

# CHAPTER 5. ECONOMETRIC ANALYSIS OF REAL EXCHANGE RATE IN NAMIBIA

## 5.1 Introduction

This chapter presents the results from the three-good model (fundamental approach) and the Cashin *et al.* model of real exchange rate and commodity prices. The real exchange rate equation is estimated and the equilibrium real exchange rate then derived. The resulting real exchange rate misalignment is computed as the difference between the equilibrium and actual real exchange rate. Section 5.2 deals with estimation techniques. Section 5.3 discusses the data. Section 5.4 presents the results of the three-good model. Section 5.5 presents the results of the Cashin *et al.* model and Section 5.6 concludes.

## 5.2 Estimation Technique

There are different econometric techniques in time series estimation and these are the traditional Ordinary Least Squares (OLS), Engle and Granger two step and Engle-Yoo third step. The OLS does not take stationarity of the variables into account and if the variables in the estimation are non-stationary there results will be spurious. The Engle-Granger two step and Engle-Yoo third step procedure take stationarity and cointegration into account, but assume that there is only one cointegrating vector. That is a main weakness of these two techniques (The Engle-Granger two step and Engle-Yoo third step) and they are not sufficient in multivariate system. Johansen's full information maximum likelihood and vector autoregression (VAR) do not assume that there is one cointegrating vector. They are necessary and appropriate for time series analysis in multivariate systems.

This study employs the Johansen (1988, 1995) full information maximum likelihood (FIML) estimator in order to investigate if there is a long-run cointegrating relationship

between the real exchange rate and the explanatory variables. The Johansen methodology was used by MacDonald and Ricci (2003) to estimate the equilibrium real exchange rate for South Africa. This econometrics methodology corrects for autocorrelation and endogeneity parametrically using a vector error correction mechanism (VECM) specification. This methodology will be employed for both the three-good model approach and the Cashin *et al.* (2004) model which models real exchange rate as a function of real commodity prices. The Johansen procedure is described as follows. Defining a vector  $x_t$  of  $n$  potentially endogenous variables, it is possible to specify the data generating process and model  $x_t$  as an unrestricted vector autoregression (VAR) involving up to  $k$ -lags of  $x_t$  is specified as:

$$x_t = \mu + A_1 x_{t-1} + \dots + A_k x_{t-k} + \varepsilon_t \quad u_t \sim IN(0, \Sigma), \quad (15)$$

where  $x_t$  is  $(n \times 1)$  and each of the  $A_i$  is an  $(n \times n)$  matrix of parameters. Sims (1980) advocates this type of VAR modelling as a way of estimating dynamic relationships among jointly endogenous variables without imposing strong *a priori* restrictions (see also Harris, 1995). This is a system in reduced form and each variable in  $x_t$  is regressed on the lagged values of itself and all the other variables in the system. Equation (15) can be re-specified into a vector error correction model (VECM) as:

$$\Delta x_t = \mu + \Gamma_1 \Delta x_{t-1} + \dots + \Gamma_{k-1} \Delta x_{t-k+1} + \Pi x_{t-k} + \varepsilon_t \quad (16)$$

where  $\Gamma_i = -(I - A_1 - \dots - A_i)$ ,  $(i = 1, \dots, k-1)$  and  $\Pi = -(I - A_1 - \dots - A_k)$ ,  $I$  is a unit matrix, and  $A_i (i = 1, \dots, p)$  are coefficient vectors,  $p$  is the number of lags included in the system,  $\varepsilon$  is the vector of residuals which represents the unexplained changes in the variables or influence of exogenous shocks.  $\Delta$  represents variables in difference form which are  $I(0)$  and stationary and  $\mu$  is a constant term. Harris (1995: 77) states that this type of expressing the system has information on both the short and long-run adjustment to changes in  $x_t$  through estimates of  $\Gamma_i$  and  $\Pi$  respectively. In the analysis of VAR,  $\Pi$  is

a vector which represents a matrix of long-run coefficients and it is of paramount interest. The long-run coefficients are defined as a multiple of two  $(n \times r)$  vectors,  $\alpha$  and  $\beta'$ , and hence  $\Pi = \alpha\beta'$ , where  $\alpha$  is a vector of the loading matrices and denotes the speed of adjustment from disequilibrium, while  $\beta'$  is a matrix of long-run coefficients so that the term  $\beta'x_{t-1}$  in Equation (16) represents up to  $(n-1)$  cointegration relationship in the cointegration model. It is responsible for making sure that the  $x_t$  converge to their long-run steady-state values. If there is cointegration it is the same as stating that the rank ( $r$ ) of the  $\Pi$  matrix. If it has a full rank, the rank  $r = n$  and it is said that there are  $n$  cointegrating relationships and that all variable are  $I(0)$ .

If it is assumed that  $x_t$  is a vector of nonstationary variables  $I(1)$ , then all terms in Equation (16) which involves  $\Delta x_{t-i}$  are  $I(0)$ , and  $\Pi x_{t-k}$  must also be stationary for  $\varepsilon_t \sim I(0)$  to be white noise. Harris (1995: 79) distinguishes between three instances when this requirement that  $\Pi x_{t-k} \sim I(0)$  is met. The first one is when all variables in  $x_t$  are stationary, and this not of paramount importance because it implies that there is no problem of spurious regression and the appropriate modelling is to estimate the standard VAR in levels as in Equation (15). In the second instance, there is no cointegration at all and this implies that there are no linear combinations of the  $x_t$  that are  $I(0)$  and therefore  $\Pi$  is an  $(n \times n)$  matrix of zeros. The appropriate modelling strategy in this case is a VAR in first differences which involves no long-run elements. The third instance is when there exists up to  $(n-1)$  cointegration relationships,  $\beta'x_{t-k} \sim I(0)$ . In this instance  $r \leq (n-1)$  cointegration vectors exists in  $\beta$  together with  $(n - r)$  nonstationary vectors. The  $r$  columns of  $\beta$  form  $r$  linearly independent combinations of the variables in  $x_t$  and each of which is stationary, and the  $n - r$  columns of  $\beta$  form  $I(1)$  common trends. Only the cointegrating vectors in  $\beta$  enters Equation (16) otherwise  $\Pi x_{t-k}$  would not be  $I(0)$ . The implication is that the last  $(n - r)$  columns of  $\alpha$  are insignificantly small. According to Harris, the problem faced is of determining how many  $r \leq (n-1)$  cointegrating vectors exist in  $\beta$  and amounts to equivalently testing which columns of  $\alpha$  are zero. Testing for cointegration amounts to finding the number of  $r$  linearly independent columns in  $\Pi$ .

MacDonald and Ricci (2003: 11) mention that a key advantage of the Johansen methodology is that the estimated coefficient, the  $\beta$  vector can be used to prove a measure of the equilibrium real exchange rate, and the expression of the gap between the actual real exchange rate and its equilibrium level.

### 5.3 Data

This study covers the period 1970 to 2004. Annual data will be used to estimate the equilibrium real exchange rate. The sample of 1970 to 2004 was chosen using annual data. It would have been interesting to use quarterly data for the post-independence period 1990 to 2004, but statistics (quarterly) for some variables such as investment, terms of trade, export and import (to compute openness and resource balance variables), GDP, government expenditure are not available. Using annual data for the period 1990 to 2004 is not adequate for econometric time series analysis. Given the above, the sample of 1970 to 2004 using annual data was considered to be appropriate. The data for the period 1980 to 2004 is obtained from the Central Bureau of Statistics of Namibia and the Bank of Namibia. Data for the period 1970 to 1979 are sourced from Cornwell *et al.* (1991). A detailed description of the data is presented in the Appendix.

Before testing for cointegration it is important to mention that in the original definition of cointegration Engle and Granger, cointegration refers to variables that are integrated of the same order. This does not necessarily mean that all integrated variables are cointegrated. It is possible to find for example a set of  $I(d)$  variables that is not cointegrated. If variables are integrated of different orders, they cannot be cointegrated. However, it is possible to have cointegration with variables of different orders. Pagan and Wickens (1989: 1002) illustrate this point clearly that it is possible to find cointegration among variables of different orders (when there are more than two variables):

*“If the dependent variable in an equation is  $I(1)$  then there must be at least one  $I(1)$  variable among the explanatory variables. If all explanatory variables are  $I(0)$  then the equation will be mis-specified and this will be reflected in the disturbance term which will be  $I(1)$  and not  $I(0)$  as required. The disturbance will also be  $I(1)$  if the dependent variable is  $I(0)$  and there is only one  $I(1)$  regressor. To achieve an  $I(0)$ , there must be at least two  $I(1)$  regressors. The reason for this is a matter of integration or growth accounting, i.e. the left and right hand sides of the equation must be of the same order of integration or trend. To explain a*

*series which is growing, at least one of the explanatory variables must also be growing otherwise the growth will be unexplained and will show up in the disturbance term. The remaining variables are simply explaining deviations about the growth path. If the dependent variable is stationary, there must be either zero or at least two trending explanatory variables, one is required to remove the growth of the other and leave their combined stationary”.*

Enders (2004: 323) agrees with Pagan and Wickens (1989) that it is possible to find cointegration among groups of variables that are integrated of different orders. This happens when there are more than two variables. This is also supported by Harris (1995: 21).

## 5.4 The Three-good model

### 5.4.1 South Africa's Exchange Rate Policy and its Implication for Namibia's Real Exchange Rate

It is important to highlight some monetary and exchange rate policies of South Africa before the estimation of Namibia's real exchange rate. During the 1970s the exchange rate regime changed frequently. The rand was pegged from the USA dollar to the British pound in the period 1971 to 1983. The rand was again pegged to USA dollar during the same period. This was a time when South Africa started implementing a flexible exchange rate (Tjirongo, 1997). The rand was then pegged to a basket of currencies. The De Kock Commission study examined the exchange rate and monetary policy and recommended a move from a government control system to a market-oriented system. There was a dual exchange rate system which consisted of a commercial rand used for current account transactions and securities, and financial rand for equity to protect the current account from capital outflows which resulted from political instability. A managed float system was introduced for the commercial rand in and the financial rand started to float freely. The authorities took steps towards financial liberalisation and the exchange rate was now determined by the market.

South Africa experienced massive capital outflows between 1985 and 1994 (Kahn *et al*, 1998). This can possibly be attributed to political instability because of unrest in the townships and low levels of exports and foreign exchange reserves. There was doubt about South Africa's ability to service its short-term debt. However, Kahn states that after the transformation of South Africa to a democracy in 1994, the country received capital inflows of more than R30 billion during the period July 1994 to December 1995. Although it was good for the economy, it resulted in monetary management difficulties. These inflows of capital to South Africa were reversed and the country experienced capital outflows in 1996 because of sentiments against emerging markets. This resulted in the depreciation of the rand. Although the change in sentiments was not related to any economic fundamental in Namibia the country had no instrument to protect itself from the shocks. These developments in South Africa are important to Namibia even though they are solely related to events in South Africa.

The financial rand was abolished in 1995 (Kahn, 1998). Non-residents started to impact directly on the current account. South African interest rates were no longer protected from world interest rates by the financial rand.

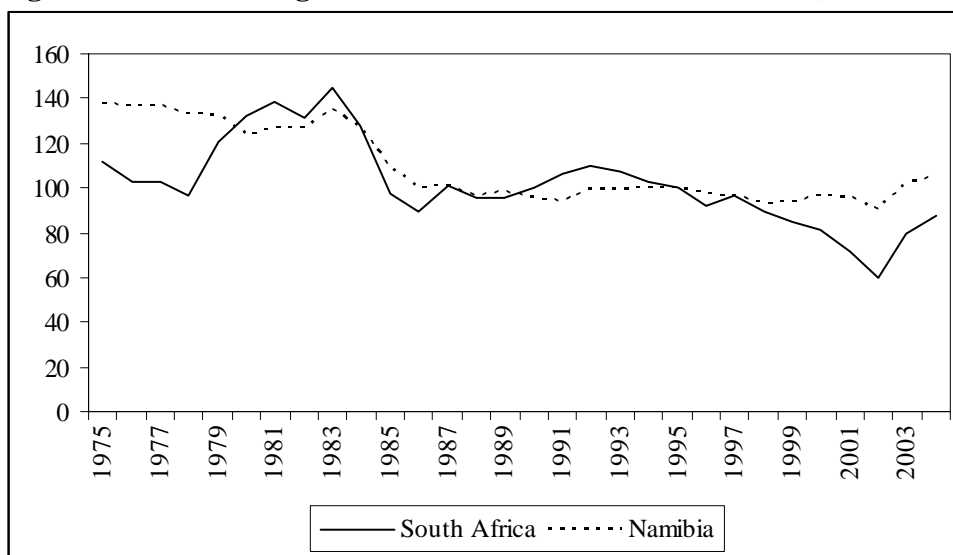
Various quarterly Bulletins of the South Africa Reserve Bank indicate that the inflation rate which averaged 15 percent in the 1980s declined to a single digit in the late 1990s. This implies that South Africa has achieved financial stability. The inflation rate of Namibia also declined since the country imports a high percentage of its products from South Africa.

There has been an expansion of the money supply in South Africa since 1994 because of the extension of credit to the private sector and individuals. The extension of credit continued to grow at a high level because of consumer confidence in the economy. Individuals who did not qualify for credit previously were now given loans. This resulted in high consumer price index. The South African Reserve Bank's stance on interest rate is determined mainly by consumer credit and this is important for Namibia.

Since the Namibia dollar is pegged to the rand, the exchange rate with other currencies is determined by South Africa, and hence it is important to understand the exchange rate policies of South Africa.

Kahn (1992) argued that during the 1980s the price of gold was the main determinant of the real exchange rate of South Africa. The rand depreciated when the price of gold decreased, and appreciated when the price of gold increased. Kahn states that the South Africa Reserve Bank intervened to prevent more appreciation of the rand when the price of gold increase. These developments since 1970 have shown that South Africa is vulnerable to speculative attack and this implies that Namibia will experience the same with respect to other currencies. In light of these discussions, Figure 1 presents the real exchange rates of South Africa and Namibia.

**Figure 1. Real exchange rates of Namibia and South Africa (1995=100)**



Source: Data are obtained from the International Financial Statistics, Bank of Namibia and South African Reserve Bank.

Figure 1 shows that although the real exchange rates of Namibia and South Africa are moving together, the two indexes showed divergence from each other especially during the periods 1970 to 1979, 1990 to 1994, and 1995 to 2004. The two indexes converged from the late eighties to late nineties. South Africa accounts for about 60 percent of the weight in Namibia's total trade and this implies that the two rates should move together.



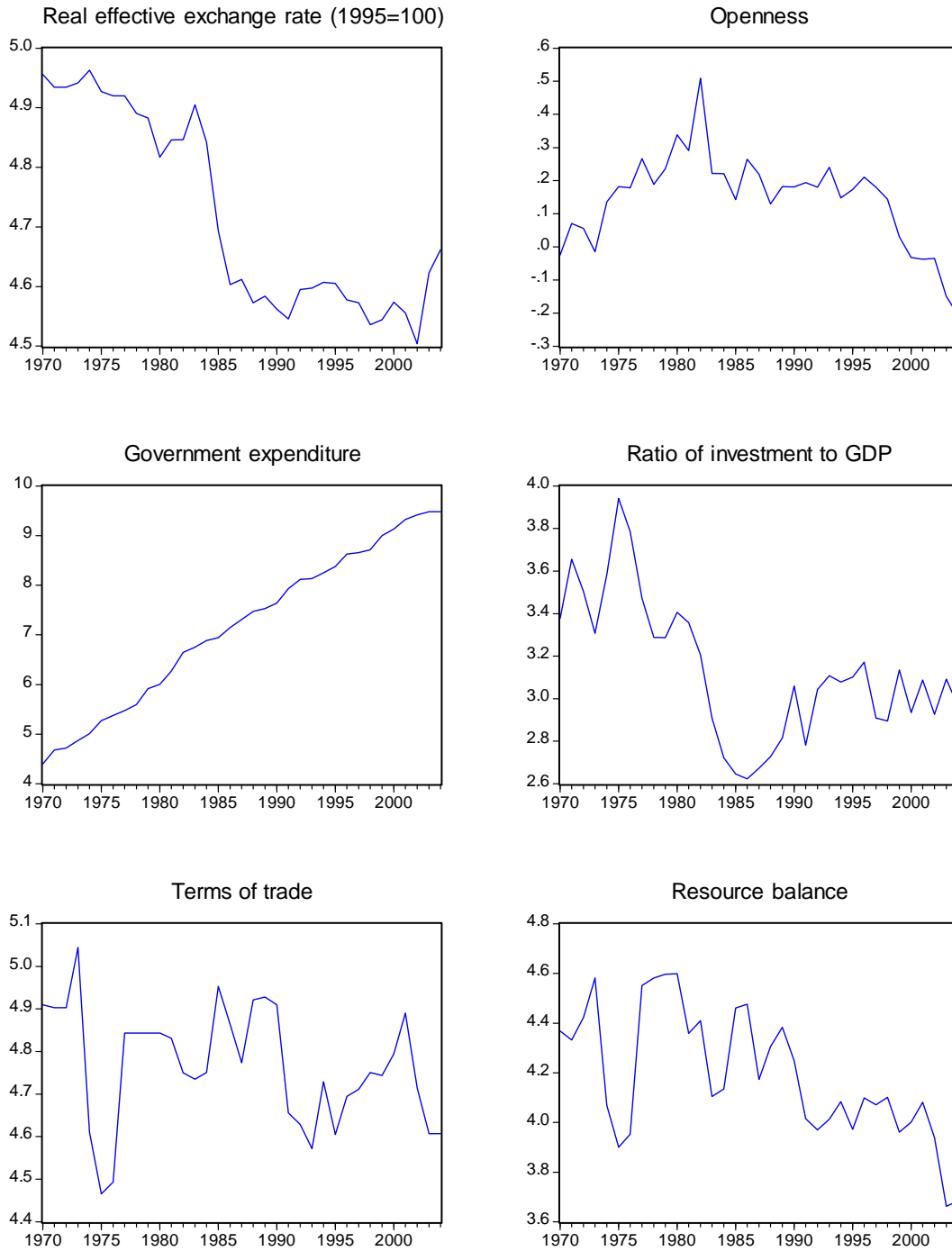
However, the divergence between the real exchange rates of the two countries is expected. This is attributed to the difference in consumer price indexes of the two countries which are used to compute the real exchange rates. The divergence is attributed to the difference in the weights applied to the computation of the consumer price indexes in the two countries. For example, food accounts for 29.63 percent in Namibia's and 22 percent in South Africa's consumer price indexes (South African Reserve Bank, 2005 and Bank of Namibia, 2005).

As mentioned in Chapter 2, the developments in South Africa's fundamentals also have an impact on the real exchange rate of Namibia and it would be interesting to include some of them in the estimation. However, not all South African fundamentals are relevant to Namibia. Determining which of the South Africa's fundamentals to include or exclude falls outside the scope of this study, but can be a subject of future research.

#### 5.4.2 Developments in Namibia's Key Fundamental Determinants of the Real Exchange Rate

Following the theoretical model of Section 2.3 and review of empirical studies in Section 2.4, this section examines the evidence on the evolution of the following fundamentals expected to have an influence on the real exchange rate of Namibia between 1970 and 2004. These include ratio of investment to GDP, terms of trade, resource balance and government expenditure and openness of the economy. These fundamentals are plotted in Figure 2.

**Figure 2. Real effective exchange rate and its fundamental determinants (in logs)**



### Terms of trade

The terms of trade is included in the determination of the real exchange rate to capture foreign price shocks. Namibia's terms of trade has been volatile between 1970 and 2004.

The terms of trade measures the behaviour of export prices relative to import prices. It is important because it looks at both the prices of exports and imports. This is of paramount importance because increase in exports would mean little if the prices of imports increase simultaneously by a higher rate.

Terms of trade deteriorated during the early 1990s and this could be attributed to the decline in the price of diamonds. Diamond production in Namibia increased by 56 percent in 1991 because with the offshore operations, higher grades of diamonds were obtained (Bank of Namibia, 1992). The sea mining operations became more significant in the early 1990s. In 1992 the Central Selling Organisation imposed a 25 percent cut on all production because of an over stock of diamonds and the slump in diamond prices (Bank of Namibia, 1992). The declining trend in uranium between 1988 and the late 1990s might also have contributed to the deterioration of the terms of trade. According to Bank of Namibia (1992) the production of uranium reached its lowest level in 1992 since 1985. The Rossing Uranium mine was operating at 43 percent of its capacity. The main reason for the decline in the production of uranium was the continuing slump in world prices of uranium. In addition, large sales from the former Soviet Union resulted in a glut in minerals in the world market and drove the prices of most minerals to low levels.

The shocks to the prices of commodities for primary product exporting countries such as Namibia have a significant impact on the terms of trade. A greater proportion of Namibia's exports are minerals (such as diamond, uranium, copper and other base metals) and fisheries products. These products cannot reduce the impact of commodity price fluctuations on the terms of trade. Countries that have a wide range of exportable (such as South Africa) have the capacity to absorb deterioration in the terms of trade resulting from a fall in commodity prices than countries (such as Namibia) with few exportables.

## **Trade Policy (Openness of the Economy)**

Openness of the economy (computed as the sum of export and import over GDP) which is a proxy for trade policy or trade and exchange rate restrictions influence the real exchange rate. It refers to the country's trade policy stance which is reflected in import tariffs and quotas. It not only measures trade and exchange restrictions but also the intensity of exchange control. As discussed previously, the coefficient of tariff can be positive or negative depending on whether the substitution or income effect of tariffs and other trade restrictions dominates. The exchange rate can appreciate or depreciate. However, the bulk of the empirical evidence suggested that the substitution effect dominates the income effect and increase in openness is expected to cause real exchange rate depreciation. Although openness of the economy is not a good indicator of trade policy, Figure 2 shows that openness increased in 1981 and 1982. It declined in 1985 and remained almost constant until the late 1990s. This may suggest that structural changes in the economy took place from the late 1990s to 2004.

## **Ratio of Investment to GDP**

The ratio of investment to GDP can appreciate or depreciate the real exchange rate. This depends on whether investment is more consumption intensive than import. If import responds more to investment it will rise spending, deteriorate the current account and results in real exchange rate depreciation. Figure 2 shows that since 1970s the ratio of investment decreased from 40 percent to below 30 percent in 1980. It declined sharply between 1980 and 1989. The decline in investment ratio could be attributed to uncertainties about the political settlement in the country. As a result, the mining sector which is a significant contributor to the GDP and export experienced a long period of inactivity in terms of investment in new technology and exploration (Bank of Namibia, 1991: 6).

The ratio increased slightly between 1990 and 2004. The Bank of Namibia (2001) attributed this increase to the fact that after independence prospecting for new minerals was revived. The long term prospects of the mining industry looked brighter because of an increase in investment in new technology and exploration.

### **Government Expenditure**

Government expenditure increase significantly between 1970 and 2004. The increase in government expenditure between 1970 and 1989 can be explained by the fact that because of the growing demands for Namibia's independence, South Africa responded by establishing a transitional government for the then South West Africa based on 13 ethnic homelands in 1978 (Tjirongo, 1997). There was an expansion of military and security forces with the formation of the South West Africa Territorial Force, and this was in response to the escalation of military activity by the People's Liberation Army of Namibia (PLAN) in Namibia and Angola (see Esterhuysen, 1991: 58-64). It should be noted however, that not all government expenditure were devoted to the expansion of military and expansion of security forces, some were devoted to imports.

Government expenditure continued to increase after independence (1990), although fiscal policy has been prudent in order to maintain macroeconomic stability for sustainable development. The Bank of Namibia (2001) states that current expenditure dominates government spending. Expenditure on human resources accounts for about 52 percent of current expenditure. There has been significant spending on the development of human capital and the education sector received on average about 25 percent of total government expenditure.

### **Resource Balance**

Resource balance is a proxy for capital control and flows (computed as  $[(\text{import}-\text{export})/\text{GDP}]$ ). This refers to a net increase in foreign borrowing, transfers and aid. Capital flows can be caused by the removal of capital control, increase in government

borrowing in order to cover its deficit, and reduction in real interest rates in the world capital markets. Although it has been fluctuating since 1970 to 2004, it followed a downward trend. This suggests that there has been a decrease in the flow of capital to Namibia. It is not easy to explain what caused fluctuations of capital, although the period 1980 to 1989 was characterised by political uncertainty about the future of Namibia. The fluctuations of the post 1990 period can be attributed decrease in grants to the country because Namibia falls under middle income status and no longer qualify for some grants. The Bank of Namibia's various annual reports state that more than 80 percent of government debt is domestic and the share of foreign in total debt is less than 16 percent. The country did not borrow much from abroad.

#### 5.4.3 Univariate Characteristics of the Variables and VAR Order

In order to estimate the empirical model the variables were tested for unit root (stationarity test). The results of unit roots tests are presented in the Appendix. Based on the Akaike Information Criteria (AIC), Final Prediction Error (FPE) and Swartz Information Criterion (SIC) the lag order was suggested to be 1. Diagnostic statistics were performed on the VAR for stability, serial correlation, normality, autocorrelation and heteroscedasticity. The diagnostic statistics show that the VAR is stable because all roots have modulus of less than one and lie within the unit circle. Diagnostic statistics are presented in Table 13 in the Appendix. The results show that there is no heteroscedasticity and no serial correlation. The error term is white noise and normally distributed.

#### 5.4.4 Testing for Reduced Rank

Cointegration between the variables was tested using the Johansen FIML. The trace and maximum eigenvalues are presented in Table 4.

**Table 4. Cointegration test results**

Null hypothesis	Alternative hypothesis		0.05 Critical value	Probability value <sup>b</sup>
<i>Trace statistic</i>				
r=0	r=1	113.7714 <sup>a</sup>	95.754	0.002
r=1	r=2	75.248 <sup>a</sup>	69.819	0.017
r=2	r=3	45.629	47.856	0.079
r=3	r=4	23.573	29.797	0.219
r=4	r=5	9.400	15.495	0.329
r=5	r=6	1.112	3.841	0.292
<i>Maximum Eigenvalue statistic</i>				
r=0	r>0	38.525	40.078	0.074
r≤1	r>1	29.618	33.877	0.148
r≤2	r>2	22.056	27.584	0.218
r≤3	r>3	14.173	21.132	0.351
r≤4	r>4	8.288	14.265	0.350
r≤5	r>5	1.112	3.841	0.292

<sup>a</sup> Denotes rejection of the null hypothesis at the 0.05 level

<sup>b</sup> MacKinnon-Haug-Michelis (1999) p-values

The trace statistics shows that there are two cointegrating vectors, while the maximum eigenvalue indicates that there is no cointegration. This study uses at least one statistic to assume a verdict of cointegration. The trace statistic confirm the appropriateness of proceeding with the vector error correction methodology (VECM). Since there are two cointegrating vectors the VECM is visualised as follows:

$$\begin{bmatrix} \Delta LREER_t \\ \Delta LTOT_t \\ \Delta LINVGDP_t \\ \Delta LGOV_t \\ \Delta LOPEN_t \\ \Delta LRESBAL_t \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \\ \mu_3 \\ \mu_4 \\ \mu_5 \\ \mu_6 \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & \gamma_{15} & \gamma_{16} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} & \gamma_{24} & \gamma_{25} & \gamma_{26} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} & \gamma_{34} & \gamma_{35} & \gamma_{36} \\ \gamma_{41} & \gamma_{42} & \gamma_{43} & \gamma_{44} & \gamma_{45} & \gamma_{46} \\ \gamma_{51} & \gamma_{52} & \gamma_{53} & \gamma_{54} & \gamma_{55} & \gamma_{56} \\ \gamma_{61} & \gamma_{62} & \gamma_{63} & \gamma_{64} & \gamma_{65} & \gamma_{66} \end{bmatrix} \begin{bmatrix} \Delta LREER_{t-1} \\ \Delta LTOT_{t-1} \\ \Delta LINVGDP_{t-1} \\ \Delta LGOV_{t-1} \\ \Delta LOPEN_{t-1} \\ \Delta LRESBAL_{t-1} \end{bmatrix} + \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \\ \alpha_{31} & \alpha_{32} \\ \alpha_{41} & \alpha_{42} \\ \alpha_{51} & \alpha_{52} \\ \alpha_{61} & \alpha_{62} \\ \alpha_{71} & \alpha_{72} \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{21} & \beta_{31} & \beta_{41} & \beta_{51} & \beta_{61} & \beta_{71} \\ \beta_{12} & \beta_{22} & \beta_{32} & \beta_{42} & \beta_{52} & \beta_{62} & \beta_{72} \end{bmatrix} \begin{bmatrix} LREER_{t-1} \\ LTOT_{t-1} \\ LINVGDP_{t-1} \\ LGOV_{t-1} \\ LOPEN_{t-1} \\ LRESBAL_{t-1} \\ CONSTANT \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \\ \varepsilon_{6t} \end{bmatrix} \quad (17)$$

#### 5.4.5 Long-run Restrictions

The long-run restrictions were done in line with the three-good model in the theoretical framework. The structural approach to time series modelling uses economic theory to model the relationship among the variables of interest. However, economic theory is not always rich enough to provide a dynamic specification that identifies all of these relationships. In addition to that, estimation and inference are made difficult by the fact that the endogenous variables may appear on both the left and right sides of the equations. Economic theory provides guidance on the variables to be included in the estimation, but some variables do not necessarily need to be included in the estimation. Testing for the long-run parameter will help to identify which variables should be included in the estimation and which ones should not be included in the estimation. Five long-run restrictions were imposed on the two cointegrating vectors as shown in Equation (18):



$$\begin{bmatrix} \Delta LREER_t \\ \Delta LTOT_t \\ \Delta LINVGDP_t \\ \Delta LGOV_t \\ \Delta LOPEN_t \\ \Delta LRESBAL_t \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \\ \mu_3 \\ \mu_4 \\ \mu_5 \\ \mu_6 \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & \gamma_{15} & \gamma_{16} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} & \gamma_{24} & \gamma_{25} & \gamma_{26} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} & \gamma_{34} & \gamma_{35} & \gamma_{36} \\ \gamma_{41} & \gamma_{42} & \gamma_{43} & \gamma_{44} & \gamma_{45} & \gamma_{46} \\ \gamma_{51} & \gamma_{52} & \gamma_{53} & \gamma_{54} & \gamma_{55} & \gamma_{56} \\ \gamma_{61} & \gamma_{62} & \gamma_{63} & \gamma_{64} & \gamma_{65} & \gamma_{66} \end{bmatrix} \begin{bmatrix} \Delta LREER_{t-1} \\ \Delta LTOT_{t-1} \\ \Delta LINVGDP_{t-1} \\ \Delta LGOV_{t-1} \\ \Delta LOPEN_{t-1} \\ \Delta LRESBAL_{t-1} \end{bmatrix} + \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \\ \alpha_{31} & \alpha_{32} \\ \alpha_{41} & \alpha_{42} \\ \alpha_{51} & \alpha_{52} \\ \alpha_{61} & \alpha_{62} \\ \alpha_{71} & \alpha_{72} \end{bmatrix} \begin{bmatrix} LREER_{t-1} \\ LTOT_{t-1} \\ LINVGDP_{t-1} \\ LGOV_{t-1} \\ LOPEN_{t-1} \\ LRESBAL_{t-1} \\ CONSTANT \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \\ \varepsilon_{6t} \end{bmatrix} \quad (18)$$

Since there are more than one cointegration vector, it is not sensible to just take the unrestricted estimates of the vectors in  $\beta$  directly as a meaningful long-run parameter estimate. It is important to impose and test restrictions on the elements of  $\beta$  in an attempt to obtain the structural relationship between the variables.

In the first cointegrating vector, long-run zero restriction was imposed on terms of trade because it is a dependent variable in the second cointegrating vector. Zero restriction was imposed on the real effective exchange rate because it is a dependent variable in the first cointegrating vector. The long-run restrictions show that in the first cointegration relation (real exchange rate equation, LREER) terms of trade (LTOT) does not play an important role in the determination of the real effective exchange rate for Namibia. In other words we can have a real exchange rate equation without a terms of trade variable. In the second cointegration relation (the terms of trade equation, LTOT) the real exchange rate variable does not play an important role in the determination of terms of trade, implying that we can have a terms of trade equation without a real exchange rate variable. The long-run cointegration equation for real effective exchange rate for Namibia can be written as:

$$LREER = 0.641LINVGDP + 0.047LGOV + 0.735LRESBAL + 0.414LOPEN - 0.782 \quad (19)$$

(6.028)
(1.738)
(4.896)
(1.995)

The t-statistics are in parentheses. The results in Equation (19) can be summarised as follows:

- A one percent increase in ratio of investment to GDP is associated with an appreciation of the real exchange rate by 0.64 percent. This is similar to the results obtained by Mathisen (2003) for Malawi.
- A one percent increase in government expenditure causes the real exchange rate to appreciate by 0.047 percent. This is comparable to the results obtained by Elbadawi (1994) for Chile and India, and by Edwards (1988) for developing countries.
- A one percent increase in resource balance (a proxy for capital control) causes the real exchange rate to appreciate by 0.735 percent. This coefficient can also be favourably compared to those obtained by Elbadawi (1994) for Chile, Ghana and India.
- A one percent increase in openness is associated with an appreciation of the real effective exchange rate by 0.414 percent. This is consistent with the results obtained by Asfaha and Huda (2002) for South Africa, and Zhang (2001) for China.

The results of the second cointegrating vector (terms of trade equation) are presented in Equation (20):

$$\begin{aligned}
 LTOT = & -2.787LINVGDP - 0.773LGGOV - 4.502LRESBAL - 4.153LOPEN \\
 & (-4.854) \quad (-5.289) \quad (-5.556) \quad (-3.711) \\
 & +38.605
 \end{aligned} \tag{20}$$

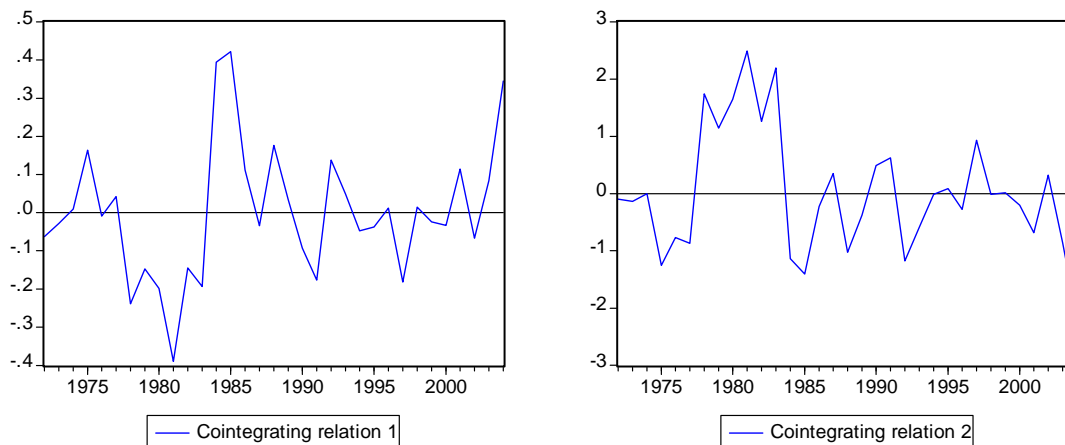
The results of Equation (20) can be summarised as:

- An increase in investment to GDP causes terms of trade to decrease. A one percent increase in investment to GDP causes terms of trade to decrease by 2.787 percent.

- A one percent increase in government expenditure causes terms of trade to decrease by 0.773 percent.
- An increase in resource balance by 10 percent is associated with a decrease in the terms of trade by 4.502 percent.
- An increase in openness causes the terms of trade to decrease.

All t-statistics are statistically significant, and the results are consistent with *a priori* expectations and literature. However, the second cointegrating vector is not important. The most important is the results of the first cointegrating vector (the real exchange rate equation). That is because the focus of this study is on the real exchange rate. Cointegration relations are plotted in Figure 3. They appear to be stationary.

**Figure 3. Cointegration relations**



#### 5.4.6 Exogeneity Test and Speed of Adjustment

The loading matrix  $\alpha_s$  determine into which equation the cointegrating vectors enter and with what magnitudes. It measures the speed of adjustment and the degree to which the variable in the equation respond from the long-run equilibrium relationship. The elements of matrix  $\alpha_s$  relate to the issue of weak exogeneity. In a cointegrated system if a

variable does not respond to the discrepancy from the long-run equilibrium, it is weakly exogenous. This implies that there are rigidities, which limit the adjustment process. If the variable is not weakly exogenous, it means that it plays some role in bringing the normalised variable in the long run equation to equilibrium. Exogeneity test results are presented in Table 5.

**Table 5. Exogeneity**

	Cointegration equation 1	Cointegration equation 2.
$\Delta$ LRREER	-0.477 (-5.687)	-0.059 (-3.955)
$\Delta$ LTOT	0.000	0.000
$\Delta$ LINVGDP	0.000	0.000
$\Delta$ LGOV	0.000	0.063 (3.502)
$\Delta$ LRESBAL	0.000	-0.061 (-5.015)
$\Delta$ LOPEN	0.000	0.000
LR test for binding restriction (rank=2): $\chi^2$ (8)		8.496,
probability		0.131

The Likelihood Ratio for binding restrictions of LR=5.835 (0.666). The number in parenthesis is the probability of committing a type I error. This test refers to both long run and the above loading matrix restrictions. Since the Likelihood Ratio does not reject the restrictions, it means that the equations are well-specified. The VECM results were diagnosed for serial correlation, normality, lag exclusion test and heteroscedasticity. The diagnostic statistics are presented in Table 6. The VECM results passed all diagnostic statistics.

**Table 6. Diagnostic statistics of the VECM**

	H <sub>0</sub>	Test	Statistic	Probability	Decision
Serial correlation	No serial correlation	LM test- $\chi^2$ (lag 1)	39.286	0.325	No serial correlation
Normality	Error terms are normally distributed	JB-Joint	20.466	0.058	Error terms are normally distributed
		Kurtosis – Joint	23.843	0.011	
		Skewness - Joint	23.926	0.708	
Heteroscedasticity	No heteroscedasticity	$\chi^2$	317.544	0.758	No heteroscedasticity

As shown in Table 5, exogeneity test shows that in the real effective exchange rate equation (Cointegration equation 1) terms of trade, ratio of investment to GDP, government expenditure, resource balance and openness are weakly exogenous and do not play any role in bringing the real effective exchange rate to equilibrium. Disequilibrium in the real exchange is corrected only through adjustment in itself. The second cointegrating vector shows that the real exchange rate and resource balance do play a role in bringing the terms of trade to equilibrium. Government expenditure moves the terms of trade away from equilibrium. Openness, ratio of investment to GDP and terms of trade are weakly exogenous in the terms of trade equation.

As Mathisen (2003: 16) stated, if there is a gap between the real exchange rate and its equilibrium value, the real exchange rate will converge to its equilibrium value. The adjustment requires that the real exchange rate move towards a new equilibrium level or return from its temporary deviation to the original equilibrium.

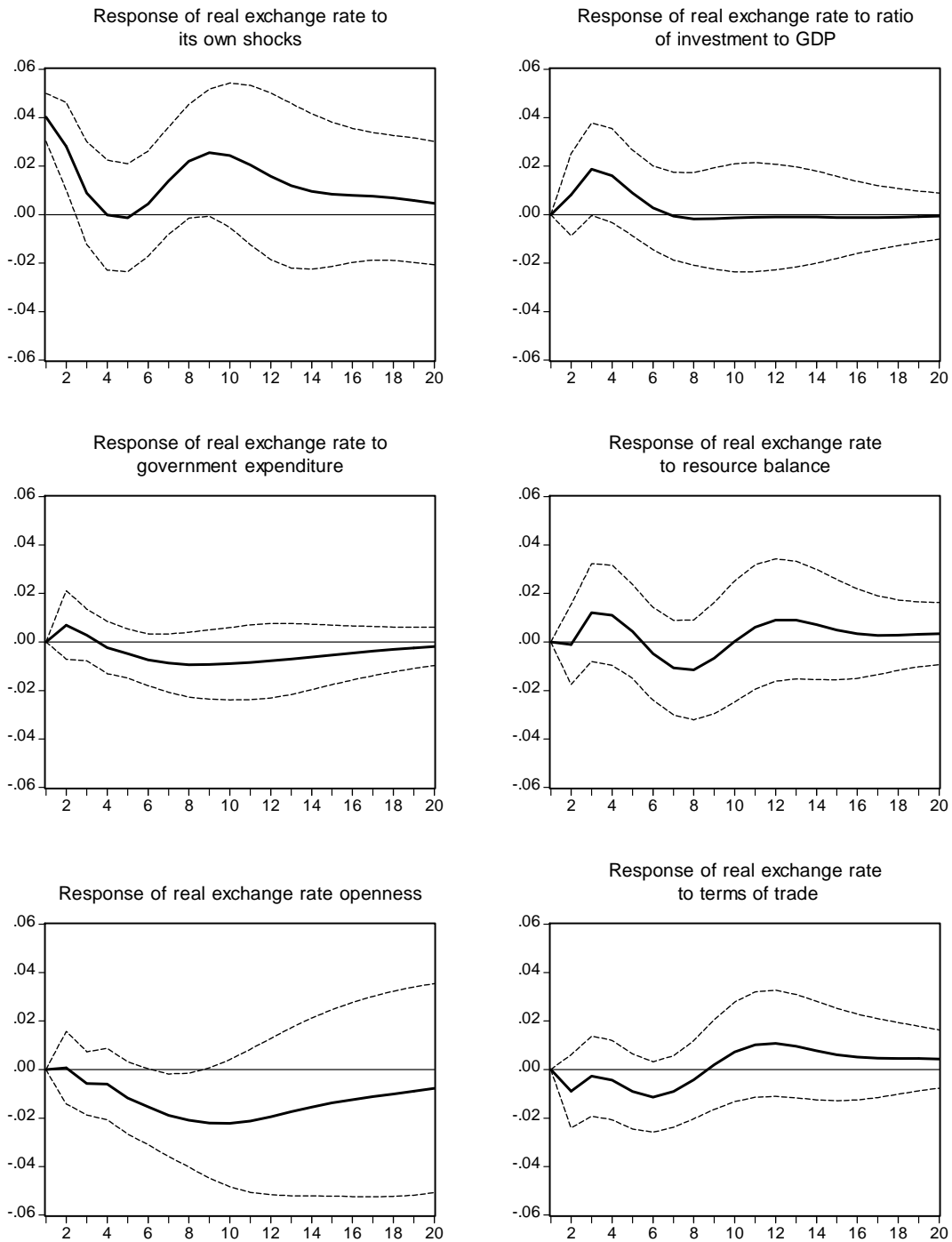
A significant error term between zero and negative two implies that the long run equilibrium is stable. Since the ECM term is -0.477, the cointegrating relationship is stable. It shows that 47.7 percent of the gap between real exchange rate and its equilibrium value is eliminated in the short run. From this estimated coefficient, the number of years required to eliminate a given real exchange rate misalignment can be derived. The time required to remove or dissipate  $x$  percent of a shock (disequilibrium) is determined as:  $(1 - \beta)^t = (1 - x)$ , where  $t$  is the required number of periods and  $\beta$  is the

coefficient of the error correction term. This implies that the adjustment takes 1.07 years for 50 percent of the deviations to be eliminated. This adjustment speed is faster than the 2.1 years obtained by MacDonald and Ricci (2003) for South Africa, although the data were quarterly. It is lower than the speed of adjustment obtained by Baffes *et al.* (1999) for Burkina Faso, but higher than the one for Ivory Coast. The adjustment estimated for Burkina Faso was -0.94 and for Ivory Coast was -0.39. The adjustment period of 1.07 years is also lower than that obtained by Mathisen (2003) for Malawi. The adjustment period for Malawi is 11 months although the data for Malawi was quarterly.

#### 5.4.7 Impulse Responses

Impulse responses, introduced by Sims (1980), show the response of the real exchange rate to shocks in fundamental determinants. The impulse responses are important in the analysis of an estimated structural VAR. They show the dynamic response of a variable to a shock in one of the structural equations. They indicate the response of present and future values of each of the variables to a one-unit increase in the present value of one of the shocks of VAR (see Stock and Watson, 2001). The impulse responses are plotted for the first cointegration relation (real exchange rate equation) and second cointegration relation (terms of trade equation). They are plotted in Figures 4 and 5. They are orthogonalised using Cholesky or lower triangular decomposition. The variables are ordered as follows: real exchange rate first because it is a variable interest or focus of the study, followed by terms of trade, ratio of investment to GDP, government expenditure, resource balance, and openness.

**Figure 4. Impulse response of the real exchange rate: response to Cholesky one standard innovations**



**Figure 5. Impulse response of the terms of trade: response to Cholesky one standard innovations**

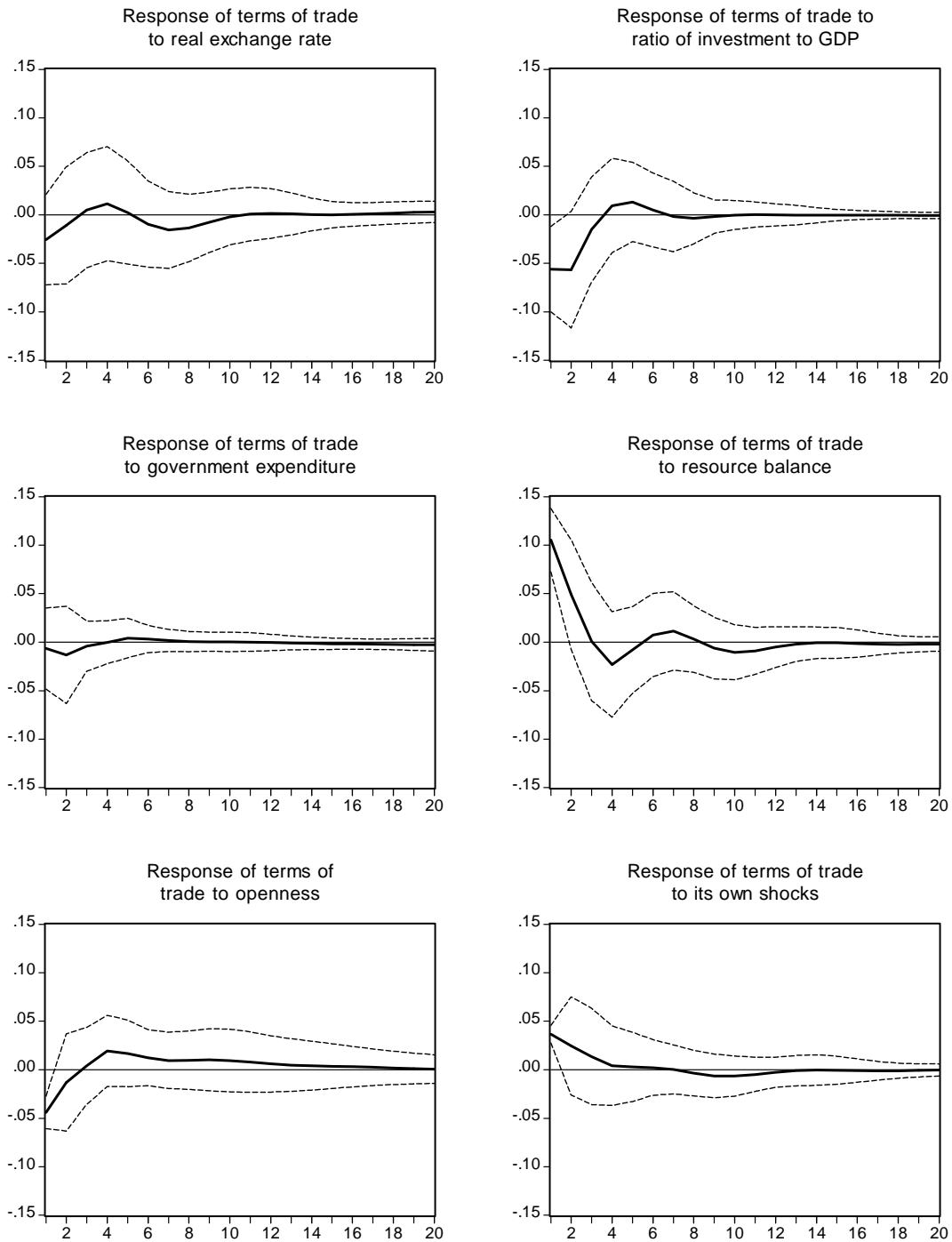


Figure 4 shows that the real exchange rate responds positively to its own shocks and return to equilibrium in period 20. It also responds positively to shocks from the ratio of investment to GDP and return to equilibrium from period 7.



A shock on government expenditure causes the real exchange rate to respond positively during the first four periods. It then starts to respond negatively from period 5. It returns to equilibrium in period 20. The real exchange rate responds positively to shocks on resources balance, but start responding negatively between periods 5 and 9. It then starts to respond positively again from period 10 and return to equilibrium.

A shock to openness causes the real exchange rate to respond negatively. Although it does not reach equilibrium, it shows that there is a move towards equilibrium. The real exchange rate responds negatively to shocks in the terms of trade between periods 1 and 8. It then responds positively between periods 9 and 20, and return to equilibrium. All shocks do not have a permanent effect on the real exchange rate. The real exchange rate returns to or has a tendency of moving towards equilibrium.

Figure 5 shows that the terms of trade responds negatively in the first 2 periods and positively between periods 3 and 5 to shocks on both real exchange rate and ratio of investment to GDP. It then responds negatively between periods 6 and 10. It returns to equilibrium from period 11 onwards.

The terms of trade responds negatively to shocks on government expenditure during the first four periods. The shocks on government expenditure do not have a permanent effect on the terms of trade. The terms of trade returns to equilibrium from the period 5. The response of the terms of trade to shocks in resource balance is positive during the first three periods, negative from periods 3 to 4, positive in period 6 to 7 and negative in periods 8 to 11. The shocks to resource balance also do not have a permanent effect on the terms of trade, because the terms of trade returns to equilibrium from period 14.

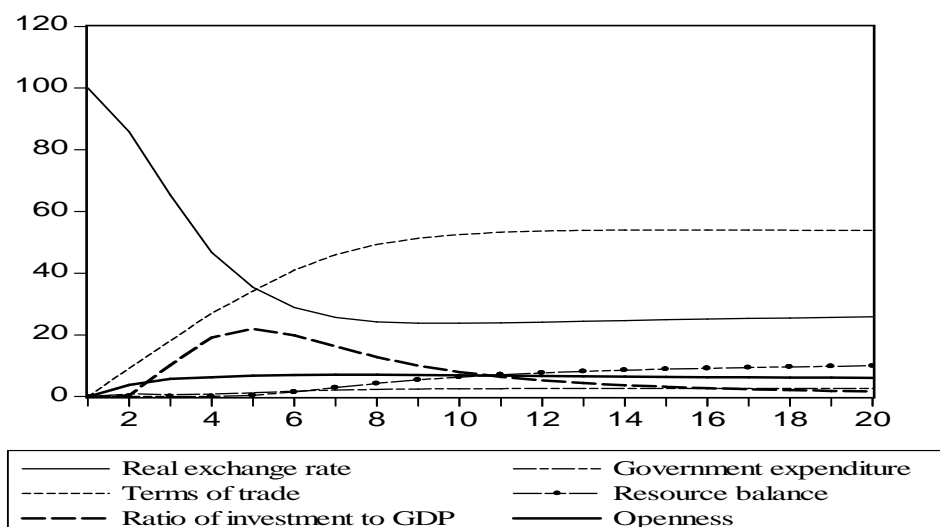
Terms of trade responds negatively to shocks on openness during the first 3 periods and become positive from period 4. It however, responds positively to its own shocks. All shocks do not have a permanent impact because the terms of trade always return to equilibrium.

### 5.4.8 Variance Decomposition

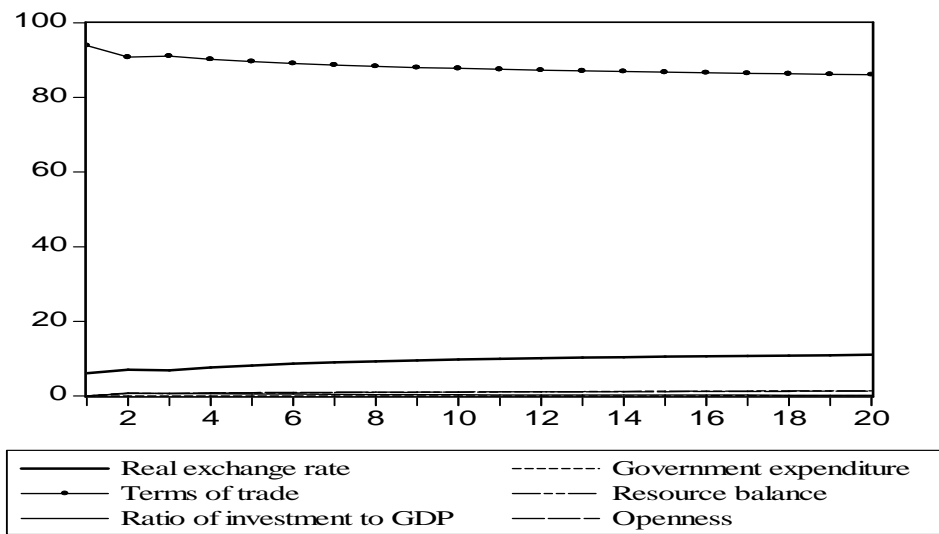
Variance decomposition is another important way of testing the relative importance of each shock to fundamental determinants in accounting for variation in the real exchange rate. Figure 6 shows that during the first period, real exchange rate is only accounted for by itself. Real exchange rate accounted for about 30 percent of the variation in itself between periods 5 and 20. The terms of trade account for about 50 percent of the variations in the real exchange rate. The ratio of investment to GDP accounts for just under 30 percent of the between periods 4 and 8, and under 10 percent of the variation of the real exchange rate. Government expenditure, resource balance, and openness account (each) for just under 10 percent of the variation of the real exchange rate.

In the second equilibrium relationship (terms of trade), Figure 7 shows that the terms of trade accounts for more than 80 percent of the variation of itself. Real exchange rate accounts for just over 10 percent of the variation of the terms of trade. Government expenditure, ratio of investment to GDP, resource balance and openness account for about 1 to 5 percent.

**Figure 6. Variance decomposition of the real effective exchange rate**



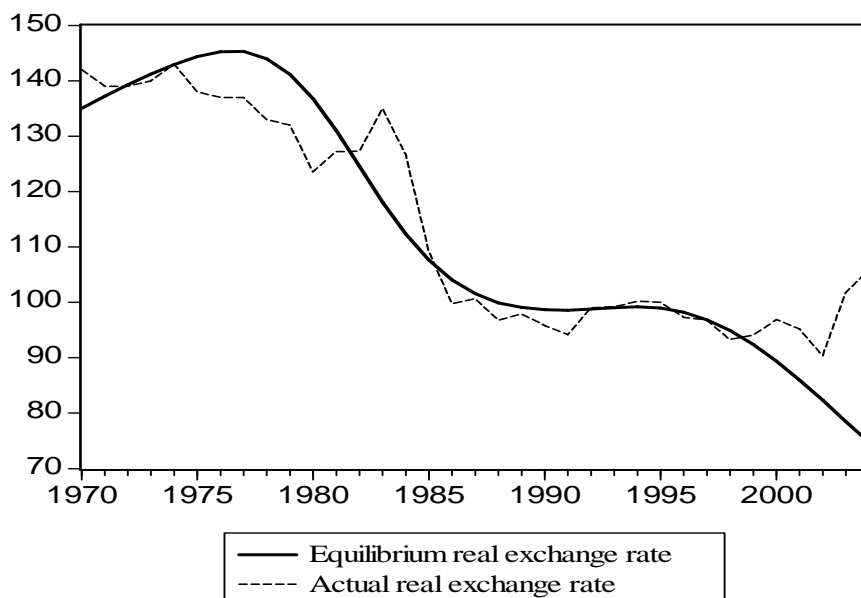
**Figure 7. Variance decomposition of the terms of trade**



#### 5.4.9 Equilibrium Real Exchange Rate

The long-run relationship above allows an estimate of the equilibrium real exchange rate to be calculated. As defined earlier, this is the level of the real exchange rate that is consistent with the long-run equilibrium value of the fundamental variables. The equilibrium real exchange rate was obtained by imposing the coefficients of the long-run equation on the permanent values of the fundamentals. Hodrick-Prescott filter with a smoothing factor of 100 was used to smooth the variables and derive their permanent values. This smoothing factor is what Hodrick and Prescott suggested for annual data. Figure 8 shows the actual and equilibrium real exchange rate.

**Figure 8. Actual and equilibrium real effective exchange rate**



When the actual real effective exchange rate is above the equilibrium, it is overvalued, and when it is below the equilibrium, it undervalued. The real exchange rate was overvalued during the periods 1970-1972, 1982-1985, 1992-1995 and 1999-2004. The highest overvaluation was during the period 2002, 2004, and 1985. The real exchange rate was undervalued during the periods 1973-1981, 1986-1991 and 1996 to 1998. The highest undervaluation happened in 1980. Misalignment of the real exchange rate is presented in Figure 9.

**Figure 9. Misalignment of the real effective exchange rate**

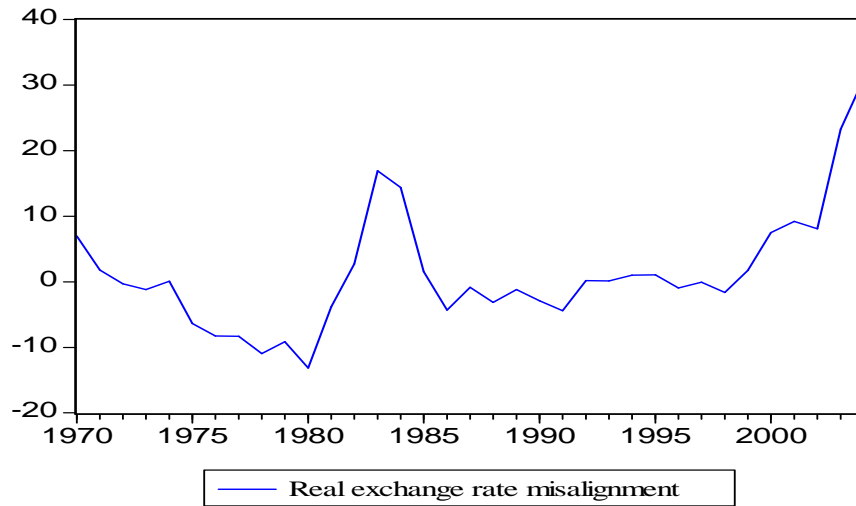


Figure 9 shows that the highest misalignment occurred in 1980 and 2002 to 2004. Real exchange rate misalignment was low between 1987 and 1999. The period 1970 to 1989 is associated with political instability and challenges for independence. The period 2001 to 2002 is associated with the weakening of the Namibia dollar. The Namibia dollar strengthened during 2003 to 2004.

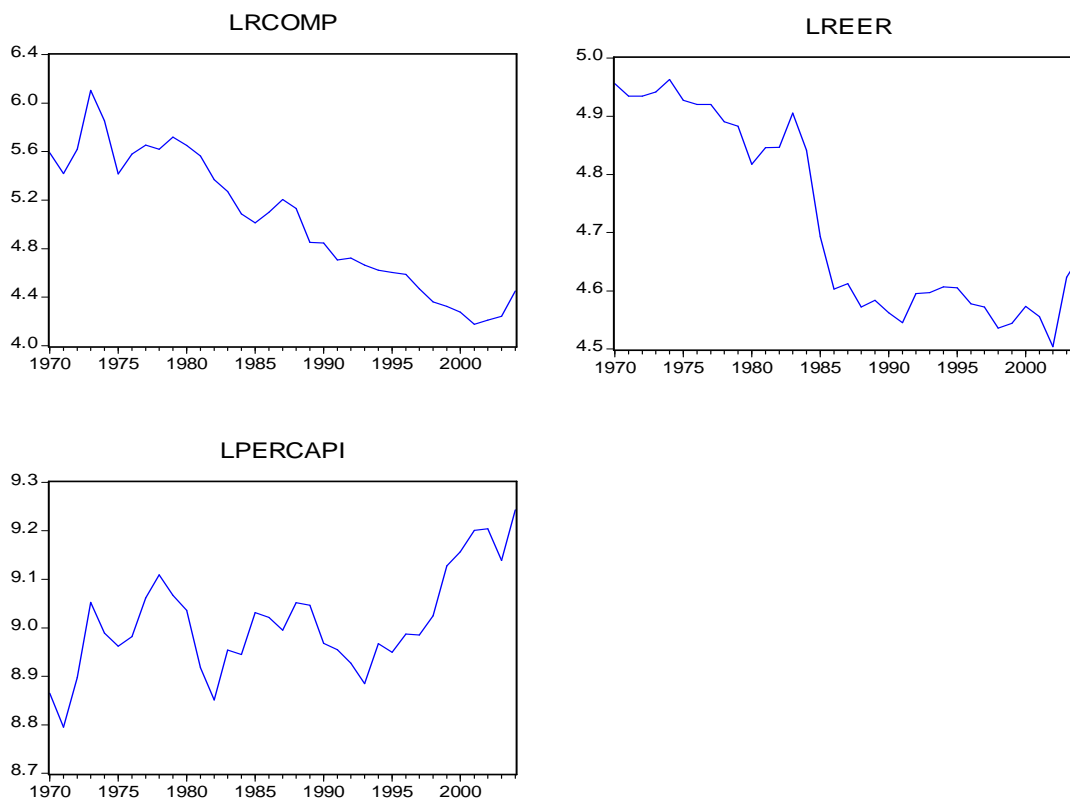
Since Namibia's real exchange rate is likely to be influenced by some South Africa's fundamentals, it is necessary to compare these results with those obtained for South Africa. A recent study on the equilibrium real exchange rate was conducted by MacDonald and Ricci (2004) and showed that like Namibia, the real exchange rate of South Africa was also undervalued during the period 1970 to 1972 and 1980 to 1985. However, it was undervalued during 1994 to 2002 while that of Namibia overvalued during the same period. While Namibia experienced low real exchange rate misalignment for the period 1994 to 1999, this was not the case for South Africa. These differences between the two countries are not unexpected because some of the fundamentals used in this study were not included in the estimation by MacDonald and Ricci. Similarly, this study does not include some of the fundamentals used by MacDonald and Ricci in the model estimated for South Africa. It has also been shown in Figure 1 in Chapter 5 that there is divergence observed between the real exchange rates of Namibia and South Africa.

## 5.5 Real Exchange Rate and Commodity Prices

### 5.5.1 Developments in Commodity prices and Productivity

Figure 10 plots the real effective exchange rate, real commodity prices and real GDP per capita. It can be seen that real commodity prices have been on a decreasing trend for the entire estimation period. The real effective exchange rate has also been on a decreasing (depreciating) trend. This suggests that real effective exchange rate and real commodity prices are moving together. Productivity as proxied by GDP per capita, fluctuated between 1970 and 1993 and then increased during the period between 1994 and 2004.

**Figure 10. Real effective exchange rate, real commodity prices and real GDP per capita (productivity proxy)**



## 5.5.2 Univariate Characteristics of the Variables and VAR Diagnostic Statistics

In order to estimate the empirical model the variables were tested for unit root (stationarity test). The results of unit root tests are presented in Table 14 in the Appendix. Diagnostic statistics were performed on the VAR for stability, serial correlation, normality, autocorrelation and heteroscedasticity. The diagnostic statistics show that the VAR is stable because all roots have modulus of less than one and lie within the unit circle. The VAR diagnostic test results show that there is no serial correlation, and heteroscedasticity. The errors are normally distributed.

## 5.5.3 Testing for Reduced Rank

Cointegration between the variables was tested using the Johansen FIML. The trace and maximum eigenvalues are presented in Table 7 below.

**Table 7. Johansen cointegration results**

<b>Null hypothesis</b>	<b>Alternative hypothesis</b>		<b>0.05 Critical value</b>	<b>Probability value <sup>b</sup></b>
<i>Trace statistic</i>				
r=0	r=1	59.218 <sup>a</sup>	35.193	0.000
r=1	r=2	18.134	20.262	0.096
r=2	r=3	8.196	9.165	0.076
<i>Maximum Eigenvalue statistic</i>				
r=0	r>0	41.084 <sup>a</sup>	22.300	0.000
r≤1	r>1	9.938	15.892	0.340
r≤2	r>2	8.196	9.165	0.076

<sup>a</sup> Denotes rejection of the null hypothesis at the 0.05 level

<sup>b</sup> MacKinnon-Haug-Michelis (1999) p-values

The trace and the maximum eigenvalue statistics show that there is one cointegrating vector. These statistics confirm the appropriateness of proceeding with the vector error

correction methodology (VECM). Since there is one cointegrating vector the VECM is visualised as follows:

$$\begin{bmatrix} \Delta LREER_t \\ \Delta LRCOMP_t \\ \Delta LPERCAPI_t \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \\ \mu_3 \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} \end{bmatrix} \begin{bmatrix} \Delta LREER_{t-1} \\ \Delta LRCOMP_{t-1} \\ \Delta LPERCAPI_{t-1} \end{bmatrix} + \begin{bmatrix} \alpha_{11} \\ \alpha_{21} \\ \alpha_{31} \\ \alpha_{41} \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{21} & \beta_{31} & \beta_{41} \end{bmatrix} \begin{bmatrix} LREER_{t-1} \\ LRCOMP_{t-1} \\ LPERCAPI_{t-1} \\ C \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix} \quad (21)$$

#### 5.5.4 Long-run Restrictions

The long-run restrictions are imposed in line with Cashin *et al.* theoretical framework. The long-run zero restrictions were imposed on real commodity prices (LRCOMP) and GDP per capita (LPERCAPI). Both restrictions were rejected and this means that real commodity prices and GDP per capita are important variables in the determination of real exchange rate of Namibia. These variables must be in the long-run equation of the determination of the real exchange rate. The long-run equation is represented as:

$$\pi X_{t-1} = \alpha \beta' X_{t-1} = \begin{bmatrix} \alpha_{11} \\ \alpha_{21} \\ \alpha_{31} \\ \alpha_{41} \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{21} & \beta_{31} & \beta_{41} \end{bmatrix} \begin{bmatrix} LREER_{t-1} \\ LRCOMP_{t-1} \\ LPERCAPI_{t-1} \\ C \end{bmatrix} \quad (22)$$

The long-run cointegration equation for the real effective exchange rate of Namibia can be written as (t-statistics in parentheses):

$$LREER = -4.592 + 0.330LRCOMP + 0.849LPERCAPI \quad (23) \\
 (-3.613) \quad (23.218) \quad (6.058)$$



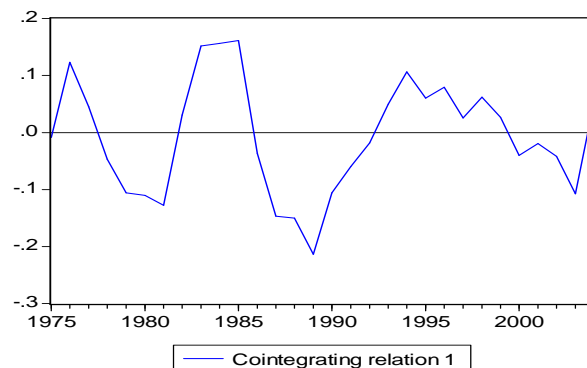
The results can be interpreted as follows:

- An increase in commodity prices by one percent causes an increase in real exchange rate or real exchange rate appreciation by 0.33 percent.
- An increase in GDP per capita, which is a proxy for technology by one percent causes real exchange rate to appreciate by 0.84 percent.

These results are consistent with Cashin *et al.* (2002, 2004) theoretical model predictions and empirical findings. The results are also in line with those obtained by Koranchelian (2005) for Algeria. Since Namibia is a commodity exporting country, fluctuations in real commodity prices have an impact on real exchange rate. The real exchange rate is also dependent on productivity and this is consistent with the Balassa-Samuelson hypothesis.

The cointegrated linear combination or cointegration relation is plotted in Figure 11 below. It appears stationary.

**Figure 11. Cointegration relations**



### 5.5.5 Exogeneity Test and Speed of Adjustment

The loading matrix measures the speed of adjustment and the degree to which the variables in the equation respond from the long-run equilibrium relationship. The elements of matrix  $\alpha_s$  relate to the issue of weak exogeneity. In a cointegrated system, if a variable does not respond to discrepancy from the long-run equilibrium it is weakly exogenous. If the variable is weakly exogenous, it means that it does not play any role in bringing the normalised variable in the long-run equation to equilibrium. Table 8 presents the results of the exogeneity test.

**Table 8. Exogeneity test**

Variable	LREER equation
$\Delta$ LREER	-0.332 (-1.700)
$\Delta$ LRCOMP	0.000
$\Delta$ LPERCAPI	0.775 (5.850)
LR test for binding restriction (rank = 1): $\chi^2(1)$ 2.343	
probability 0.126	

The results of the exogeneity test show that real GDP per capita variable is not weakly exogenous but moves the real effective exchange rate or the system away from equilibrium. It does not bring the real effective exchange rate into equilibrium. Real commodity price is weakly exogenous. It does not play any role in the bringing the real effective exchange rate into equilibrium. Disequilibrium in the real exchange rate is corrected only through adjustment in the real exchange rate itself.

If there is a gap between the actual real effective exchange rate and its equilibrium value, the real exchange rate will converge to its equilibrium value. This requires that the real exchange rate moves to the new equilibrium value or returns from its temporary deviation to its original equilibrium value.

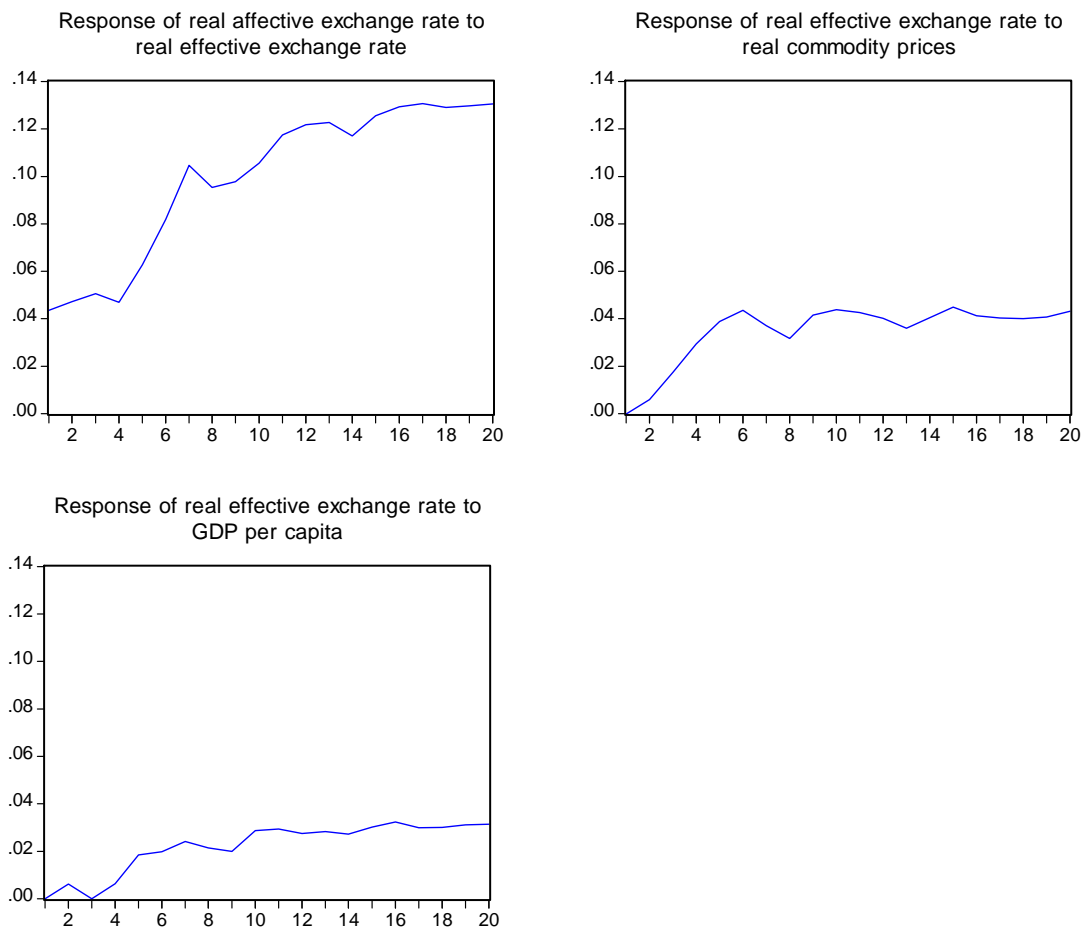
Since the ECM coefficient is -0.332, the cointegration relationship is stable. It shows that 33.2 percent of the deviations from the equilibrium are eliminated in the short run. This

implies that the adjustment process takes 1.7 years to eliminate 50 percent of the misalignments. This speed of adjustment is slightly longer than the one obtained under fundamental approach or three-good model.

### 5.5.6 Impulse Responses and Variance Decomposition

Impulse responses which show the response of the real exchange rate to shocks in real commodity prices and GDP per capita are plotted in Figure 12.

**Figure 12. Impulse response: response to Cholesky standard innovations**

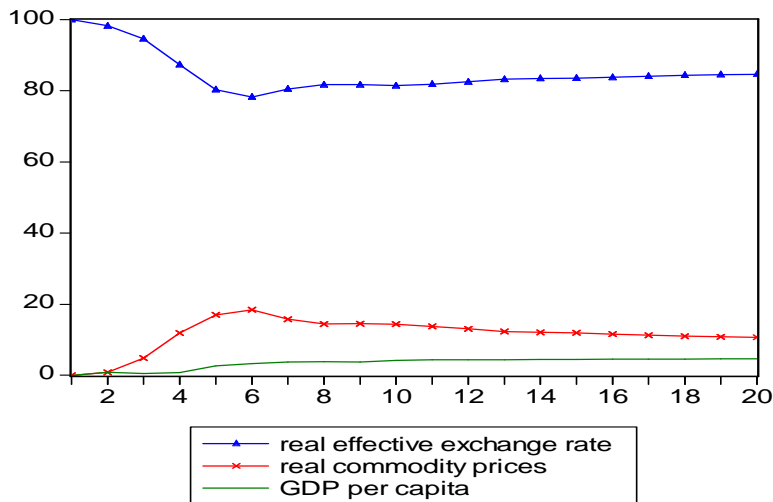


The real exchange rate responds positively to shocks from itself as well as to shocks from real commodity prices and GDP per capita. Both variables do not return to equilibrium, which indicate that policy makers are slow in responding to shocks that affect the economy. However, given the exchange rate regime in Namibia, policy makers can do

little to respond to disequilibrium in the real exchange rate because the exchange rate is determined by South Africa. Fiscal policy is the main instrument used by Namibian policymakers to adjust the economy to shocks.

Variance decomposition tests the relative importance of shocks in fundamental determinants in accounting for variations in the real exchange rate. The variance decomposition is plotted in Figure 13.

**Figure 13. Variance decomposition of the real exchange rate**



The results of the variance decomposition show that from the first to the second period real exchange accounts for 100 and 98 percent. From period 6 the real exchange rate accounts for over 80 percent of the variations in the real exchange rate. The real commodity prices account for zero percent of the variations in the exchange rate during the first and second period. It increased to 18 percent in period 6. It accounted for just over 10 percent of the variations in the real exchange rate from the 6<sup>th</sup> to 20<sup>th</sup> period. Real GDP per capita accounted for zero percent of the variations in the real exchange rate during the first 3 periods. It accounted for over 4 percent between period 6 and 20.

### 5.5.7 Robustness of the VECM Results

Several diagnostic statistics have been performed on the VECM to assess robustness of the results. The results are robust because they passed all diagnostic statistics. The diagnostic test results are presented in Table 9.

**Table 9. Diagnostic statistics of the VECM**

	H <sub>0</sub>	Test	Statistic	Probability	Decision
Serial correlation	No serial correlation	LM test- $\chi^2$ (lag 4)	12.133	0.206	No serial correlation
Normality	Error terms are normally distributed	JB-Joint	17.458	0.008	Errors are normally distributed
		Kurtosis – Joint	16.954	0.000	
		Skewness - Joint	0.504	0.918	
Heteroscedasticity	No heteroscedasticity	$\chi^2$	154.501	0.519	No heteroscedasticity

The diagnostic test results show that there is no serial correlation and no heteroscedasticity. The error term is white noise even though there is lack of normality because of kurtosis. Paruolo (1997) states that if normality is rejected because of kurtosis the Johansen results are not affected as long as the skewness is fine (see also Sichei *et al.* 2005: 24).

### 5.5.8 Equilibrium Real Exchange Rate

The estimated long-run relationship allows the equilibrium real exchange rate to be computed. Like in the fundamental approach, the equilibrium real exchange rate was computed by imposing the estimated long-run coefficients on the permanent values of the fundamentals. The values of the permanent fundamentals were obtained by using Hodrick Prescott filter. The Hodrick-Prescott filter with a smoothing factor of 100 was used to smooth the variables (real commodity prices and GDP per capita). The actual and equilibrium real exchange rate are plotted in Figure 14.

**Figure 14. Actual and equilibrium real exchange rate**

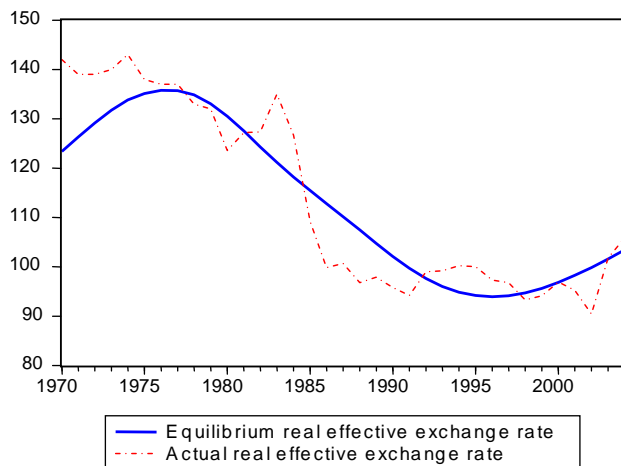


Figure 14 shows that the real exchange rate has been on a depreciating trend since the 1970s. The real exchange rate was overvalued during the periods 1970-1977, 1982-1984, and 1992-1997. It was undervalued during the periods 1978-1981, 1985-1991 and 1998-2002. Misalignment of the real exchange rate is plotted in Figure 15.

**Figure 15. Real exchange rate misalignment**



The highest overvaluation of the real exchange rate was in 1970 and 1983, while the highest undervaluation took place in 1986. Misalignment was relatively low between 1990 and 2004.

## 5.6 Conclusion

This chapter estimated the equilibrium real exchange rate and the resulting real exchange rate misalignment for Namibia. The estimation was based on the three-good model and the Cashin *et al.* model of real exchange rate and commodity prices. The equilibrium real exchange rate for both models (three-good and Cashin *et al.*) was estimated using the Johansen FIML. According to the three-good model, the real exchange rate is determined by openness, government expenditure, resource balance, terms of trade and the ratio of investment to GDP. An increase in both variables causes real exchange rate depreciation. The results are consistent with the *a priori* expectations.

The variance decomposition analysis showed that real exchange rate accounted for about 30 percent of the variations in itself, while terms of trade account for about 50 percent of the variations in the real exchange rate. The ratio of investment to GDP accounts for just under 30 percent between periods 4 and 8 and under 10 percent of the variations of the real exchange rate. Government expenditure, resource balance, and openness account (each) for just under 10 percent of the variations of the real exchange rate.

The estimation results illustrates that the real exchange rate was overvalued for the periods 1970-1972, 1982-1985 and 1999-2004. The highest overvaluation was during the periods 2002, 2004 and 1985. The real exchange rate was undervalued during the periods 1973-1981, 1986-1991 and 1996-1998, and the highest undervaluation happened in 1980. The highest real exchange rate misalignment occurred in 1980 and 2002 to 2004. The speed of adjustment shows that it takes 1.07 years to eliminate 50 percent of the deviations from equilibrium.

The estimation results from the model of the real exchange rate and commodity prices show that an increase in commodity prices causes real exchange rate appreciation and this confirms the theory and findings of the literature. An improvement in technology proxied by GDP per capita is also associated with real exchange rate appreciation. The impulse responses show that both variables do not return to equilibrium and this may suggests that

policy has been slow in responding to shocks that affect the economy. Variance decomposition revealed that commodity prices account for about 20 percent of the variation in real exchange rate, while GDP per capita accounts for less than 5 percent. The speed of adjustment is 1.7 years and this is longer than the one obtained under the three-good model. The estimation showed that real exchange rate was overvalued during the periods 1972-1977, 1982-1984 and 1992-1997. The results have implications for monetary and exchange rate policies. From the literature on exchange rate, the nature of the real shocks determines the behaviour of the real exchange rate and not the type of exchange rate regime. If real shocks have a dominant influence on the real exchange rate, a commodity exporting country can have either a flexible nominal exchange rate regime which facilitates the slow change of relative inflation rate, or can have price and wage flexibility in order to facilitate the maintenance of nominal exchange rate peg.

In proposing a monetary regime for small commodity exporting countries, Frankel (2003) argues that small countries that want a nominal anchor and concentrate on the production of a mineral or agricultural commodity, should peg their currencies to the prices of those commodities. For these countries, movements in the value of their currencies which result from fluctuations in the world commodity market would not be an external source of volatility. Frankel (2003: 69) stated that in these cases, insulation which is normally thought to be provided only by flexible exchange rate is instead provided by pegging to the prices of commodities. Since Namibia is a commodity exporting country, this argument suggests that the country is a good candidate for pegging its currency to the prices of the main commodities exported. However, it is important to state that the monetary authorities of Namibia affirmed their commitment to the CMA as long as South Africa continues to pursue prudent economic policies. A determination of whether South African monetary and exchange rate policies are sound falls outside the scope of this study. It is also important to note that countries are moving towards regional integration. Namibia is a proponent of the regional integration in Southern Africa. The Southern African Development Community (SADC) is aiming at establishing a monetary union in 2016 and a move by Namibia out of the CMA will not be consistent with SADC's objective.