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The determinants of real exchange rate: theory and evidence from Papua New Guinea

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Abbreviations

ERER	Equilibrium real exchange rate
PNG	Papua New Guinea
RER	Real exchange rate
TOT	Terms of trade

Abstract

This paper examines the determinants of real exchange rate in Papua New Guinea employing annual data for the period 1970-1994. The theoretical framework for the analysis is provided by the two goods (tradable and nontradable) dependent economy (Australian) model modified in the light of recent theoretical advances of macroeconomic modelling of external shocks in developing countries. In this dynamic model of the real exchange rate both real and nominal determinants of real exchange rate misalignment are studied, with emphasis on macroeconomic policy and nominal devaluation, along with other explanatory variables suggested by the theory. The findings are generally consistent with the predictions of the model. They suggest that nominal devaluation plays a major role in determining real exchange rate behaviour, whereas an improvement in external terms of trade seems to have no long run effect on the trade-weighted real exchange rate. Net capital inflow, foreign aid, trade restrictions and expansionary macroeconomic policies tend to cause the real exchange rate of Papua New Guinea to appreciate.

Introduction

The role of the real exchange rate in the economic performance of both developed and developing economies has been one of the major issues of macroeconomic policy debate in recent years. There is growing agreement among economists and policymakers that while stability in the real exchange rate (RER) promotes economic expansion and improved welfare, misaligned real exchange rate hinders export growth and generates macroeconomic instability. In spite of the crucial role of real exchange rate in policy discussion, empirical analyses of the factors behind the behaviour of the real exchange rate in developing countries are sparse. In particular, there have been very limited attempts to distinguish formally between equilibrium real exchange rate (ERER) and the deviation or misalignment of RER from its equilibrium level.

Like other relative prices, real exchange rate—the price ratio of tradable to nontradable goods— is affected by real and nominal disturbances, which may be either long lasting or transient. The real exchange rate reacts to a series of real and nominal disturbances, including international terms of trade shocks, government expenditure patterns, trade restrictions, net capital inflow, foreign aid flow and technological progress, as well as to expansionary macroeconomic policies and nominal devaluation.

The objective of this paper is to present a dynamic model of RER determination and empirically test the implications of changes in possible determinants of the real exchange rate for the economy of Papua New Guinea (PNG). In this analysis, particular emphasis will be placed on the major real and nominal variables in determining RER behaviour both in the short and long run.

Theoretical Framework

The basic theoretical framework used in this study has been adopted from Edwards' (1989) model of real exchange rate determination. The model captures most of the stylised features of a small open developing economy, including the existence of exchange and trade controls. This model allows only the 'fundamentals' or real variables to play a role in determining the long run equilibrium real exchange rate, whereas both real and nominal factors influence the actual real exchange rate in the short run.

The model assumes a small, open economy, which produces and consumes two goods - tradables and nontradables. Importables and exportables are aggregated into one tradable category. The government sector consumes both tradables and nontradables and finances its expenditures by non-distortionary taxes and domestic credit creation. The country holds both domestic money and foreign money. At a later stage of the study it is assumed that there are no capital controls, and that there are some capital flows in and out of the country. The nominal exchange rate of the economy is fixed with a basket of currencies of its major trading partners. It is also assumed that there is a tariff on imports. The price of tradables in terms of foreign currency is fixed and equal to unity, that is, $P_T = 1$. Finally, perfect foresight is assumed in this model.

The model is represented by the following equations

Portfolio Decisions

$$A = M + FM \quad (1)$$

$$a = m + fm \text{ where } a = A/E,\ m = M/E,\ fm = FM/E \quad (2)$$

$$\dot{F}M \neq 0 \quad (3)$$

Demand Side

$$e = E^*P_T/P_{NT} \quad (4)$$

$$C_T = C_T(e, a); \qquad \delta C_T/\delta e < 0;\ \delta C_T/\delta a > 0 \quad (5)$$

$$C_{NT} = C_{NT}(e, a); \qquad \delta C_{NT}/\delta e > 0;\ \delta C_{NT}/\delta a > 0 \quad (6)$$

Supply Side

$$S_T = S_T(e); \qquad \delta S_T/\delta e > 0 \quad (7)$$

$$S_{NT} = S_{NT}(e); \qquad \delta S_{NT}/\delta e < 0 \quad (8)$$

Government Sector

$$G = P_{NT}G_{NT} + E^*G_T \quad (9)$$

$$g = g_T + g_{NT;} \text{ where } g = G/E;\ g_T = G_T;\ g_{NT} = P_{NT}G_{NT}/E = G_{NT}/e \quad (9')$$

$$E^*G_T/G = \lambda \quad (10)$$

$$G = t + DC \quad (11)$$

External Sector

$$CA = S_T(e) - C_T(e, a) - G_T \quad (12)$$

$$KA = f(i - i_f) \quad (13)$$

$$\dot{R} = CA + KA \quad (14)$$

$$\dot{M} = \dot{D}C + \dot{E}R \quad (15)$$

Equation 1 defines the total assets, A, as the sum of domestic money M and foreign money, FM. Equation 2 defines real assets (a) in terms of tradables, where E is the nominal effective exchange rate (foreign currency value in terms of domestic currency). Domestic money (m) and foreign money (fm) are also defined in terms of the nominal exchange rate in this equation. Equation 3 shows there is international capital mobility, therefore, $FM \neq 0$.

The demand side of the economy is given by Equations 4 to 6. The real exchange rate, e, is defined as the ratio of foreign price in terms of domestic currency to the price of domestic nontradables in Equation 4. Demand for tradables and nontradables is determined by the real exchange rate and the level of real assets. Demand for both tradables and nontradables is positively affected by the asset level whereas real depreciation reduces the domestic demand for tradables and increases the demand for nontradables, which is shown in Equations 5 and 6.

Equations 7 and 8 summarise the supply side of the economy. The supply of tradables and nontradables is solely determined by the real exchange rate. An appreciation of the real exchange rate reduces the supply of tradables and increases the supply of nontradables. To keep the model simple the tax function is not included (Equations 5–8) in the demand function and the tariff function is not included in the demand for importables.

Equations 9 to 11 summarise the government sector, where G_{NT} and G_T are government consumption of nontradables and tradables, respectively. Equation 9´ is the real government consumption of tradables and nontradables in terms of tradable. Equation 10 defines the share of government consumption of tradables to the total government expenditure as λ, which is equal to (g_T/g) in real terms. Equation 11 represents the government budget constraint where government consumption is financed by taxes (t) and domestic credit creation (DC).

The external sector is represented by Equations 12 to 15. Equation 12 defines the current account as the difference between the output of tradables and both private and public consumption of tradables expressed in foreign currency. Equation 13 indicates that there is inflow and outflow of capital. The capital account is defined as a function of interest rate differentials between domestic and foreign economies. Equation 14 defines the change in stock of international reserves. Finally the model is closed with Equation 15 which shows that the change in domestic money ($\dot{m}$) is determined by changes in domestic credit creation and changes in international reserves.

Long run equilibrium is attained when the nontradable goods market and external sector are simultaneously in equilibrium, which implies that the current account is equal to the capital account in the long run. However, in the short and medium run, there can be departures from CA = KA, which will result in the accumulation and decumulation of international reserves. Therefore, the long run steady state is attained under four scenarios, which can be summarised as follows

(1) there is internal equilibrium or equilibrium in the nontradable sector

(2) there is external equilibrium so that $\dot{R} = 0 = CA = KA = \dot{m}$

(3) the government runs a balanced budget such that $G = t$ and $\dot{DC} = 0$, that is, fiscal policy is sustainable; and

(4) portfolio equilibrium holds.

The real exchange rate attained under these steady-state conditions is known as the long run equilibrium real exchange rate, ERER, that is,

$$ERER = e^* = E^*P_T/P_{NT} \qquad (16)$$

The nontrable market clears when

$$C_{NT}(e, a) + g_{NT}(e) = S_{NT}(e) \qquad (17)$$

The real government consumption of nontradables in terms of tradables has been defined as g_{NT}. Thus, the P_{NT} can be expressed as a function of a, g_{NT}, P_T and τ (trade restrictions).

$$P_{NT} = n\,(a, g_{NT}, P_T, \tau) \qquad (18)$$

where, $\delta n/\delta a>0$; $\delta n/\delta g_{NT}>0$; $\delta n/\delta P_T>0$, $\delta n/\delta \tau>0$

Equilibrium in the external sector requires that $\dot{m} = 0$. The following equation of $\dot{m}$ can be derived from earlier equations as:

$$\dot{m} = \{S_T\,(e) - C_T\,(e, a)\} - KA + g_{NT} - t/E \qquad (19)$$

When government expenditures are fully financed with taxes, the $\dot{R} = 0$ will coincide with the $\dot{m} = 0$.

From Equations 18 and 19 it is possible to find an equilibrium relation between e, a, gNT and τ.

$$ERER = e^* = x\,(a, g_{NT}, P_T \text{ and } \tau\,) \qquad (20)$$

where, $\delta x/\delta a<0$; $\delta x/\delta g_{NT}<0$; $\delta x/\delta P_T>0$; $\delta x/\delta \tau<0$

An increase in domestic money, m, in terms of foreign currency, results in higher real wealth and a current account deficit. To restore equilibrium real wealth, the price of nontradables will rise (Equation 18). Thus, an increase in real assets increases the price of nontradables and causes the An increase in, domestic money, m, in terms of foreign currency, results in higher real wealth and a current account deficit. To restore equilibrium real wealth, the price of nontradables will rise (Equation 18). Thus, an increase in real assets increases the price of nontradables and causes the RER to appreciate in order to maintain long run equilibrium. Increases in government expenditure on nontradables (g_{NT}) have the same effects on the ERER. A rise in the price of tradables generally causes the RER to depreciate, given that the price of nontradables and the nominal exchange rate remain constant. However, if the increase in the P_T increases export earnings, and is spent in the nontradable sector, the demand for and price of nontradables increase more than the P_T causing a RER appreciation. The total effect of an import tariff depends on the initial expenditure on domestic nontradables and importables. An increase in the tariff on importables worsens the current account by increasing import bills, lowers the demand for tradables, raises the demand and price for nontradables and tends lead to an appreciation of the long run real exchange rate. But if an increase in tariff worsens the current account balance without any substitution effects, it will increase the composite P_T alone and may depreciate the real exchange rate. It is therefore, possible to observe, simultaneously, a real depreciation and a worsening of the current account. So the increase in the P_T and changes in trade policies can have either positive or negative impacts on the RER.

Equation 20 stipulates that the long run equilibrium RER is a function of real variables only. The value of real assets, government consumption, price of tradables and trade restrictions in this equation are normally influenced by changes in other real variables such as terms of trade (TOT) shocks, changes in government expenditure, technological progress, and changes in trade and capital restrictions. Changes in these real variables can cause the actual RER to deviate from its equilibrium level. However, changes in nominal variables, such as domestic credit expansion, and changes in the values of the nominal exchange rate, also affect the path of the actual RER in the short run. The impacts of real and monetary disturbances on the RER, both in the short and long run, are discussed in the next sub-section.

Real disturbances and misalignment of real exchange rate

Changes in the long run sustainable values of real variables have important effects on the ERER and can cause it to deviate from its equilibrium level. This is commonly known as *structural misalignment* of the real exchange rate. In fact, the movement of the ERER from its sustainable long run position has significant consequences for policy evaluation as it can imply either gain or loss of external competitiveness. According to the purchasing power parity version of the real exchange rate, this movement of ERER is considered a disequilibrium situation. According to recent developments in the theory of the real exchange rate, however, this movement of ERER does not necessarily reflect a disequilibrium. Since the change in ERER is induced by changes in fundamentals it can represent a new long run equilibrium for the real exchange rate (Edwards 1988). This section attempts to analyse the ways in which the ERER reacts to a number of real disturbances.

Real exchange rate fundamentals are often categorised as external and domestic fundamentals. Domestic fundamentals can be divided into policy-related and non-policy-related fundamentals. The most important external fundamentals, which affect the RER in the long run, include international terms of trade and international transfers, including foreign aid and world real interest rates. Included among policy-related domestic fundamentals are import restrictions, export taxes or subsidies, exchange and capital controls, and government consumption expenditure. Technological progress and productivity improvement are the two most important domestic non-policy fundamentals. The role of these fundamental factors is discussed below.

Terms of trade disturbance. International terms of trade (TOT) is one of the most important external real exchange rate fundamentals and is often included as one of the major determinants of RER in the literature since foreign price shocks have accounted for large fluctuations in RERs of both developed and developing countries. The overall effects of TOT on the real exchange rate are ambiguous. The price of tradables is a weighted average of the price of exportables and importables. TOT may have two different effects on the real exchange rate, namely, income and substitution effects. The income effect results when an increase in export prices, or a fall in import prices, raises the income of an economy and increases the demand for nontradables. This, in turn, tends to reduce the relative price of tradables to nontradables and causes the RER to appreciate. On the other hand, the substitution effect can be observed, because nontradables are relatively cheap. An improvement in TOT due to an export price increase brings about a RER depreciation for given levels of nominal exchange rate and nontradable prices. However, if the improvement in TOT is brought about by a fall in the price of imports alone, then the improvement in the current account balance would increase income and the aggregate price of nontradables and cause an appreciation of the RER. The income effect would be more prominent in this case. Because of the ambiguity about the final effects of a TOT shock on the RER, the price of importables and exportables should be regarded as two separate variables in determining real exchange rate behaviour.

Government expenditure. Government expenditure is another fundamental real variable which can cause the real exchange rate to deviate from its equilibrium value. Increases in government expenditure increase the demand for nontradables if the major portion is spent on nontradable goods and services. In the short run this excess demand for nontradables bids up their price and results in RER appreciation. However, there will be depreciation of the RER if the larger share of government expenditure is spent on the tradable sector rather than on consumption of nontradables. Thus, the sign of this variable can be either positive or negative in determining behaviour of the equilibrium real exchange rate.

Trade restrictions. Trade restriction in the form of tariffs generally cause a RER appreciation. If the tariff worsens the current account position and increases the demand for and price of nontradables, the RER appreciates. An increase in binding quantitative trade restriction (import quota) also increases the demand for import substitutes, which behave as nontradables due to imposition of quantitative trade restrictions during boom period (Warr 1986). This results in higher prices and profitability for nontradables and leads to a long run equilibrium real appreciation. In these cases, the increase in the price of nontradables due to trade restrictions is higher than the increase in the composite price of tradables. However, if trade restrictions lead to a worsening of the current account deficit and reduce the demand for nontradables, there will be a RER depreciation. In this case the negative income effect will outweigh the positive substitution effect.

Exchange and capital controls. Relaxation of capital controls may affect the movement of the RER in either way. If liberalisation of capital controls increases net capital inflow, it leads to an expansion in the monetary base. This raises current expenditure over income and increases the demand for nontradables, resulting in an appreciation of the equilibrium RER. A fall in world real interest rates or a rise in international transfers, such as foreign aid flows, also affects the equilibrium RER in a similar way to net capital inflow. If the major share of foreign aid is spent on nontradables, the price of tradables will be pushed down, relative to nontradables, which tends to appreciate the RER.

Technological and productivity improvement. The non-policy domestic fundamental variable, namely, technological advancement (growth rate of real GDP), generally increases the efficiency and productivity of the tradable sector. Increased productivity induced by technological progress increases factor availability. By reducing the cost and price of tradables, increased productivity makes the tradable sector more competitive and tends to depreciate the RER of the sector. In this situation, supply effects of technological progress offset the demand effects according to the Rybczynski principle (Edwards 1989:48). If the advancement in technology increases income, however, which, in turn, increases demand for nontradables and reduces the relative price of tradables to nontradables, there will be a real appreciation. In this case, the demand effects of technological progress are greater than the supply effects and this is known as the Ricardo-Balassa effect (Edwards 1989:136).

Nominal determinants and real exchange rate misalignment

The real exchange rate often departs from its equilibrium values under the influence of macroeconomic pressures, which is commonly known as macroeconomic policy induced misalignment of the real exchange rate. The effects of macroeconomic policies and changes in the nominal exchange rate on the real exchange rate will now be discussed.

Domestic money supply. In order to maintain a sustainable macroeconomic equilibrium in an open economy, fiscal and monetary policies must be consistent with the exchange rate regime. Misalignment of the real exchange rate occurs due to inconsistencies between macroeconomic policies and the official exchange rate policy. Under a fixed exchange rate regime, expansionary monetary or fiscal policy raises the real stock of money, increasing demand for both tradable and nontradable goods and financial assets. The excess demand for tradable goods results in a higher trade deficit and loss of international reserves, whereas the increased demand for nontradables raises their price and tends to cause the actual RER to deviate further from its equilibrium value. The over-valuation of the RER, which is a fall in the actual real exchange rate from its long run equilibrium, will be short-lived and the economy adjusts through reduction of the money stock. The higher demand for nontradables, induced by the higher stock of money, would require a higher (actual) RER to re-establish equilibrium in the nontradables market. The stock of international reserves will fall by the decline (increase?) of the real domestic money supply. The actual RER will continuously depreciate through reductions in the price of nontradable goods and revert towards the long run sustainable equilibrium RER position in the long run. The time involved in the readjustment of a misaligned RER to its long run equilibrium depends on the original stock of money as well as a number of other variables.

Nominal exchange rate. Adjustment of the nominal exchange rate (devaluation/revaluation) could be one possible strategy to speed up this readjustment. In the case of an over-valued real exchange rate, a nominal devaluation reduces the stock of money since m=M/E and thus reduces the real value of financial assets. This induces expenditure reducing effects, by reducing expenditures on both tradable and nontradable goods. A nominal devaluation also induces expenditure switching effects by switching expenditure from tradables. It tends to increase the production of tradables, since, given the price of tradables, the exportable sector is more competitive following a devaluation. This causes the RER to depreciate resulting in an expansion of the export sector. Expenditure switching effects tend to increase the demand for nontradables but expenditure reducing effects may reduce their price. Therefore, following a nominal devaluation, the demand for nontradables increases and the price falls to re-establish equilibrium in the nontradable market, and this induces a real depreciation.

Following a nominal devaluation a number of policies can lead to an increase in the price of nontradables, most obviously expansionary monetary and/or fiscal policy and wage indexation policy. However, if a nominal devaluation is accompanied by restrained fiscal and monetary policies in the absence of wage indexation, the nominal devaluation will probably succeed in generating a real devaluation and achieving competitiveness in the tradable sectors. Simultaneous imposition of an import tariff and an export subsidy can affect the RER in the same way as devaluation. While export subsidies increase demand for exportables, a tariff increases the price of importables, so that the composite price of tradables as a group will increase in this situation. The relative price of exportables and importables will not be affected as long as the rate of tariff and subsidy is the same, but the price of tradables (as a composite measure of exportables and importables) will rise relative to nontradables as in the case of devaluation. However, while devaluation does not directly affect fiscal policy, a tariff with subsidy policy has a direct impact on the government budget. Furthermore, while a tariff with subsidy policy only affects the domestic price of tradable goods and services, devaluation affects the domestic price of both tradable goods and tradable assets. Accordingly, while the expectation of further devaluation may affect the domestic interest rate, the tariff with subsidy policy does not have any direct effect on the domestic interest rate (Edwards 1988:31).

Empirical model

The purpose of this section is to analyse empirically the relative importance of real and nominal variables in explaining the real exchange rate movements in PNG. In an attempt to estimate the dynamics of the real exchange rate, it is necessary to specify an empirical equation for the equilibrium real exchange rate e_t^*. Based on the theoretical model developed earlier, the equilibrium real exchange rate is exclusively determined by the following real variables

- international terms of trade
- government expenditure
- trade restrictions
- exchange and capital controls, and
- technological progress and productivity gain.

Incorporating the above-mentioned ‘fundamentals’, a model of equilibrium real exchange rate was formulated in the following equation.

$$\log e_t^* = \beta_0 + \beta_1 \log(TOT)_t + \beta_2 \log(GEX)_t + \beta_3 (NKI)_{t-1} + \beta_4 \log(AID)_{t-1} + \beta_5 \log(OP)_t + \beta_6 \log(TECP)_t + u_t \quad (21)$$

The following notations have been used in the above model

e*:	equilibrium real exchange rate
TOT:	barter terms of trade, defined as Px*/Pm*
GEX:	share of government expenditure to GDP
NKI:	net capital inflow (proxied for capital control)
AID:	foreign aid and grant
OP = (X+M)/Y:	trade restrictions substituted by the openness of an economy[1]
TECP:	measure of technological progress
u_t:	error term

The actual RER is a function of both real and nominal variables. Three major factors determine the dynamics of the actual RER and are specified by the following equation

$$\log e_t = \alpha \{\log e_t^*\} - \lambda \{MP_t\} + \gamma \{\log E_t - \log E_{t-1}\} \quad (22)$$

where, e is the actual real exchange rate, and e* is the equilibrium RER, which is a function of real variables as specified in Equation 21. The second determinant of the actual RER in Equation

22 is MP_t, which states that if macro policies are unsustainable in the long run under a fixed rate, there is a tendency for the RER to appreciate. A large λ represents a large over-valuation of the actual RER from its long run equilibrium value. Finally, RER movements are affected by the changes in the nominal exchange rate ($\log E_t - \log E_{t-1}$). A nominal devaluation has a short run positive impact on an over-valued RER in restoring a misaligned real exchange rate towards its equilibrium value. The actual magnitude of a short run depreciation of the RER depends on the parameter γ. The long and medium-run effects of changes in the nominal exchange rate would depend on the initial condition of the equilibrium real exchange rate, $\log e_t^*$, and on the accompanying macroeconomic policies of credit creation. The parameters α, λ, γ are positive and capture the most important dynamic aspects of the adjustment process.

The term, MP_t, in Equation 22 indicates the role of macroeconomic policies in determining real exchange rate behaviour. If macro policies are unsustainable in an expansionary direction, the real exchange rate would tend to appreciate, given that the other variables remain constant. To capture the impacts of macro policies, macroeconomic policy behaviour is proxied in two ways. Firstly, by the excess supply of domestic credit, measured as the rate of growth of domestic credit minus the rate of growth of real GDP.

$$EXMS = [\Delta \log \text{domestic credit} - \Delta \log GDP_t]$$

Second, the rate of growth of domestic credit is used to measure the macroeconomic policy impacts on real exchange rate movements.

By successive substitution for $\log e_t^*$, the macroeconomic policy variable by excess supply of domestic credit, the rate of growth of domestic credit and the change in nominal devaluation by NDEV in Equation 22, the following estimable equation for the actual RER is given by

$$\log e_t = \theta_1 \log (TOT)_t + \theta_2 \log (GEX)_t + \theta_3 (NKI)_{t-1} + \theta_4 \log(AID)_t + \theta_5 \log (OP)_t + \theta_6 (DTR)_t + \theta_7 \log (TECP)_t - \lambda_1 EXMS_t - \lambda_2 DCR_t + \gamma NDEV_t + u_t \quad (23)$$

where θs are the combination of αs and βs.

This model incorporates the real and nominal factors affecting the observed RER both in the short and long run. The ‘fundamentals’ or the real variables affect the equilibrium RER in the long run, whereas the nominal variables impact on the RER only in the short run. An improvement in the TOT can result in either real depreciation or real appreciation, and so is similar to the outcome of an increase in government spending. Relaxation of exchange and capital controls tends to increase capital inflow given the political and economic stability of a country. It will appreciation of the RER if the major share of this capital flow is spent on the domestic nontradable market, thus reducing the price of tradables relative to nontradables. Increased openness in international trade policy tends to cause depreciation of the RER if it worsens the current account by increasing the demand for imports and reducing the demand for and price of nontradables. Moreover, if openness in the trade regime brings more competition in the tradable sector by reducing the domestic price of tradables in line with the world price level, a real depreciation will occur. Outwardness in international trade policies may appreciate the RER, however, if it improves the trade account by reducing import bills and increasing the demand for and price of nontradables.

Since a resources boom can be reflected by an increase in the TOT, government expenditure or capital inflow, a positive change in any of these 'fundamentals' under the most plausible conditions will reduce the price of tradables relative to nontradables, and tend to cause appreciation of the RER, as postulated by the discussion in the theoretical section. A more restrictive trade regime (quantitative restrictions) would worsen the situation by increasing demand for, and price of, semi-traded and import substitutes, since they behave as nontradables and their prices are determined by domestic demand and supply conditions during the boom years.

The model predicts that an expansionary macro policy associated with domestic money creation would widen the current account deficit, deplete international reserves, and cause a RER appreciation. Thus, a restrictive wage and income policy can slow appreciation of the RER by reducing demand for and price of nontradables. A change in the nominal exchange rate can help restore the misaligned real exchange rate to its equilibrium value. A nominal devaluation helps to prevent erosion of competitiveness in the export sector by reducing the foreign currency price of exports in the world market. The effectiveness of a change in the nominal exchange rate in correcting a misaligned real exchange rate would be greater and longer lasting if it were accompanied by appropriate macroeconomic policies. These two assumptions of nominal determinants of the real exchange rate portray most of the stylised features of the macroeconomic policy options available for a small open developing economy, such as PNG, to correct a misalignment of the RER.

Variable definition and measurement

The real exchange rate model in Equation 23 is estimated over the sample period 1970-1994 using annual data. In this section, data sources are listed and both the chosen method of data transformation, and its key limitations, are discussed. All variables, except net capital inflow, are measured in natural logarithms.

The real exchange rate series have constructed from the available secondary data sources in the absence of ready-made data for the key dependent variable. The explanatory variables are extracted from a variety of sources including The World Bank *World Tables*, IMF *International Financial Statistics*, Bank of PNG *Quarterly Economic Bulletin* and from National Centre for Development Studies International Economic Data Bank.

Before estimating Equation 23, a number of issues relating to data availability should be mentioned. One of the major obstacles faced was the non-availability of annual data for most of the real exchange rate fundamentals. External TOT is the only real variable for which data are readily available. Therefore, some proxies had to be constructed to estimate the real exchange rate equation (Equation 23). Government expenditure is included in the model as a ratio of GDP (GEX). It is possible for this ratio to increase with a reduction in government consumption on nontradables. Thus, the actual sign of GEX can be either positive or negative depending on its share in the nontradable or tradable sector.

Exchange and capital mobility is represented by the lagged long-term net capital inflow (NKI). Net capital inflow is defined in the World Bank *World Tables* as 'residents' long-term foreign liabilities less long-term assets'. Changes in capital control affect the flow of capital and any relaxation of capital controls will, in principle, increase the inflow of capital. This, in turn, increases international reserves and would be expected to appreciate the RER. For PNG, as for most developing countries, capital inflow is induced by a resources boom, direct foreign investment or international grants and aid flows. Therefore, foreign aid flows have been included as a separate variable in the empirical model (Equations 27.1, 27.2, and 27.3). Foreign aid usually increases the expenditure on nontradable sector and is expected to lead to appreciation of the RER.

It is difficult to find a good proxy for trade policy due to the non-availability of consistent and longer period data on tariff rates or tariff revenues as a proportion of imports. The standard practice in the literature is to proxy exchange and trade controls by the degree of openness of the economy. This is given by the expression [(X+M)/Y] and used is as an indicator of trade policy restrictions such as tariffs and quotas. It should not be overlooked that a less restrictive trade regime is only one of the major factors of openness, as international trade is also determined by other factors affecting imports and exports, including the RER itself (Cottani *et al*. 1990). For example, an increase in import quotas reduces openness and is usually expected to lead to an appreciation of the RER, whereas more openness in the trade regime tends to depreciate the RER by reducing the price of tradables relative to nontradables. A dummy variable has also been included to capture the effects of broad trade policy responses. This dummy variable, DTR, takes a value of 1 for years 1983-94, a period of increased trade restrictions, and 0 for 1970-82 when PNG had virtually no restrictions in its trade regime.

Technological progress (TECP) has been used as an explanatory variable to capture the Ricardo-Balassa effect on the equilibrium RER and is proxied by the rate of growth of real GDP[2] . According to this hypothesis, productivity improvement in rapidly growing economies tends to be concentrated in the tradable sector and usually accounts for an appreciation of the RER through increasing the income and price of nontradables (Balassa 1964).

Regarding the dependent variable, the trade-weighted real exchange rate (RER1) and real exchange rates for the export sector (RER2) and import competing sector (RER3) are used as alternative measures and have been constructed from the available secondary data.

Econometric procedure

The conventional approach to time-series econometrics is based on the implicit assumption of stationarity of time-series data. A recent development in time-series econometrics has cast serious doubt on the conventional time-series assumptions. There is substantial evidence in the recent literature to suggest that many macroeconomic time-series may possess unit roots, that is, they are non-stationary processes. A time-series integrated of order zero, I(0), series is stationary in levels, while a time-series integrated of order one, I(1), is stationary in first differences. Most commonly, series are found to be integrated of order one, or I(1). The implication of some systematic movements of integrated variables in the estimation process may yield spurious results. In the case of a small sample study, the risk of spurious regression is extremely high. In the presence of I(1) or higher order integrated variables, the conventional t-test of the regression coefficients generated by conventional OLS procedure is highly misleading (Granger and Newbold 1977).

Resolving these problems requires transforming an integrated series into a stationary series by successive differencing of the series depending on the order of integration (Box and Jenkins 1970). However, Sargan (1964), Hendry and Mizon (1978) and Davidson *et al*. (1978) have argued that the differencing process loses valuable long run information in data, especially in the specification of dynamic models. If some, or all, of the variables of a model are of the same order of integration, following the Engle-Granger theorem, the series are cointegrated and the appropriate procedure to estimate the model will be an error correction specification. Hendry (1986) supported this view, arguing that error correction formulation minimises the possibilities of spurious relationships being estimated as it retains level information in a non-integrated form (Hendry 1986:203). Davidson *et al*. (1978) proposed a general autoregressive distributed lag model with a lagged dependent variable, which is known as the 'error-correction' term. Hendry *et al*. (1985) also advocated the process of adding lagged dependent and independent variables up to the point where residual whiteness is ensured in a dynamic specification. Therefore, error correction models avoid the spurious regression relationships.

Mindful of these considerations, the estimation process begins by testing the time-series properties of the data series. Many test procedures are available for testing non-stationarity in a time-series. In this study, the Dickey-Fuller procedure is used with Augmented Dickey-Fuller test statistics to test the null hypothesis of a unit root against the alternative of stationarity of data series. The results from these tests suggest that all the variables used in this model do not have the same order of integration. The key dependent variable (RER) and some of the explanatory variables are found to be stationary. The test results are reported in the Appendix Table A1.

To guard against the possibility of estimating spurious relationships in the presence of some nonstationary variables, estimation is performed using a general-to-specific Hendry-type error correction modelling (ECM) procedure. This procedure begins with an over-parameterised autoregressive distributed lag (ADL) specification of an appropriate lag. The consideration of the available degrees of freedom and type of data determine the decision on lag length. With annual data, one or two lags would be long enough, while with quarterly data a maximum lag of four can be taken. Under this ECM procedure, the long run relationship is embedded within the dynamic specification. Therefore, the general model of real exchange rate can be specified as follows

$$Y_t = \alpha_0 + \Sigma\, \alpha_i Y_{t-I} + \Sigma\, \beta_i X_{t-I} + u_t \qquad (24)$$

where α_0 is a vector of constants, Y_t is a (n x 1) vector of endogenous variables, X_t is a (k x 1) vector of explanatory variables, and α_i and β_i are (n x n) and (n x k) matrices of parameters. As annual data are used for the model, a one period lag is assumed. When the lag length is one, the general model can be written as

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \beta_1 X_t + \beta_2 X_{t-1} + u_t \qquad (25)$$

Now we can consider the error correction version of the model can be considered as

$$\Delta Y_t = \alpha_0 - (1-\alpha_1)\, Y_{t-1} + \beta_1 \Delta X_t + (\beta_1 + \beta_2)\, X_{t-1} + u_t \qquad (26)$$

The above equation can be reparameterised in terms of differences and lagged levels so as to separate the short run and long run multipliers of the system

$$\Delta Y_t = \beta_1 \Delta X_t - (1-\alpha_1) [Y_{t-1} - \gamma_1 - \gamma_2 X_{t-1}] + u_t \qquad (27)$$

where the new parameters

$$\gamma_1 = \alpha_0 / -(1-\alpha_1)$$

$$\gamma_2 = \beta_1 + \beta_2 / -(1-\alpha_1)$$

In Equation 27, short run relationships are captured by the coefficients on differenced variables, while long run relationships are captured by the coefficients on lagged level variables, namely by γ_1 and γ_2.

The error correction specification for the different versions of the real exchange rate model can be represented by the following equations with a one period lag as annual data has been used for the model estimation

$$\Delta RER1 = f(\Delta TOT, \Delta GEX, \Delta NKI, \Delta OP, \Delta AID, \Delta EXMS, \Delta NDEV, TOT_{t-1}, GEX_{t-1}, NKI_{t-1}, OP_{t-1}, AID_{t-1}, EXMS_{t-1}, NDEV_{t-1}, DTR, RER1_{t-1}) \qquad (27.1)$$

$$\Delta RER2 = f(\Delta TOT, \Delta GEX, \Delta NKI, \Delta OP, \Delta AID, \Delta EXMS, \Delta NDEV, TOT_{t-1}, GEX_{t-1}, NKI_{t-1}, OP_{t-1}, AID_{t-1}, EXMS_{t-1}, NDEV_{t-1}, DTR, RER2_{t-1}) \qquad (27.2)$$

$$\Delta RER3 = f(\Delta TOT, \Delta GEX, \Delta NKI, \Delta OP, \Delta AID, \Delta EXMS, \Delta NDEV, TOT_{t-1}, GEX_{t-1}, NKI_{t-1}, OP_{t-1}, AID_{t-1}, EXMS_{t-1}, NDEV_{t-1}, DTR, RER3_{t-1}) \qquad (27.3)$$

The following notations have been used in these above equations

Dependent variables

RER1 = Trade-weighted real exchange rate; RER2 = RER for export sector (Export Price Index/Price of nontradables); RER3 = RER for importable sector (Import Price Index/Price of nontradables).

Independent variables

TOT = international terms of trade (1990 =100); GEX = government expenditure to GDP; NKI = net capital inflow; OP = (X+M)/Y: index of trade restrictions substituted by the openness of an economy; AID = flow of foreign aid and grant; EXMS = excess supply of domestic money supply; NDEV = nominal devaluation; DTR = a dummy variable which takes 0 for the years 1970-82 of an open trade regime and 1 for years 1983-94 with increased trade restrictions. All variables, except NKI, which takes negative values in some years, are measured in natural logarithms. NKI is in terms of millions of kina.

The above equations are 'tested down' using OLS by dropping statistically insignificant differenced and lagged terms. The testing procedure continues until a parsimonious error correction representation is obtained which retains the *a priori* theoretical model as its long run solution. The selection of final equations is made after careful diagnostic tests on the OLS error process.

Results

The estimates of parsimonious dynamic Error Correction Models are reported in Table 1 together with the most common diagnostic tests. The long run elasticities relating to the key explanatory variables and their t-ratios are reported in Table 2. While the long run elasticities are derived from the short run estimated equations, their respective standard errors are derived by using Kmenta's (1986) formula[3] .

The results are satisfactory and indicate that all equations perform well by all diagnostic tests. The adjusted $\bar{R}^2$ are quite high and suggest the models have a fairly good fit. The equations are also statistically significant in terms of the standard F-test. The lagged error correction terms for the real exchange rate equations (Equations 27.1, 27.2, 27.3) are statistically significant at the 5 per cent level and have the expected negative signs. The computed values for the Jarque-Bera tests for normality of the residuals are much smaller than the critical values at a one per cent significance level, indicating normality of the residual errors. The computed values for Lagrange multiplier tests of residual serial correlation are also smaller than the critical values and indicate no serial correlation among the residuals in the real exchange rate models. The residual correlograms of up to six years are estimated for each equation, with no evidence of significant serial correlation in the error terms. The equations also comfortably passed the CUSUM tests on recursive residuals and the CUSUM tests on backward recursive residuals. The ARCH-c^2 tests for error variance show that the computed values of ARCH-c^2 are smaller than the tabulated values ARCH-c^2 at a one per cent significance level. Thus, the results suggest the error variances are not correlated in Equations 27.1, 27.2, 27.3.

The equations also passed the specification choice in terms of joint variable deletion tests against the maintained hypothesis of the theory of the real exchange rate. Ramsey's RESET tests for specification error indicate that the calculated F values are much smaller than the critical values at a one per cent significance level. Hence, the computed RESET-F values for the equations are not significant, indicating the equations are not misspecified. The equations passed the Chow tests for parameter stability as the computed F-value of Chow-tests for the equations are smaller than the critical values at a one per cent significant level which indicates parameter stability for Equations 27.1, 27.2, and 27.3.

Equation 27.1 indicates that an improvement in external TOT does not have any significant long run impact on the trade-weighted real exchange rate. Although the coefficient indicates a positive sign in relation to RER, it is not statistically significant in either the short run or the long run at the conventional 5 per cent level.

The coefficient of the government expenditure variable (GEX) has the expected negative sign with respect to the trade-weighted real exchange rate in Equation 27.1 but does not have any significant short run or long run effect at the conventional 5 per cent level.

The net long-term capital inflow significantly affects the trade-weighted real exchange rate. The sign of the coefficient is negative as expected in the theoretical model. A one per cent increase in capital inflow causes the RER to appreciate by 0.35 per cent in the long run.

Table 1: Determinants of real exchange rates in Papua New Guinea, 1970-94

Trade-weighted real exchange rate (Equation 27.1)

$$\Delta RER1 = 3.28 + \underset{(3.57)}{0.61}\,\Delta NDEV + \underset{(1.56)}{0.10}\,TOT_{t-1} - \underset{(1.73)}{0.28}\,NKI_{t-1} - \underset{(1.85)}{0.23}\,AID_{t-1} - \underset{(1.12)}{0.01}GEX_{t-1}$$

$$- \underset{(1.68)}{0.03}\,EXMS_{t-1} - \underset{(1.92)}{0.06}\,DTR + \underset{(3.92)}{0.63}\,NDEV_{t-1} - \underset{(3.90)}{0.81}\,RER1_{t-1}$$

Adjusted R^2 = 0.82 F(8,14) = 13.5 JBN-$\chi^2(2)$ = 0.05 LM-$\chi^2(6)$ = 3.99

ARCH-$\chi^2(1)$ = 0.95 RESET(2)-F(1,13) = 0.32 CHOW-F(11,12) = 0.67

Real exchange rate for export sector (Equation 27.2)

$$\Delta RER2 = 2.63 + \underset{(4.57)}{0.66}\,\Delta TOT + \underset{(2.01)}{0.39}\,TOT_{t-1} - \underset{(2.11)}{0.27}\,AID_{t-1} - \underset{(1.88)}{0.09}\,EXMS_{t-1}$$

$$- \underset{(1.93)}{0.20}\,GEX_{t-1} - \underset{(2.12)}{0.15}\,DTR + \underset{(1.94)}{0.12}\,NDEV_{t-1} - \underset{(4.52)}{0.64}\,RER2_{t-1}$$

Adjusted R^2 = 0.80 F(8,14) = 15.6 JBN-$\chi^2(2)$ = 0.58 LM-$\chi^2(6)$ = 2.37

ARCH-$\chi^2(1)$ = 0.29 RESET(2)-F(1,13) = 0.65 CHOW-F(11,12) = 2.80

Real exchange rate for import competing sector (Equation 27.3)

$$\Delta RER3 = 3.53 - \underset{(2.93)}{0.30}\,\Delta TOT - \underset{(2.25)}{0.17}\,TOT_{t-1} - \underset{(2.08)}{0.09}\,DTR - \underset{(1.79)}{0.09}\,GEX_{t-1} - \underset{(2.12)}{0.12}\,EXMS_{t-1}$$

$$- \underset{(3.20)}{0.20}\,AID_{t-1} - \underset{(2.97)}{0.17}\,NDEV_{t-1} - \underset{(5.49)}{0.53}\,RER3_{t-1}$$

Adjusted R^2 = 0.72 F(7,15) = 9.06 JBN-$\chi^2(2)$ = 0.86 LM-$\chi^2(6)$ = 11.0

ARCH-$\chi^2(1)$ = 0.24 RESET(2)-F(1,14) = 1.74 CHOW-F(11,12) = 1.91

Notes:

1. Figures in parentheses are t-statistics.
2. The F statistic is against the null that all coefficients = 0. The Durbin Watson statistic for first order serial correlation is not reported for these models since it is strictly not valid in these models with lagged dependent variables.
3. LM is the Lagrange multiplier general test for residual serial correlation. ARCH is the test for Autoregressive Heteroscedasticity, RESET is the Ramsey's RESET test for functional mis-specification, and residual normality test for skewness and excess kurtosis is given by Jarque Bera Normality (JBN) test. Foreign aid and grant flows have the expected negative sign with respect to the RER in Equation 27.1 but do not have any significant long run effect at the 5 per cent significance level.

Trade restrictions, as measured by the dummy variable (DTR), have a significant negative effect on the trade-weighted real exchange rate. The dummy variable for trade restriction indicates that the introduction of restrictive trade policies from the mid-1980s appreciated the RER of PNG in the long run. Trade restrictions tend to have appreciated the RER of PNG by 0.08 per cent in the long run. Thus, the trade regime has an important bearing on the movement of the real exchange rate in PNG.

The role of macro policy, as proxied by the excess growth of money supply over the growth rate of real GDP (EXMS), is found to be significant in affecting the trade-weighted real exchange

TABLE 2 Estimates of long run elasticities of RERs in Papua New Guinea,1970-94

Dependent Variable	RER1	RER2	RER3
Independent Variables	(IV.4.1)	(IV.4.2)	(IV.4.3)
TOT	**0.12****	**0.61****	**-0.16****
	(1.45)	**(2.56)**	**(2.77)**
NKI	**-0.35****		
	(1.76)		
GEX	**-0.01**	**-0.3**	**-0.17**
	(0.12)	**(1.97)**	**(1.79)**
DTR	**-0.08****	**-0.23**	**-0.16****
	(2.20)	**(3.05)**	**(2.77)**
EXMS	**-0.05**	**-0.14**	**-0.22**
	(1.76)	**(1.96)**	**(2.17)**
AID	**0.28**	**-0.41****	**-0.37****
	(0.67)	**(2.03)**	**(2.75)**
NDEV	**0.77****	**0.18***	**-0.23***
	(2.45)	**(1.95)**	**(3.17)**

Notes: Figures in parentheses are t-statistics. ** denotes significant at 5 %, * denotes significant at 10 %.
Source: Long run multiplier values are computed from the long run steady state solutions to the estimated models reported in Table 4.3.

rate of PNG in Equation 27.1. A one per cent excess money supply over the growth of GDP appreciates the RER by 0.05 per cent in the long run. Unsustainable macroeconomic policy, in terms of excess money supply, raises the domestic price of nontradables and appreciates the RER of PNG, confirming the theoretical analysis of the real exchange rate.

The coefficient of the nominal exchange rate variable (NDEV) is statistically significant and positive, as expected by the theoretical model. The econometric results indicate that there is a close link between the two variables in PNG. A one per cent nominal devaluation causes the RER to depreciate by 0.61 per cent in the short run and 0.8 per cent in the long run.

Equations 27.2 and 27.3 indicate the major factors affecting the RER in PNG's export and import competing sectors. An improvement in the TOT significantly depreciates the RER for the export sector in the short run as well as in the long run as the price effect outweighs the income effect of the improved TOT. A one per cent increase in TOT depreciates the real exchange rate for the export sector by 0.66 per cent in the short run and 0.61 per cent in the long run. The change in TOT, however, has significant negative effects on the real exchange rate for the import-substitute sector in the short run as well as in the long run which indicates that the income effect is much greater than the price effect. A one per cent improvement in the TOT causes the real exchange rate of the import competing sector to appreciate by 0.3 per cent in the short run and 0.16 per cent in the long run. The coefficient of government expenditure has a significant negative impact on the real exchange rate for the export and import substitute sectors (RER2 and RER3) in the long run.

The impact of net capital inflow (NKI) is found to be insignificant with respect to the real exchange rate for the export and import competing sectors and was dropped from the final equations. However, it is found that foreign aid has a significant negative impact on the real exchange rate of PNG's export and import–competing sectors. A one per cent increase in foreign aid flows causes appreciation of the real exchange rate for exportable sector by 0.41 per cent and the real exchange rate for the import–competing sector by 0.37 per cent in the long run. As expected by the theoretical proposition that increased aid and grant flows are usually spent mostly in the nontradable sector, increases in the demand for, and prices of, nontradables generate the real appreciation in the economy.

Trade restrictions measured by the dummy variable, DTR, have significant negative impacts on the real exchange rate for the export and import–competing sectors' real exchange rates (RER2 and RER3). From the mid-1980s, trade protection for selected industries has caused the real exchange rate for the export sector to appreciate by 0.15 per cent in the short run and 0.23 per cent in the long run. The real exchange rate for import–competing industries has also appreciated by 0.09 per cent in the short run and 0.16 in the long run due to an increase in trade restrictions.

Nominal devaluation improved the competitiveness of the export sector by 0.18 per cent in the long run. But nominal devaluation seems to have a significant negative impact on the import-competing sector's real exchange rate in the long run. A one per cent devaluation of the nominal exchange rate causes appreciation of the real exchange rate of the import competing sector by 0.23 per cent in the long run by increasing the demand for, and price of, nontradables due to substitution effect.

Summary and Conclusion

The purpose of this study has been to examine the real exchange rate behaviour in PNG and evaluate whether the movements in the real exchange rate follow the theoretical expectations postulated by the theoretical framework of the study. The theory of real exchange rates states that, while the long run equilibrium value of the real exchange rate is determined by real variables, the actual or observed real exchange rate is influenced by both real and nominal variables in the short run. Movement of the equilibrium RER from its original position does not necessarily represent disequilibrium since the long run equilibrium is affected by the real variables. This paper has examined the extent to which real and nominal determinants can explain the behaviour of the real exchange rate in PNG.

The results suggest that a resources boom brought about by an improvement in the external TOT seems to have no long run effect on the trade-weighted RER in PNG, whereas increased net capital inflow and foreign aid flows cause the RER to appreciate. Increased trade restrictions from the early-1980s appear to have adversely affected the traded-goods sector through RER appreciation. It was found that the nominal variables also significantly affect the real exchange rate of the economy over the study period. In particular, expansionary fiscal policy results in an increased domestic price of nontradables and leads to an appreciation of the real exchange rate, whereas a nominal devaluation helped to re-establish the real exchange rate in the short run, as well as in the long run. Nominal devaluation has a significant positive impact on the trade-weighted real exchange rate and the real exchange rate for the export–competing sector in the long run, indicating that a nominal devaluation can be a powerful device to correct real exchange rate misalignment.

Notes

[1] This is admittedly a weak proxy because factor accumulation itself can increase GDP with little technical progress.

[2] As Kmenta (1986:486) writes 'The formula refers to the general case where an estimator, say α, is a function of k other estimators such $\beta_1, \beta_2, \ldots \beta_k$; that is

$$\alpha = f(\beta_1, \beta_2, \ldots \beta_k)$$

Then the large sample variance of α can be approximated as

$$Var(\alpha) = \sum[\delta f / \delta\beta k]^2 \, Var(\beta k) + 2 \sum[\delta f / \delta\beta j] \, [\delta f / \delta\beta k] \, Cov[\beta j, \beta k] \; (j, k = 1, 2 \ldots \ldots k) \; (j < k)$$

(The approximation is obtained by using Taylor's expansion for $f(\beta_1, \beta_2, \ldots \beta_k)$ around $\beta_1, \beta_2, \ldots \beta_k$ dropping terms of the order two or higher and then obtaining the variance by the usual formula)'.

TABLE A.1 Test for unit roots

Variables	Data series	DF/ADF Statistics Ho: I(1) versus Ha: I(0)
Real income (real GDP)	Y	-2.25 (1)
Trade-weighted real exchange rate	RER1	-4.25 (0)*
Real exchange rate defined as EPI/CPI	RER2	-3.31 (0)*
Real exchange rate defined as IPI/CPI	RER3	-2.27 (0)
Nominal effective exchange rate	NEER	-1.37 (0)
External terms of trade	TOT	-3.41 (0)*
Openness of trade regime	OP	-1.65 (0)
Money supply	MS	-2.09 (0)
Government expenditure to GDP	GEX	1.00 (0)
Gross investment to GDP	GIY	-4.45 (0)*
Lag net long term capital inflow	NKI	-2.64 (0)
Foreign aid flow	AID	-14.49 (0)*
Nominal devaluation	NDEV	-96.36 (0)*

Notes: The critical value of null hypothesis of nonstationarity at the 10 per cent level is -3.13 with total number of observation n = 23
The null hypothesis of rejecting that there is no serial correlation lies outside $1.54<d<2.46$
The null hypothesis of rejecting that there is no 1st order autocorrelation lies out side $-1.96<h<1.96$
A * indicates the rejection of null hypothesis. Figures in parentheses indicate the number of lags on the differenced variable used in the auxiliary regression to achieve residual whiteness.

References

Balassa, B., 1964. 'The purchasing power parity doctrine: a reappraisal', *Journal of Political Economy*, 72(6):584–96.

Bank of Papua New Guinea, *Quarterly Economic Bulletin*, Various Issues, Port Moresby.

Box, G.E.P. and G.M. Jenkins, 1970. *Time Series Analysis, Forecasting and Control*, Holden-Day, San Francisco.

Cottani, J.A., Domingo, F.C. and Khan, M.S., 1990. 'Real exchange rate behaviour and economic performance in LDCs', *Economic Development and Cultural Change*, 39(1):61-76.

Davidson, J., Hendry, D., Sbra , F., and Yeo, S., 1978. 'Econometric modelling of the aggregate time series relationship between consumers' expenditure and income in the United Kingdom', *Economic Journal*, 88(352):661-92.

Edwards, S., 1989. *Real Exchange Rates, Devaluation, and Adjustment: Exchange Rate Policy in Developing Countries*, MIT Press, Cambridge, Massachusetts.

Edwards, S., 1988. *Exchange Rate Misalignment in Developing Countries, World Bank Occasional Papers*, New Series, No. 2, World Bank, Washington, DC.

International Monetary Fund, Various years, *International Financial Statistics*, Washington, DC.

Granger, C.W.J. and Newbold, P., 1977. 'The time series approach to econometric model building' in C.A. Sims (ed.), *New Methods in Business Cycle Research*, Federal Reserve Bank of Minneapolis, Minneapolis.

Hendry, D.F., 1986. 'Econometric modelling with cointegrated variables: an overview', *Oxford Bulletin of Economic and Statistics*, 48(3):201–12.

Hendry, D.F., Pagan, A.R., and Sargan, J.D., 1985. 'Dynamic specification', in Z. Griliches and M.D. Intriligator (eds), *Handbook of Econometrics*, Vol. 2, North Holland, Amsterdam.

Hendry, D.F. and Mizon G., 1978. 'Serial correlation as a convenient simplification, not a nuisance: a comment on a study of the demand for money of the Bank of England', *Economic Journal*, 88(351):549-63.

Kmenta, J., 1986. *Elements of Econometrics*, Second Edition, Macmillan, New York.

Sargan, J. D., 1964. 'Wages and prices in the UK: a study in econometric methodology', in P. Hart, G. Mills and J. Whittaker (eds), *Econometric Analysis for National Planning*, Butterworths, London.

Warr, P.G., 1986. 'Indonesia's other Dutch disease: economic effects of the petroleum boom", in J.P. Neary and S.V. Wijnbergen (eds), *Natural Resources and the Macroeconomy*, Basil Blackwell Ltd., Oxford.

World Bank, 1995, *World Tables*, Various Issues, Washington, DC.