CHAPTER IV

Estimating Equilibrium Exchange Rate with Edwards' Model

4.1 Introduction

The PPP model estimates the exchange rate solely based on the assumption that the moving of stock or products are due to differences of prices for the countries concerned and this will lead to the equilibrium exchange rate in long-run. This also assumes no trade restriction, and no government intervention through monetary policy or fiscal policy that will affect the movement of stock or capital. But this assumption is not realistic in the real world.

Liberalization in capital market of Malaysia prior to economic crisis in 1997 had encouraged substantial capital inflows and put upward pressure on the real exchange rate of ringgit Malaysia (RM). In these circumstances, the policy maker faced the option of either intervening in the exchange market and tightening the fiscal policy to counteract the upward pressure of ringgit Malaysia against United States dollar (USD) and to maintain the competitiveness of the tradable sector. Alternatively the policy can be left unchanged, then raising the specter of an unsustainable current account deficit down the road. So there is a policy dilemma between keeping the current pegged exchange rate or introducing flexibility in the foreign exchange market and hoping a market driven correction would happen in medium-term.

During the financial crisis in 1997, Malaysia experienced a huge capital outflows with the capital control imposed in September 1998 and foreign exchange has been pegged at RM3.80 to USD to restore the market confidence and to halt the outflow of foreign capital. In view of most of the currencies of Asian countries were depreciated during the recession and the low labor cost in developing countries like China and Thailand, Malaysia faced competitive pressure to peg ringgit Malaysia at RM3.80 to USD. We need to consider whether the ringgit Malaysia is still competitive to be pegged at RM3.80 to USD.

Edward's model is employed to estimate the real effective exchange rate (REER) by studying the fundamentals of the economy. In the contest of policy dilemma, it is important to determine whether the real exchange rate is consistent with the fundamental exchange rate after the effectiveness of capital control policy. If the exchange rate is in line with fundamental variables of economy, then there is no reason to believe that a move to a more flexible exchange rate policy would lead to the desired appreciation or depreciation. On the other hand, if the real exchange rate is indeed mis-aligned, a flexible exchange rate would tend to reduce the misalignment over the medium-term.

4.2 Literature Review on Edwards' Model

Feyzioglu (1997) estimated the equilibrium real exchange rate. Equilibrium real exchange rate (ERER) of Finland was estimated by using the reduced forms for the period 1975-1995 implied by a theoretical model along the lines of Edward's model. The long-run ERER is the exchange rate level that is consistent with simultaneous internal and external balances of economy. Cointegration technique was used to estimate the reduced form. The equilibrium exchange rate appreciated with positive shocks to term of trade, world real interest rates and the productivity differential between Finland and its trading partners. The real exchange rate moved to correct short-run disequilibrium slowly. The real exchange rate was affected positively by the price differential between Finland and its trading partners and by deviation from uncovered interest parity.

External equilibrium is attained when the level of consumption and the real exchange rate lead to a sustainable current account balance. Internal equilibrium is defined by non-traded goods market balance. Short-run dynamics that are consistent with long-run equilibrium are modeled as an error correction mechanism. It is affected by the past deviation from the equilibrium. All the coefficients in short-run model are highly significant.

Macdonald (1995) used reduced form model of the real exchange rate multilateral cointegration methods on real effective exchange rate of the dollar, mark and yen for the period 1974-1993.

Sources of trends in the long-run real exchange rate in his models are the fundamental determinants, namely fiscal balances, net foreign assets and real interest rates. Significant long-run relationships for REER were shown for mark, dollar and yen. Short-run behavior was examined by calculating the impulse response functions for real exchange rate with respect to orthogonalised shocks on fundamental variables. The impulse response analysis provided a set of results that were statistically significant. The modeling exercise indicated that fundamentals have an important and significant determination on both long-run and short-run exchange rate.

Mongardini (1998) estimated empirically Egypt's equilibrium real exchange rate (ERER) that was consistent with the economic fundamentals. In his model, ERER was only able to provide an estimate of medium-term competitiveness of economy, and it did not take into account of the long-term growth benefits of a vibrant external sector. This is quite relevant for Malaysia, as we want to forecast the medium-term exchange rate in the capital control period. Competitiveness and ERER of ringgit Malaysia are also depend on exchange rate of other Asian countries. Mongardini has developed an model for Egypt based on Edward's model. Edward's model is an inter-temporal general equilibrium model for a small open economy where both tradable and non-tradable products are exchanged. Time was comprising of short- and long-run behaviour economy, and show no substantial differences in infinite horizon.

Internal equilibrium is determined by clearing of all non-tradable markets (static equilibrium). External equilibrium holds when net present value of future current account is not negative, given the level of exogenous long-run capital inflows.

The kernel of empirical analysis is to determine ERER by modeling the fundamental changes in the level of the actual exchange rate from temporary influences brought about by nominal exchange rate shifts as well as changes in monetary and fiscal policies.

Fundamental variables that stated in the model for Egypt are as the following:

- The debt service ratio. When the debt service ratio reduce, and the balance of current account increases substantially, this will bring appreciation of ERER.

- A Gulf war dummy for the period of August 1990 to March 1991 brought downward pressure to the real effective exchange rate (REER).

- Nominal depreciation was measured by changes in the nominal effective exchange rate (NEER).

- Overall government consumption as a percentage of GDP was used in the model due to no government consumption of non-tradable goods is available.

- Lagged capital account balance as a percentage of GDP was used as a proxy to measure capital controls.

- Dummy variable was used for trade and exchange liberalization policy in January 1991 when most exchange rate restriction were lifted.

- Estimated total factor productivity was used to measure technological progress.

Econometric results were statistically significant. From the results, it showed that Paris Club debt relief phased in during 1991-1996 had significant impact on ERER.

4.3 Edwards' Model

Mongardini (1998) employed the Edwards' model to estimate the Egypt's equilibrium real exchange rate (ERER). Edwards' model determines equilibrium real exchange rate by disentangling fundamental changes of actual exchange rate from temporary influences brought about by nominal exchange rate shifts as well as monetary and fiscal policy changes.

i) Fundamental factors that are affecting ERER

$$\log(e_t') = \beta\gamma_0 + \beta_i \log(FUND_{it}) + u_t \qquad (4.1)$$

e'_t is equilibrium real exchange rate (ERER)

β_0 is intercept

β_i is partial coefficient

$FUND_{it}$ is vector of fundamental variables

u_t is disturbance term

ii) Dynamics of real exchange rate

Edwards' model also assumes that in the short-run real exchange rate adjusts to equilibrium exchange rate at a speed given by the parameter θ. The equation is as following:

$$\Delta\log(e_t) = \theta[\log(e'_t) - \log(e_{t-1})] - \lambda[Z_t - Z_t'] \qquad (4.2)$$

e_t is real exchange rate

Z_t is vector of measuring fiscal and monetary policy

Z_t' is vector of policy measures that is consistent with equilibrium rate.

λ is speed of adjustment to the policy gap

The real exchange rate level adjusts between today and tomorrow in the direction of the equilibrium exchange rate, and adjustment speed θ is the time needed for relative price in economy to adjust. Changes in policy variables away from the optimal level will affect the adjustment positively or negatively. This dynamic equation states that the real exchange rate will revert to equilibrium exchange rate in the long-run.

By substituting equation 4.1 into 4.2, we get the following reduced form equation for the real exchange rate.

$$\log(e_t) = \alpha_0 + \alpha_i \log(FUND_{it}) + (1-\theta)\log(e_{t-1})] - \lambda[Z_t - Z_t'] + v_t \qquad (4.3)$$

α_i is combination of βi and θ

Equation 4.3 can be estimated empirically. From the estimated result of parameter α_i, the coefficients of equation 4.1 can be derived. Then we can estimate the equation of real exchange rate with the assumption that long-run elasticities of the nominal depreciation and the policy variables are zero. This also means that all policies and nominal factors do not affect equilibrium exchange rate.

The following are important factors selected in Edwards' model that summarize by Mongardini and these factors are also included in our model:

- The external term of trade (TOT) is defined as the ratio of world price of a country's export over the world price of its import. Index of TOT is estimated by gross export in ringgit Malaysia divided by gross import in ringgit Malaysia. An improvement in term of trade will have positive impact on current account, and lead to appreciation of ERER.

- Government consumption of non-tradable goods (GCN). An increase in public consumption of non-tradable vis-à-vis tradable will improve the current account, and lead to appreciation of ERER.

  As the government consumption of non-tradable is not available, then the overall government consumption as a percentage of GDP will be used.

- The severity of capital and exchange rate controls. (CCD). A liberalization of current account usually lead to an increase of imports, a worsening of current account, and thus a depreciation of ERER. However, capital control that deter the outflow of capital may lead to real appreciation of ERER. Dummy variable will be used to account for capital control and fixed exchange rate policy since September 1, 1998.

- Technological progress to GDP (TECH). Technological progress will increase productivity in economy and thus lead to appreciation of the ERER. This is a well-known Balassa Samuelson effect which suggests that productivity improvement will generally concentrate in tradable sector. Using industrial production index as an indicator for technological progress.

- Debt service ratio (DEBT) is the index estimated from total external debt divided by GDP. This index is to reflect debt burden to reflect debt sustainability of the nation. If the debt service ratio falls permanently, this will improve the sustainability of the current account and lead to an appreciation of the ERER.

In addition to the fundamental variables outlined above, Edward and Mongardini used excess supply of domestic credit and the ratio of fiscal defisit to lagged high powered money as variables to measure effect of monetary and fiscal policies on real exchange rate. The following variables will be used for monetary policy:

- Money supply (MS) is estimated as total currency in circulation which is comprising of demand deposit, saving deposit, fixed deposits, NIDs Repos and foreign currency deposits. They are also known as M2 in total. When MS increases market interest rate will reduce and this will lead to a depreciation of ERER.

- Interest rate (IR) is referred to inter bank rate on over night money as index. When government reduces the interest rate, demand of money will increase. This is due to the opportunity cost of holding money is reduced. This will lead to an appreciation of ERER for a given level of real income and price.

The comparison of long-run and short-run variables used in Edwards' model for different research papers namely Edward, Mongardini and Yoong are summarised in Table 4.1.

Table 4.1 Comparison on Variables Used in Edwards' Model for Different Research Papers

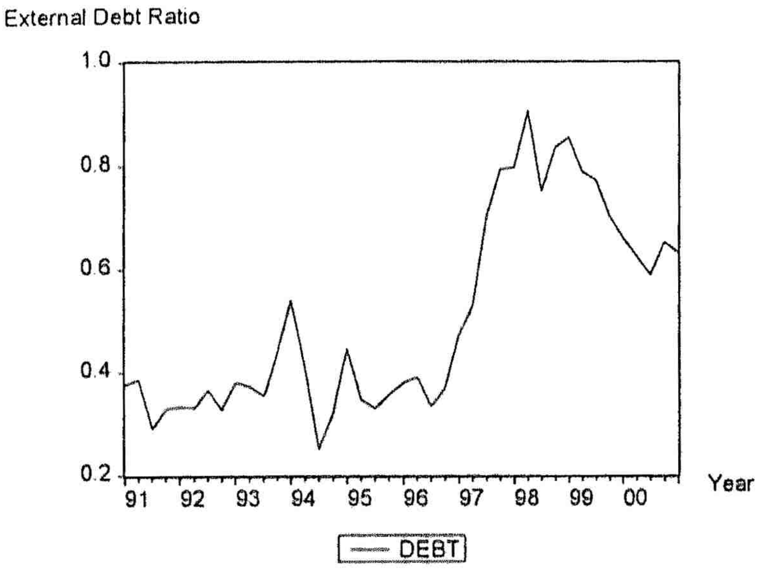
		Sebastian Edwards (research for 33 developing countries)	Joannes Mongardini (research paper for Egypt)	Yoong (research paper for Malaysia)
Long -run Edwards' Model Variables	Short-run Edwards' Model Variables	**Fundamental variables that are affecting ERER**		
		Term of Trade	Term of Trade	Term of Trade
		Government Consumption of non-tradables	Government Consumption in percent of GDP	Government Consumption in percent of GDP
		Control over capital flows	Lagged capital account balance in percent of GDP	
		Severity of trade restrictions and exchange rate		
		Technological Progress	Technological innovation	Index of Industrial output
		The ratio of investment to GDP		
			Debt service ratio	Ratio of external debt to GDP
			Gulf War Dummy	
			Lag of real effective exchange rate	Lag of real effective exchange rate
		Variables for monetary and fiscal policy		
		Excess supply of domestic credit	Excessive Credit	Money Supply
		Ratio of fiscal deficit to lagged high powered money	Ratio of Fiscal Deficit to H-Money	
			Nominal Depreciation	
				Interest Rate
				Capital Control Dummy

Notes:
ERER is equilibrium real exchange rate

4.4 Data

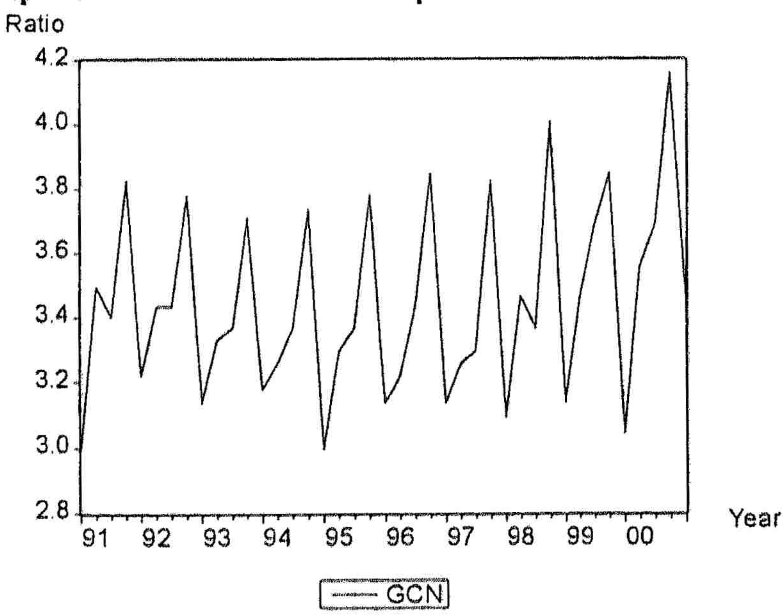
All data used is obtained from monthly bulletin reports from Central Bank of Malaysia for year 1991-2001. Quarterly data for the period 1991:Q1 to 2001:Q1 is used for the above model.

Graph 4.1 Ratio External Debt to GDP Malaysia



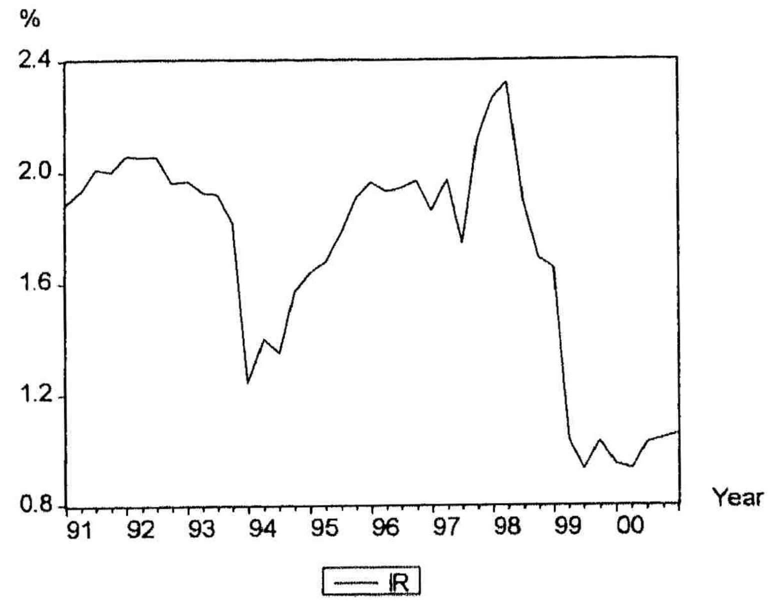
Notes: Debt is the external debt ratio to GDP

Graph 4.2 Government Consumption in Percent of GDP Malaysia



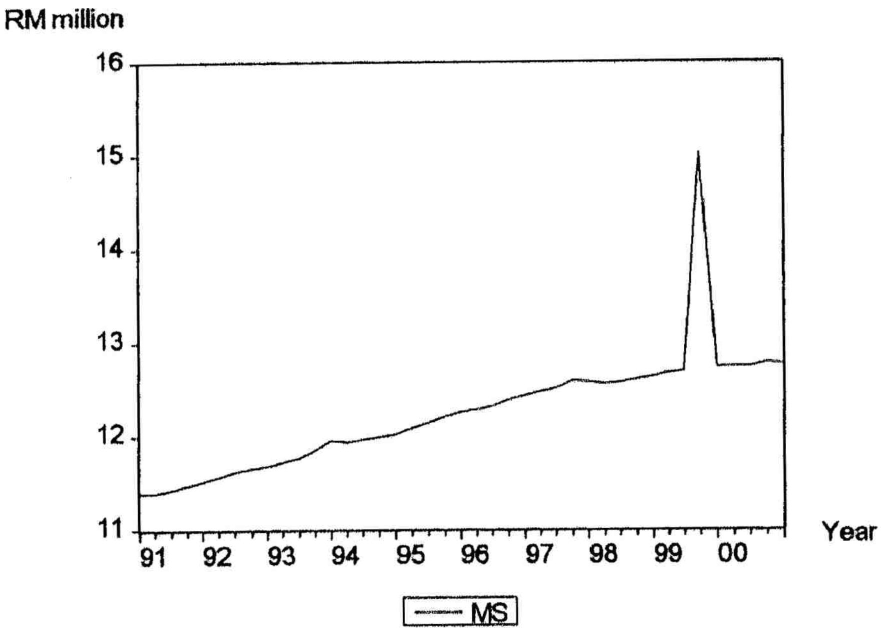
Notes: GCN is the government consumption in percentage of GDP

Graph 4.3 Interest Rate of Malaysia



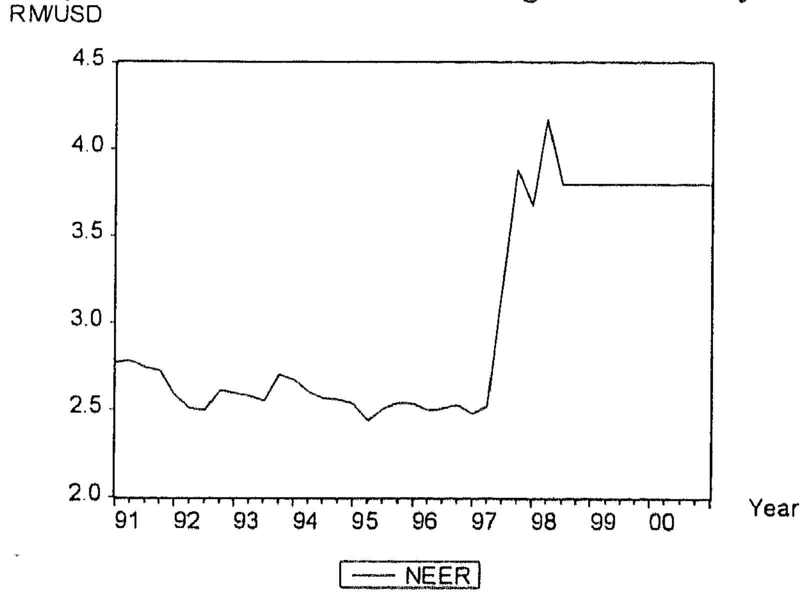
Notes: IR is the weighted average interbank rates of overnight money

Graph 4.4 Money Supply of Malaysia



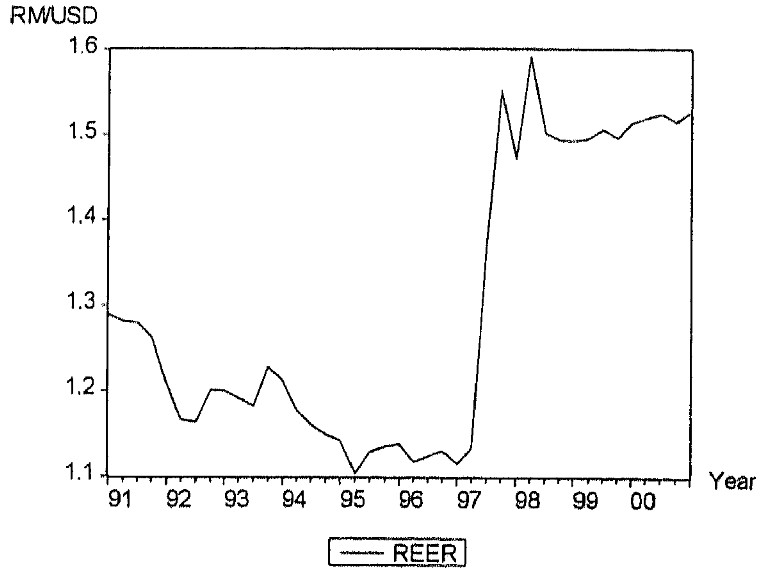
Notes: MS is the money supply (M2)

Graph 4.5 Nominal Effective Exchange Rate of Malaysia



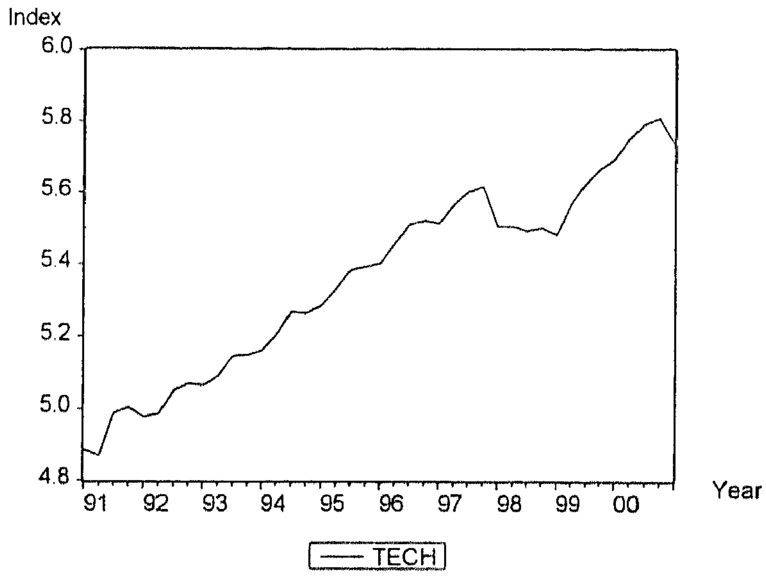
Notes: NEER is the nominal effective exchange rate

Graph 4.6 Real Effective Exchange Rate of Malaysia



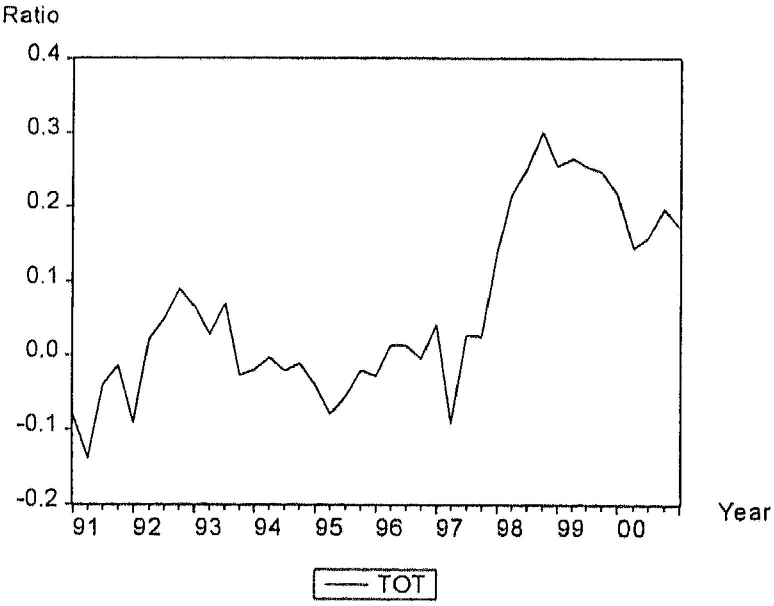
Notes: REER is the real effective exchange rate

Graph 4.7 Index of Industrial Output of Malaysia



Notes: TECH is the index of industrial output

Graph 4.8 Term of Trade of Malaysia



Notes: TOT is the term of trade

4.5 Econometric Results

To estimate equation 4.3, we need to first test the stationarity of the fundamental variables and then proceed with the appropriate estimation procedure. Unit root test is testing the stationarity of variables in particular model. Augmented Dickey Fuller test is employed to test the stationarity of variables. We perform the regression $\Delta Z_t = \alpha Z_{t-1} + \Sigma^{p}_{i=1} \beta_i \Delta Z_{t-1} + \varepsilon_t$, then under the null hypothesis that $\alpha = 0$, against $\alpha < 0$, we perform a t-test to find whether α is significantly less than zero. The t statistic on α is the augmented Dickey Fuller statistic.

Unit root test is very important prior to the estimation of the model for the cointegration test. Cointegration test strictly requires all variables are integrated of the same order. Series cannot be cointegrated if they are integrated of different orders. All test statistics are integrated at $I(1)$ level, we then proceed to estimation procedure.

From the unit root test in Table 4.2, we understand that all the variables are nonstationary at level and stationary at first level. If the error term or residuals from the estimated equation 4.3 and 4.1 are $I(0)$ or stationary, then we say that variables are cointegrated. This also means that these variables are on the same wavelength, and equilibrium relationship appears among the exchange rate and variables in the Edwards' model. Cointegration means that despite being individually nonstationary of variables in a specific model, a linear combination of two or more series can be stationary. This also suggests that there is a long-run or equilibrium relationship between the difference series. Ordinary least square method will be used to estimate the equation 4.3 (short-run Edwards' model) and 4.1 (long-run Edwards' model).

Table 4.2 Unit Root Tests for Variables in Edwards' Model

Variable	ADF Test Statistic for level	ADF Test Statistic for 1st difference
Real effective exchange rate (REER)	0.491802	−3.820202[b]
Terms of Trade (TOT)	−0.840920	−4.136222[b]
Government consumption in percent of GDP (GCN)	0.066213	−6.811183[b]
Technological innovation (TECH)	2.566639	−3.846697[b]
Debt service ratio (DEBT)	0.038502	−4.986310[b]
Money Supply (MS)	0.612993	−7.066844[b]
Interest Rate (IR)	−0.950148	−3.749732[b]

Notes:
[b] significance at 5% confidence level
ADF test is augmented Dickey Fuller test

OLS test on the model comprising of the following stage:

i) Short-run model with different time frame (equation 4.3):

a) For the period of 1991:Q1 – 1998:Q3

b) For the period of 1991:Q1 – 2001:Q1

ii) Long-run model with different time frame (equation 4.1):

a) For the period of 1991:Q1 – 1998:Q3

b) For the period of 1991:Q1 – 2001:Q1

The following Table 4.3 is summary of OLS test results for all the above four models:

Table 4.3 Short-run and Long-run Edwards' Model for 1991:Q1 – 1998:Q3

		Short-Run		Long-Run	
	Expected Sign of var.	1991:Q1-1998:Q3	1991:Q1-2001:Q1	1991:Q1-1998:Q3	1991:Q1-2001:Q3
	Dependent Variable: Real effective exchange rate				
Variable		Coefficient *t* value	Coefficient *t* value	Coefficient *t* value	Coefficient *t* value
Constant		2.682 [b] (5.025)	0.116 (0.375)	1.825 [b] (6.581)	0.951 [b] (2.863)
Lag REER		0.572 [b] (6.514)	0.669 [b] (6.892)		
Term of Trade (TOT)	Negative	0.044 (0.459)	−0.147 (−1.112)	0.125 (0.858)	0.324 (1.843)
Government consumption in percent of GDP (GCN)	Negative	0.082 [b] (3.395)	0.067 [b] (2.421)	0.104 [b] (2.673)	0.081 (1.790)
Technological innovation (TECH)	Negative	0.861 [b] (4.022)	0.036	−0.250 [b] (−4.874)	−0.051 (−0.805)
Debt Service Ratio (DEBT)	Positive	0.674 [b] (9.153)	0.372 [b] (4.462)	0.835 [b] (10.033)	0.632 [b] (5.529)
Interest Rate (IR)	Negative	−0.019 (−0.723)	−0.011 (−0.315)		
Money supply (MS)	Positive	−0.602 [b] (−4.552)	−0.022 (−1.068)		
Capital Control Dummy (CCD)	Positive		0.007 (0.162)		
Sample size		30	40	31	41
R^2		0.963112	0.944105	0.865324	0.80785
Standard error of regression		0.030	0.045	0.053	0.078
Correlogram of residuals for the model		Non stationary	Stationary	Stationary	Non stationary

Notes:

[b] significant at 5% confidence level.

Overall cointegration results in Table 4.3 show a high value of R^2 and low standard errors of regression when tested with correlogram for the residuals of the models. Only two models are stationary, namely short-run model for period 1991:Q1 – 1998:Q3 and long-run model for the period 1991:Q1 – 2001:Q1.

Capital control dummy variable performs poorly in the above model. The coefficient is very low which is only 0.007 and not significantly different from zero. This may be due to the sample period for the capital control to take into effect as this period (1998:Q4 – 2001:Q1) is too short to justify the effect of capital control policy.

The estimated coefficient on the lagged REER of 0.67 for short-run model from 1991:Q1-1998:Q3 (θ=0.33) implies a slow speed of adjustment (θ) to shocks in fundamental variables. These results are similar to the results obtained by Mongardini (θ =0.2 for Egypt.). In Mongardini's model (1998), a positive unitary shock would be reflected in the equilibrium rate by 50% after 5 months, by 75% after 8 months, and by 90% after 11 months, and this is coefficient is similar to the results estimated by Edward, where θ varies from 0.739 to 0.941 for 33 developing countries.

Variables for the term of trade and interest rate perform badly and not significantly different from zero. The coefficient for money supply shows the wrong sign. Government consumption as percentage of GDP although is significant, but shows a different sign from expectation. An increase in public consumption of non-tradable vis-à-vis tradable will improve the current account and this will lead to appreciation of ERER. However, the data for government consumption of non-tradable is not available and we therefore employ the data of total government consumption as replacement. Coefficient of the government consumption in percent of GDP shows a positive sign which is different from the expected positive sign. This may be due to the fact that government consumption on tradable is relatively high during the sample period.

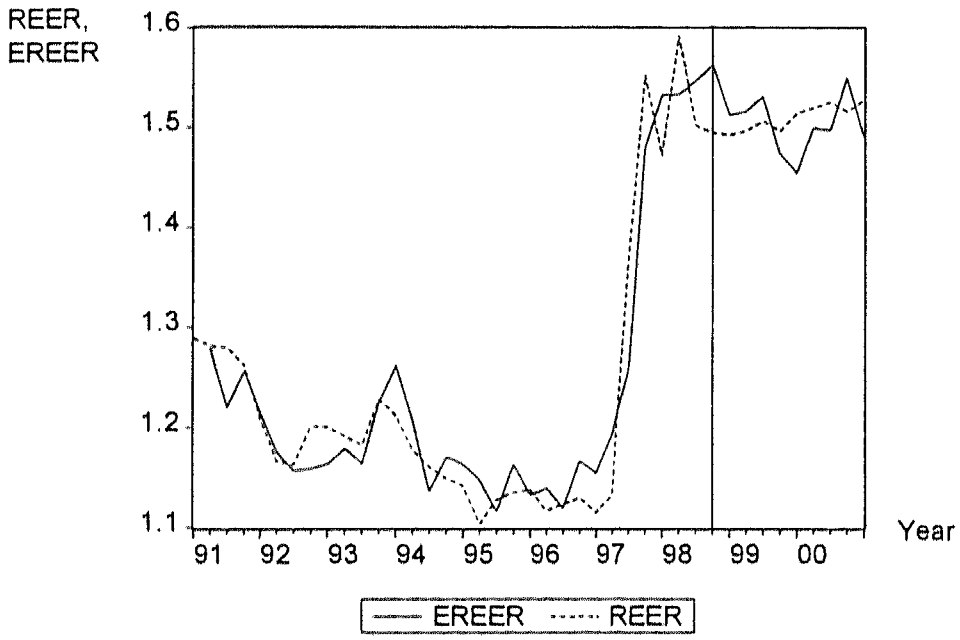
Debt service ratio performs well in the model. Coefficient shows a high value of 0.37-0.84 for the above models and significantly different from zero. Debt service ratio affects real effective exchange rate significantly for short and long-run period.

4.6 Estimate Real Exchange Rate with Edwards' Model

This section estimates the REER for the long-run Edwards' model, estimated for the period 1991:Q1 –1998:Q3. The results are shown as in the Graph 4.9. For period prior to 1998:Q4, both real effective exchange rate (REER) and the estimated real effective exchange rate (EREER) are on the different lines that near to each other. But after capital control take into effect on September 1998, both REER and EREER are split to two different lines that far apart from each other. As the ringgit Malaysia is pegged at RM3.80 to USD, REER is shown as a more stable dotted line as compared to the estimated EREER, with is a more fluctuated line.

From the Graph 4.9, we can clearly know that prior to the period 1999:Q3, REER is lower than EREER. This also means that ringgit Malaysia is pegged at an over valued level as compared to real EREER, given all fundamental economic variables. However after 1999:Q3, ringgit Malaysia is under-valued by pegging at RM3.80 to USD.

Graph 4.9 Real Effective Exchange Rate and Estimated Real Effective Exchange Rate Based on Short-run Edwards' Model



Notes:

EREER is the estimated real effective exchange rate and REER is the real effective exchange rate.

4.7 Conclusion

In this chapter, we set out to shed some light on the estimation of the equilibrium real exchange rate based on the development of the fundamental economy of Malaysia in the past ten years.

In the recent years, a lot of studies are forecast on estimating equilibrium real exchange rate with consideration on external competitiveness, internal and external economic equilibrium. Government policy on pegging of exchange rate should be consistent with economic fundamentals. Edwards' model is employed to estimate equilibrium exchange rate of Malaysia. Edwards' model determines equilibrium real exchange rate by disentangling fundamental changes of actual rate changes from temporary influences brought about by exchange rate shifts. The changes in monetary and fiscal policies are accounted as temporary influences to exchange rate shifts. On the other hand, the fundamental factors affect ERER according to the development of economy.

We have estimated the short-run and long-run version of Edwards' models. Long-run Edwards' model consists of the fundamental variables, and the short-run Edwards' model consists of fundamental variables as well as variables for monetary and fiscal policies. Fundamental variables are term of trade, government consumption in percentage of GDP, index of industrial output, ratio of external debt to GDP and lag of real effective exchange rate. Variables for monetary policy are money supply, interest rate and capital control dummy.

Quarterly data from bulletin report of Central Bank of Malaysia is employed. Short-run and long-run models are estimated based on two different time frames, namely from 1991:Q1 to 1998:Q3 and from 1991:Q1 to 2001:Q1.

Econometric results of unit root test show that all variables are stationary at first difference. Therefore we can use cointegration test through ordinary least squares method to estimate all the short-run and long-run Edwards' models. Edwards' short-run model shows that residuals for period of 1991:Q1 to 2001:Q1 is stationary through correlogram of residuals. However residual of the model for the period 1991:Q1 to 1998:Q3 is nonstationary. On the other hand, residuals of long-run Edwards' model is stationary for the period of 1991:Q1 till 1998:Q3, and nonstationary for the period of 1991:Q1 till 2001:Q1. Debt service ratio behaves well in all the above models.

Estimating the REER through Edwards' model show that after the ringgit Malaysia pegged at RM3.80 to USD, ringgit Malaysia is under-valued till 1999:Q3. After 1999:Q3 ringgit Malaysia is over-valued.