EXCHANGE RATE DETERMINATION USING A LINEAR REGRESSION MODEL: A MONETARY APPROACH

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Abstract

The monetary approach to exchange rate determination has been criticised because of the lack of empirical evidence. In this research note, a linear regression equation was estimated according to the monetary approach to explain changes in the nominal United States dollar/rand exchange rate for the years 1960-1988. Results indicate that this exchange rate is determined by relative United States and South African money supplies, nominal interest rates and real incomes. The R_a^2 value was 0.965 percent.

Uittreksel:
Bepaling van die wisselkoers deur middel van 'n linere regressie model: 'n monetre benadering.

Die monetêre benadering tot wisselkoersbepaling is gekritiseer omdat daar nie genoeg empiriese bewyse daarvoor is nie. In hierdie navorsingsnota is 'n lineêre regressiemodel ooreenstemmend met die monetêre benadering gebruik om veranderings in die nominale VSA dollar/rand wisselkoers vir die jare 1960 tot 1988 te verduidelik. Die resultate toon dat die wisselkoers deur die volgende faktore beïnvloed word: Die relatiewe aanbod van geld in die VSA en Suid Afrika, nominale rentekoerse en reële inkome. Die R_a^2 waarde is 0.965 persent.

1. Introduction

Volatility in world financial markets in the late 1960's and early 1970's led to the collapse of the Bretton Woods system of fixed (adjustable peg) exchange rates. This was followed by a general realignment of currencies and the floating of the exchange rates of major currencies. In December 1971 the rand was linked to the British pound, and from June 1972 to December 1978 the rand was linked to the United States (US) dollar. Since January 1979, the South African (SA) monetary authorities have pursued a managed float exchange rate policy as recommended by the De Kock Commission.

The US dollar/rand exchange rate (hereafter referred to as the exchange rate) has fluctuated markedly since 1972 (South African Reserve Bank Quarterly Bulletin). Evidence suggests that exchange rate movements influence real agricultural trade flows (Schuh, 1974; Chambers and Just, 1981; 1982; Batten and Belongia, 1984; 1986), and prices of imported agricultural inputs (Le Clus, 1979; Groenewald, 1982; Dushmanitch and Darroch, 1989; 1990). The aim of this research note is to use the monetary approach to exchange rate determination to explain movements in the exchange rate during the period 1960-1988. This approach views the exchange rate as an asset price which, like any other asset price, is determined by the forces of supply and demand (Frenkel, 1976).

2. Theoretical model

The monetary approach to exchange rate determination views the exchange rate as the relative price of two national money stocks, and as such, is determined by demands for and supplies of these money stocks. Efficient capital markets are assumed and the equilibrium exchange rate is attained when both money stocks are willingly held. The exchange rate reflects all available information and is sensitive to expectations which are heavily influenced by monetary policy (Humphrey and Keleher, 1982:247-248).

Eight relationships constitute the monetary approach to exchange rate determination (Humphrey and Keleher, 1982:247-263). Domestic and foreign money demands are represented by relationship (1). The public's demand for real cash balances, D, is a function of a fixed constant, K, real income, Y, and nominal interest rates, i, and interest elasticity of the exchange rate denoted by a, where asterisks denote the foreign country,

$$D = KYi^{a} \text{ and } D^{*} = K^{*}Y^{*}i^{*-a} \quad (1)$$

Real income represents the transactions demand for money and the interest rate represents the opportunity cost of holding money rather than interest bearing assets.

Domestic and foreign money market equilibriums are represented by relationship (2). The price level, P, adjusts to equate the nominal stock of money, M, with real money demand and thus clearing the market for real cash balances.

$$P = M/D \text{ and } P^{*} = M^{*}/D^{*} \quad (2)$$

The exchange rate, e, equates the general price levels in both countries ensuring purchasing power parity. This is required if the two national currencies are to be willingly held and money market equilibrium maintained in both countries (equation 3).

$$P = eP^{*} \quad (3)$$

Nominal interest rates in both countries are the sum of the respective real interest rates, r, and the expected rate of inflation, p^{e} (relationship 4).

$$i = r + p^{e} \text{ and } i^{*} = r^{*} + p^{e*} \quad (4)$$

Equation (5) represents real interest rate parity between countries. This relationship implies that the real rate of return on capital assets is the same in all countries, rw, and represents the monetarist assumption of a highly integrated, efficient global capital market. Real interest rate parity ensures asset market equilibrium.

$$r = r^* = r_w \quad (5)$$

Expectations concerning prices and monetary growth are expressed by equations (6) and (7) respectively. Inflationary expectations reflect anticipations of future depreciations in the value of the national money stock. In turn, inflationary expectations depend on anticipated future money growth, m^e, and other expectations forming information, I.

$$p^e = m^e \text{ and } p^{e*} = m^{e*} \quad (6)$$

$$m^e = m^e(m,I) \text{ and } m^{e*} = m^{e*}(m^*,I^*) \quad (7)$$

The reduced form of the above model constitutes the monetary approach to exchange rate determination, and is expressed as,

$$e = [K^*/K, M/M^*, Y^*/Y, [(r + m^e(m,I))/(r^* + m^{e*}(m^*,I^*))]^n] \quad (8)$$

3. ECONOMETRIC METHODOLOGY AND RESULTS

The exchange rate was specified as a function of relative SA and US money supplies, interest rates and real incomes. Expressing the explanatory variables as relative values reduces multicollinearity between highly correlated variables. This procedure however assumes equal elasticities of money demand in the US and South Africa (MacDonald, 1984).

Nominal money supply was represented by the broad definition of money (money plus near money) in both countries. Nominal market interest rates were proxied by the respective treasury bill rates. Real incomes in the US and SA were represented by real gross national and domestic products respectively. Data were obtained from the South African Reserve Bank (various years) and International Monetary Fund (1990).

The model was estimated by ordinary least squares (OLS) using annual data from 1960-1988. The grafted polynomial technique developed by Fuller (1976:393-397) was used to explain exchange rate movements under three different exchange rate regimes. This technique obviates the need to use higher order polynomials to estimate different segments of the function. The segments are approximated by a low order polynomial and joined into a continuous function by a grafted polynomial variable.

A grafted polynomial variable, π_t, was defined to explain movements in the exchange rate under three exchange rate regimes, such that,
1960 - 1971, $\pi_t = 0$: fixed exchange rates,
1972 - 1978, $\pi_t = 1$: flexible/pegged exchange rates, and,
1979 - 1987, $\pi_t = 2$: managed float as recommended by the De Kock Commission.

Defined as zero in the period of fixed exchange rates, π_t explains movements in the rand exchange rate only after 1971. Movements in each period are explained when π_t is included as a separate regressor and all explanatory variables are multiplied by π_t. The exchange rate is therefore estimated as,

$$e_t = f[\pi_t, (M_{SA}/M_{US})_t*\pi_t, (i_{SA}/i_{US})*\pi_t, (Y_{SA}/Y_{US})*\pi_t, e_t] \quad (9)$$

Ordinary least squares estimation results show that all estimated coefficient signs agree with the monetarist specification and are significant at the five percent level of probability.

$$e_t = \underset{\substack{(75,04)\\(53,06)}}{1,399} - \underset{\substack{(-0,98)\\(-0,70)}}{0,199\pi} - \underset{\substack{(-4,67)\\(-3,30)\\[-0,319]}}{12,603[M_{SA}/M_{US}]} - \underset{\substack{(-9,68)\\(-6,84)\\[-0,427]}}{0,196(i_{SA}/i_{US})} + \underset{\substack{(2,00)\\(1,41)}}{11,892[Y_{SA}/Y_{US}]}$$

$R^2_a = 0.9647\%$ d = 2,24 df = 24 adjusted df = 12

Round brackets below the reported coefficients contain the actual t-statistics and adjusted t-statistics. Actual t-statistics are adjusted for degrees of freedom (df) as all explanatory variables have zero values for the period 1960-1971. Each t-statistic is adjusted by the factor $\sqrt{(n-k/n-k)}$, where (n-k) is the original degrees of freedom, and (n_1-k_1) is the adjusted degrees of freedom. The actual and adjusted degrees of freedom are 24 and 12 respectively, as n = 29, n_1 = 17, k = 5 and k_1 = 5.

The adjusted t-statistics show that all coefficients are significant at the five percent level except for the relative real income variable. The square brackets below the money supply and interest rate coefficients contain the respective exchange rate elasticities. The elasticities of the exchange rate with respect to relative money supplies and Treasury bill rates are -0,319 and 0,427 respectively. This implies that a one percent increase in domestic nominal money supply relative to the US nominal money supply will lead to a 0,319 percent depreciation in the value of the rand against the US dollar. Similarly, a one percent increase in the domestic nominal treasury bill rate relative to that in the US will depreciate the rand by 0,427 percent. This indicates an active role for monetary polices for exchange rate determination.

4. Conclusion

This research note attempts to explain movements in the US dollar/rand exchange rate during 1960-1988 using a linear OLS regression model. The exchange rate was estimated according to the monetary approach by which the exchange rate was estimated as a function of relative SA and US money supplies, nominal interest rates and real incomes. Signs of the estimated coefficients agreed with the theoretical model which lends support to the monetary approach to exchange rate determination. Although the model is simple and the existence of dual exchange rates and exchange controls for much of the study period are not consistent with the assumption of efficient capital and foreign exchange markets, these results may be of interest to South African agriculturalists since evidence exists that rand exchange rate fluctuations influence South African agriculture.

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