients, it is felt that the residuals are too large and erratic for practical use. The results of the other four currencies showed that the model managed to forecast their underlying trends extremely well, so providing useful information for foreign exchange management. At times, the forecast exchange rate was extremely close to the actual rate. However, the closeness of these forecasts are seen to be too erratic to be of great practical use, although they remain pertinent as a guiding factor in decision-making.

The results of the model show that the highest residuals were recorded in the few months following the devaluation of the rand in terms of the dollar in September 1975. This is to be expected, as the underlying determinants of the exchange rate movements for the five currencies used in the model do not influence the rate which is

maintained between the rand and the dollar. The updating process, illustrated in the application of the model, shows that in spite of some changes in the regression coefficients and the intercepts on the Y-axis, the multiple correlation coefficients were remarkably stable over time. If the model is to be valid and useful for foreign exchange management, the relationships postulated in it must be stable.

### CONCLUSION

This article has covered the postulating and testing of an econometric model for foreign exchange rate forecasting. It is hoped that this research may provide a basis, a methodology and some insight for using a model in practical foreign exchange management.

### Footnotes

- 1 Evitt, H. E., *A Manual of Foreign Exchange*, p. 15.
- 2 The equations and correlation coefficients generated by these runs are grouped under the heading "Basic run" in section 4.
- 3 The equations and correlation coefficients generated by this process are grouped under the headings "Update run 1, 2 and 3" in section 4.