RATIONAL EXPECTATIONS AND MONETARY POLICY IN MALAYSIA

David L. Schulze and Jong-Say Yong

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Department of Economics
University of New England
Armidale
New South Wales 2351
Australia

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David L. Schulze
The University of New England

Jong-Say Yong
National University of Singapore

I INTRODUCTION

Rational expectations theorists have produced a substantial body of empirical evidence to support their conclusion that, with the rational expectations hypothesis and a classical market clearing framework, money is neutral.[1] The original theoretical and empirical studies used closed developed economy models and data. N. W. Duck[2] extended the theoretical rational expectations model to open economies.

Nevertheless, many governments still regard monetary policy as a useful counter-cyclical tool. Malaysia is no exception, as the following statement by the central bank, Bank Negara Malaysia[3], indicates:

"Because the Bank can affect the flow of credit and money as economic conditions change, it is in a good position to counteract instability in the economy arising from other forces. Efforts by the Central Bank to minimise cyclical fluctuations in economic activity with price and external stability helps to foster an environment in which the nation can progress at a pace consistent with its growth potential."

The objectives of this paper are to test the hypotheses that expectations are formed rationally and that money is neutral in Malaysia. This is of interest for economic policy making in Malaysia and also provides some evidence for the applicability of the rational expectations model and its conclusions to developing economies. Section II reviews Duck's Macro Rational Expectations model (MRE) for open economies. Section III discusses the econometric methods used in Section IV for the estimation and testing of the MRE model. Section IV presents the empirical results and their implications for the conduct of monetary policy in Malaysia. Section V provides some concluding remarks.

II Duck's Open Economy MRE Model

Duck[4] extended the island concept of Lucas[5] to the case of an open economies by introducing an external sector. His model preserves the main features of the closed MRE model : markets are assumed to clear continuously and instantaneously; economic agents do not have perfect information; and expectations are formed rationally. This section describes Duck's model in some detail as it serves as the basis for Models (A) - (D) in Section III.

Assume that there are two countries, H and F, in which there are h and f 'islands' (goods markets), respectively. Suppliers in all markets are local citizens, while demanders can be citizens of either country. Legal tender is assumed to be the currency of the country in which the market is located, creating a foreign exchange market to which all individuals have access. Also assume that each country has a population proportional to the number of its markets, i.e. the population of H and F are hq and fq, respectively. Furthermore in each country half the population are suppliers and half demanders. The suppliers are randomly distributed across the markets in their country while demanders are randomly distributed across the markets of both countries. Hence, the proportion of foreign demanders is f/(h+f) in H and h/(h+f) in F.

Each market participant is assumed to observe only the current price in his own market but not current prices of other goods. Thus supply and demand in all markets are influenced by a locally perceived relative price term, i.e. the actual local price in relation to the expected general price level. The supply function for market i in H at time t is,[6]

$$y_t^s(Hi) = \beta_0 + \beta_1 [P_t(Hi) - E_{Hi}(PW_t^H)] \tag{1}$$

where $P_t(Hi)$ is the local price, E_{Hi} the subjective expectations of the suppliers in market i and PW_t^H the world price level expressed in terms of country H's currency. Where

$$PW_t^H = \frac{h}{h+f} PH_t + \frac{f}{h+f}(PF_t + e_t) \tag{2}$$

Where PH is the average price level in country H and PF the average price in country F, i.e.,

$$PH = \frac{1}{h} \sum_{i=1}^{h} P(Hi)$$

and

$$PF = \frac{1}{f} \sum_{i=1}^{f} P(Fi).$$

and

e_t is the exchange rate at time t.

Since demanders can either be local citizens or foreigners, we can express demand in market i in country H as a weighted average of domestic and foreign demand, i.e.,

$$y_t^d(Hi) = \frac{h}{h+f} y_t^d(Hi)_H + \frac{f}{h+f} y_t^d (Hi)_F \tag{3}$$

where $y_t^d(Hi)_H$ is the local demand and $y_t^d(Hi)_F$ represents foreign demand.

Demand is a function of (1) a locally perceived relative price term, $P_t(Hi) - E_{Hi} PW_t^H$, (2) the expected value of real money holdings, $MH_t^s - E_{Hi}PW_t^H$, and (3) a random term representing relative demand shocks, ε_t^d (Hi). If only domestic currency is used to store wealth and foreign currency is used solely to purchase foreign goods (i.e., as a medium of exchange), then for citizens of H the relevant nominal money variable in the demand function is MH^s, the money supply of country H. Thus the local demand in the Hith market is

$$y_t^d(Hi)_H = \alpha_0 - \alpha_1 [P_t(Hi) - E_{Hi}PW_t^H] + (MH_t^s - E_{Hi}PW_t)^H + \varepsilon_t^d(Hi) \tag{4}$$

Foreign demand is a function of the same variables with the foreign money supply, $MF^s + e$, converted into local currency. Hence foreign demand in the Hith market is [7]

$$y_t^d(Hi)_F = \alpha_0 - \alpha_1 \ [P_t(Hi - E_{Hi}PW_t^H] + (MF_t^s + e_t - E_{Hi}PW_t^H) + \varepsilon_t^d(Hi) \tag{5}$$

Note that the random terms $\varepsilon_t^d(Hi)$ must sum to zero across all markets of country H [8].

Substituting eq(4) and (5) into eq(3) yields

$$y_t^d(Hi) = \alpha_0 - \alpha_1 \ [P_t(Hi) - E_{Hi}PW_t^H] + (MW_t^H - E_{Hi}PW_t^H) + \varepsilon_t^d(Hi) \tag{6}$$

where

$$MW_t^H = \frac{h}{h+f} MH_t^s + \frac{f}{h+f}(MF_t^s + e_t)$$

is the weighted average of the world money supply expressed in terms of country H's currency.

Expressions equivalent to eq(1) through eq (6) for country F are

$$y_t^s(Fi) = \beta_0 + \beta_1[P_t(Fi) + e_t - E_{Fi}PW_t^H] \tag{1'}$$

$$PW_t^F = \frac{h}{h+f}(PH_t - e_t) + \frac{f}{h+f}PF_t \tag{2'}$$

$$y_t^d(Fi) = \frac{h}{h+f} y_t^d(Fi)_H + \frac{f}{h+f} y_t^d(Fi)_F \tag{3'}$$

$$y_t^d(Fi)_H = \alpha_0 - \alpha_1 \ [P_t(Fi) + e_t - E_{Fi}PW_t^H] + MH_t^s + E_{Fi}PW_t^H + \varepsilon_t^d(Fi) \tag{4'}$$

$$y^d_t(Fi)_F = \alpha_0 - \alpha_1 [P_t(Fi) + e_t - E_{Fi}PH^w_t] + MF^s_t + e_t - E_{Fi}PW^H_t + \varepsilon^d_t(Fi) \qquad (5')$$

$$y^d_t(Fi) = \alpha_0 - \alpha_1 [P_t(Fi) + e_t - E_{Fi}PH^H_t] + MW^H_t - E_{Fi}\, PW^H_t + \varepsilon^d_t(Fi) \qquad (6')$$

with PW^H_t as defined in eq(2).

Assuming the structural parameters are the same for both countries, it follows that the error terms ε^d_t (Hi) and ε^d_t (Fi) are also the same.

The local price in each market is determined by equating the relevant demand and supply equations. Equating eq(1) and eq (6) gives

$$P_t(Hi) = \frac{\alpha_0 - \beta_0}{\delta} + \frac{\delta\text{-}1}{\delta} E_{Hi}PW^H_t + \frac{MW^H_t}{\delta} + \frac{\varepsilon^d_t(Hi)}{\delta} \qquad (7)$$

Equating eq(1') and eq (6') gives the foreign counterpart of eq (7), i.e.

$$P_t(Fi) = \frac{\alpha_0 - \beta_0}{\delta} + \frac{\delta\text{-}1}{\delta} E_{Fi}PW^H_t + \frac{MW^H_t}{\delta} + \frac{\varepsilon^d_t(Fi)}{\delta}$$

where $\delta = \alpha_1 + \beta_1$. (7')

Economy wide equivalences of eq(7) and eq (7') are

$$P^H_t = \frac{\alpha_0 - \beta_0}{\delta} + \frac{\delta-1}{\delta} E_{Hi}PW^H_t + \frac{MW^H_t}{\delta} \tag{8}$$

$$P^F_t = \frac{\alpha_0 - \beta_0}{\delta} + \frac{\delta-1}{\delta} E_{Fi}PW^H_t + \frac{MW^H_t}{\delta} - e_t \tag{8'}$$

Assume each country follows a simple money growth process, i.e.,

$$MH^s_t = MH^s_{t-1} + g^H + v_{1t} \tag{9}$$

$$MF^s_t = MH^s_{t-1} + g^F + v_{2t} \tag{9'}$$

where g^F and g^H are known constants and v_{1t} and v_{2t} are serially uncorrelated disturbance terms with variances $\sigma^2{}_1$ and $\sigma^2{}_2$, respectively.

An analysis of the balance of payments of the two countries is required to complete the model. Since no bonds are traded by assumption, the balance of payments is only a current account. A balance of payments surplus occurs for country H when the amount of local currency demanded by foreigners to acquire goods in the local markets exceeds the amount of foreign currency,valued in local currency, demanded by local citizens to acquire goods in foreign markets, that is,

$$B^H = P^H + y^d(H)_F - P^F - e - y^d(F)_H \tag{10}$$

where

$$y^d(H)_F = \sum_{i=1}^{h} y^d\,(Hi)_F$$

and

$$y^d(F)_H = \sum_{i=1}^{f} y^d\,(Fi)_H\,.$$

The problem facing each market participant is to distinguish between relative and nominal changes in price. Market participants will adjust quantity supplied or demanded in response to a relative price change, while a nominal price change will be ignored. In this model, the problem can be solved by predicting the values of the two nominal disturbances, v_{1t} and v_{2t}, and the local relative demand disturbances $\varepsilon_t^d(Hi)$ and $\varepsilon_t^d(Fi)$.[9] Under a fixed exchange rate regime, knowledge of the current exchange rate does not convey any useful information for the market participants. However, some information about disturbances v_{1t}, v_{2t}, $\varepsilon_t^d(Hi)$ and $\varepsilon_t^d(Fi)$ can be obtained from the observed equilibrium prices $P_t(Hi)$ and $P_t(Fi)$. Rearranging eq (7) and eq (7') shows that this information comes in the form of a composite disturbance term,

$$\eta_t = v_{1t} + \frac{f}{h} v_{2t} + \frac{h+f}{h}\,\varepsilon_t^d(Hi) \tag{11}$$

for participants in the Hith market, and

$$\Phi_t = v_{1t} + \frac{f}{h}\,v_{2t} + \frac{h+f}{h}\,\varepsilon_t^d(Fi) \tag{11'}$$

for participants in the Fith market.

If v_{1t}, v_{2t}, and ε_t^d(Hi) (which is the same as ε_t^d (Fi) by assumption) are i.i.d. normal with zero means and variances σ_1^2, σ_2^2, σ_ε^2 respectively and given the assumption of rational expectations with the composite error term of eq(11), the subjective expectations of agents in the Hith market are equal to the objective expectations conditional on η_t. Thus the economy wide average expectations of v_{1t} and v_{2t} are:

$$E_H v_{1t} = \Theta_1(v_{1t} + \frac{f}{h} v_{2t})$$

where

$$\Theta_1 = \frac{\sigma_1^2}{\sigma_1^2 + (\frac{f}{h})^2 \sigma_2^2 + (\frac{f+h}{h})^2 \sigma_\varepsilon^2}$$

and

$$E_H v_{2t} = \frac{h}{f} \Theta_2 (V_{1t} + \frac{f}{h} V_{2t})$$

where

$$\Theta_2 = \frac{(f/h)^2\sigma_2^2}{\sigma_1^2 + (\frac{f}{h})^2 \sigma_2^2 + (\frac{f+h}{h})^2 \sigma_\varepsilon^2}$$

Note that the term ε_t^d(Hi) does not appear in the economy wide average expectations because relative demand shocks cancel out when aggregated over the economy.

If citizens of both countries have access to the same information set, then

$$E_H v_{1t} = E_F v_{1t}$$

and

$$E_H v_{2t} = E_F v_{2t}.$$

Given these expectations terms, the solutions for prices and output in each country can be obtained by the method of undetermined coefficients,

$$P_t^H = \alpha_0 - \beta_0 + \frac{h}{h+f}(MH_{t-1}^s + g^H) + \frac{h/(h+f)}{\delta(1-\tau)+\tau} v_{1t} + \frac{f}{h+f}\bar{e}$$

$$+ \frac{f}{h+f}(MF_{t-1}^s + gf) + \frac{f/(h+f)}{\delta(1-\tau)+\tau} v_{2t} \qquad (12)$$

$$P_t^F = \alpha_0 - \beta_0 + \frac{h}{h+f}(MH_{t-1}^s + g^H) + \frac{h/(h+f)}{\delta(1-\tau)+\tau} v_{1t} + \frac{h}{h+f}\bar{e}$$

$$+ \frac{f}{h+f}(MF_{t-1}^s + gf) + \frac{f/(h+f)}{\delta(1-\tau)+\tau} v_{2t} \qquad (12')$$

$$y_t(H) = \beta_0 + \frac{[h/(h+f)]\,\beta_1(1-\tau)}{\delta(1-\tau)+\tau} v_{1t} + \frac{[f/(h+f)]\,\beta_1(1-\tau)}{\delta(1-\tau)+\tau} v_{2t} \qquad (13)$$

$$y_t(F) = \beta_0 + \frac{[h/(h+f)]\,\beta_1(1-\tau)}{\delta(1-\tau)+\tau} v_{1t} + \frac{[f/(h+f)]\,\beta_1(1-\tau)}{\delta(1-\tau)+\tau} v_{2t} \qquad (13')$$

where $\tau = \Theta_1 + \Theta_2$.

From these solutions, several conclusions follow regarding the impact of monetary policy under a fixed exchange rate regime:

(1) Anticipated components of monetary growth, either foreign or local, do not affect aggregate output in either country.

(2) The random components of monetary growth, both foreign and local, do affect aggregate output with the magnitude of the effect depending on the size of the country, price elasticities of supply and demand, and the Θ_1 and Θ_2 coefficients. These in turn depend on the variances of the disturbances. In general the greater σ_1^2 and σ_2^2, the smaller the effects of monetary shocks on real output. In particular, when σ_1^2 and σ_2^2 tend to infinity, it can be easily shown that real output tends to the natural level β_0.

(3) Both anticipated and unanticipated components of monetary growth affect prices, with the magnitude depending upon the size of the country and Θ_1 and Θ_2.

In the case of flexible exchange rates, knowledge of the current exchange rate implies additional knowledge of monetary disturbances, since the exchange rate will respond to both domestic and foreign monetary shocks. From eq(10), setting $B^H = 0$, we have

$$e_t = p_t^H + y_t^d(H)_F - p_t^F - y_t^d(F)_H \tag{14}$$

After substituting for p_t^H and p_t^F from eq(8) and (8'); and using the definitions of $y_t^d(H)_F$ and $y_t^d(F)_H$ from eq(10), we obtain

$$e_t = MH_{t-1}^s + g^H + v_{1t} - MF_{t-1}^s - g^F - v_{2t} \tag{15}$$

Eq(15) shows that the exchange rate depends on relative money supplies . Knowledge of e_t from eq(15) implies knowledge of the composite monetary disturbance $v_{1t} - v_{2t}$, i.e. the relative monetary growth shocks. Market participants have two pieces of information to predict the values of v_{1t} and v_{2t}. These are

$$\eta_t = v_{1t} + \frac{f}{h} v_{2t} + \frac{f+h}{h} \varepsilon_t^d \text{ (Hi)} \quad \text{and}$$

$$\phi_t = v_{1t} - v_{2t}$$

for participants in the Hith market

and

$$\Phi_t + v_{1t} + \frac{f}{h} v_{2t} + \frac{f+h}{h} \varepsilon_t^d \text{ (Fi)}$$

and

$$\phi_t = v_{1t} - v_{2t}$$

for participants in the Fith market.

Assuming that individuals are rational and the disturbance terms are normally distributed the economy-wide average expectations are

$$E_H v_{1t} = \Theta_1^* v_{1t} + \Theta_1^* v_{2t}$$

and

$$E_H v_{2t} = (\Theta_1^* - 1) v_{1t} + (\Theta_1^* + 1) v_{2t}$$

where

$$\Theta_1^* = \frac{\sigma_1^2 \sigma_2^2 + \sigma_\varepsilon^2 \sigma_1^2}{\sigma_1^2 \sigma_2^2 + \sigma_\varepsilon^2 (\sigma_1^2 + \sigma_2^2)} \quad \text{and} \quad \Theta_2^* = \frac{- \sigma_\varepsilon^2 \sigma_1^2}{\sigma_1^2 \sigma_2^2 + \sigma_\varepsilon^2 (\sigma_1^2 + \sigma_2^2)}$$

Since market participants in both countries have access to the same information,

$$E_F v_{1t} = E_H v_{1t}$$

and

$$E_F v_{2t} = E_H v_{2t}.$$

Given these expectations the solutions for prices and output can be obtained by using the same technique as above. Hence,

$$P_t^H = \alpha_0 - \beta_0 + MH_{t-1}^S + g^H + \frac{1 + \Theta_2^* - \Theta_2^* \delta}{\delta (1 - \tau^*) + \tau^*} v_{1t} + \frac{\Theta_2^* (\delta - 1)}{\delta (1 - \tau^*) + \tau^*} v_{2t} \tag{16}$$

$$P_t^F = \alpha_0 - \beta_0 + MF_{t-1}^S + g^F + \frac{(1 - \Theta_1^*)(1 - \delta)}{\delta (1 - \tau^*) + \tau^*} v_{1t} + \frac{\Theta_1^* + \delta (1 - \Theta_1^*)}{\delta (1 - \tau^*) + \tau^*} v_{2t} \tag{16'}$$

$$y_t(H) = \beta_0 + \frac{\beta_1 (1 - \Theta_1^*)}{\delta (1 - \tau^*) + \tau^*} v_{1t} + \frac{- \beta_1 \Theta_2^*}{\delta (1 - \tau^*) + \tau^*} v_{2t} \tag{17}$$

$$y_t(F) = \beta_0 + \frac{\beta_1 (1 - \Theta_1^*)}{\delta (1 - \tau^*) + \tau^*} v_{1t} + \frac{- \beta_1 \Theta_2^*}{\delta (1 - \tau^*) + \tau^*} v_{2t} \tag{17'}$$

where $\tau^* = \Theta_1^* + \Theta_2^*$

The main conclusions from these solutions are:

(1) Systematic monetary growth, irrespective of foreign or domestic, has no effect on real output.

(2) Domestic prices are affected by systematic domestic monetary growth but not by systematic foreign monetary growth due to the insulating effects of flexible exchange rates.

(3) Monetary shocks, both domestic and foreign, affect prices and output through the exchange rate. A foreign monetary shock, for example, will move the exchange rate. But if market participants are assumed not to realise this, they will attribute the observed change in the exchange rate to all three disturbances (i.e., a relative demand shock and domestic and foreign monetary shocks). Consequently, both domestic real output and prices are affected. Again, the exact magnitude depends on the variances of the three disturbances. In the limiting case where τ_1^2 and τ_2^2 tend to infinity, real output will tend to the natural level β_0.

Hence under flexible as well as fixed exchange rate regimes, both domestic and foreign monetary shocks have no effect on real output.

III Econometric Testing

To test for rationality and the neutrality of money, the following system of equations needs to be estimated.[10]

$$X_t = Z_{t-1}\,\tau + u_t \tag{18}$$

$$y_t = \sum_{i=1}^{h} \beta_i \,(X_{t-1} - Z_{t-i-1}\,\tau^*) + \sum_{i=1}^{h} \delta_i \, Z_{t-i-1}\,\tau^* + \varepsilon_t \tag{19}$$

Eq(18) is the forecasting equation where X_t is the policy variable and Z_{t-1} is a vector of variables relevant in forecasting X_t. Z_{t-1} may include lagged dependent variables X_{t-i},

$i=1,2,...,$ and other available information at time t-1, t-2, etc. The error term, u_t, is assumed to be white noise. Eq(19) is the output equation with y_t the deviation of output from the natural level. The first and second terms on the right hand side are the unanticipated and the anticipated parts of the policy variable X_t, respectively. The error term, e_t, is assumed to be uncorrelated with u_t, but may itself be serially correlated. If both the rationality and neutrality propositions hold, (i.e. $\tau=\tau^*$ and $\delta_i=0$) eq(19) becomes

$$y_t = \sum_{i=1}^{n} \beta_i (X_{t-i} - Z_{t-i-1}\, \tau) + \varepsilon_t$$

$$= \sum_{i=1}^{n} \beta_i (X_{t-i} - E\ X_{t-i}) + \varepsilon_t \qquad (20)$$

Eq(20) is a Lucas-type aggregate supply function where only unanticipated changes in the policy variables matter.

Obviously before estimating eq(18) and (19) identification of both individual equations and parameters has to be ascertained. The identification of eq(18) presents no problem since all the right-hand-side variables are exogenous. For eq(19) to be identified, note that every variable that appears on the right-hand-side of eq(18) also appears among the regressors in eq(19). The fact that no variables on the right-hand-side of eq(18) are excluded from eq(19) implies if eq(19) is to be identified, the source of identification must be found in restrictions different from the usual exclusion restriction. These identification restrictions come from the cross-equation restrictions under which the error term is not contemporaneously correlated with all the right-hand-side variables or with the error term in eq(18). In other words, eq(19) is assumed to be a true reduced form.[11]

Another identification problem that arises is the observational equivalence problem.[12] This problem arises because under certain conditions regression analysis cannot discriminate between our MRE model and competing hypotheses. For example, a Keynesian "unnatural rate" model (where anticipated aggregate demand policy affects output and unemployment) has been shown to be observationally equivalent to the MRE model[13] when the forecasting equation contains only lagged values of X_t as explanatory variables and there are no restrictions on the lag length of the effects of unanticipated and anticipated policy in the output equation.[14]

One way of estimating eq(18) and (19) jointly is by the nonlinear full-information-maximum-likelihood (NLFI) method. To apply NLFI, it is necessary to assume that the error terms, u_t and e_t, are each i.i.d normal. Estimation then proceeds under the usual identification condition that eq(19) is a true reduced form. This implies that $E(u_t e_t) = 0$ and the estimated variance-covariance matrix of the residuals is

$$\hat{\Sigma} = \begin{bmatrix} SSR_X & 0 \\ 0 & SSR_y \end{bmatrix}_{TxT} \tag{21}$$

where SSR_X and SSR_y are, respectively, the sums of squared residuals of the X and y equations, and T is the number of observations. The NLFI estimators can be obtained by maximizing the concentrated log likelihood function

$$\log L = \alpha \quad - T/2 \log |\hat{\Sigma}| \tag{22}$$

where $|\hat{\Sigma}|$ is the determinant of the matrix $\hat{\Sigma}$. It is clear from eq(22) that the same values that minimize $|\hat{\Sigma}|$ also maximize the likelihood function. As the parameters enter $|\hat{\Sigma}|$ in a nonlinear fashion, a nonlinear minimization algorithm is required.[15]

This estimation method will produce estimators that are consistent, asymptotically efficient and asymtotically normally distributed with means equal to the true parameter values.[16] Hypothesis testing can be carried out by first estimating eq(18) and (19) under the null hypothesis, and then reestimating the system under the alternative hypothesis. The likelihood ratio can be computed as

$\mu = L^c/L^u$

where L^c and L^u are, respectively the maximized likelihood under the null (constrained) hypotheses and the alternative (unconstrained) hypothesis. It is well known in large sample theory that $-2 \log\mu$ is distributed as a Chi-square with q degree of freedom, where q is the number of constraints imposed. Goldfeld and Quant[17] show that

$$-2 \log\mu = n \log(SSR^c / SSR^u) \qquad (23)$$

which greatly simplifies the computation of the test statistic.

In practice, however, the applicability of NLFI is rather restricted. To see this, write eq(19) and eq(20) in a more compact form,

$$h = f(W;\Theta) + v \qquad (24)$$

where the vector h consists of the two dependent variables X_t and y_t, f is a vector that defines the functional form of the two equations, W is a matrix of the right-hand-side variables, Θ is a vector of the parameters , and v is a vector of the error terms. To apply NLFI, v must be i.i.d. normal and eq(24) must define a one-to-one correspondence between h and v.[18]

As a viable alternative to NLFI, Amemiya[19] suggests the use of nonlinear three-stage least squares (NL3S). The NL3S estimators are defined, in terms of eq(24), as the value of Θ that minimizes

$$F' \hat{\Omega}^{-1} S \quad (S' \hat{\Omega}^{-1} S) \; S' \hat{\Omega}^{-1} F$$

where

$F = (f_{1t} \, f_{2t})', \quad t = 1, 2, \ldots, T,$

and

$$\hat{\Omega} = \hat{\Sigma} \otimes I$$

where $\otimes$ is the Kronecker product.

Note that F is a 2T-vector, $\hat{\Sigma}$ a consistent estimate of $\Sigma = E(vv')$ and S a matrix of constants with 2T rows and with rank of at least the number of estimable parameters in the system. Amemiya[20] outlines a practical way of obtaining this matrix.

Amemiya[21] shows that NL3S is more robust than NLFI because the NL3S estimator is consistent even if the true distribution of v is not normal. The NLFI estimator, on the other hand, is in general inconsistent if v is not normal. This result is contrary to the linear FIML case where the FIML estimator is consistent even if the distribution of the error terms is not normal. Hence the result in the linear case where the FIML and 3SLS estimators have the same asymptotic distribution does not carry over to the nonlinear case.

Hypothesis testing in the case of NL3S can be carried out by first estimating the unconstrained version and then the constrained version of eq(24). Amemiya, [22] using Gallant and Jorgenson's result, [23] suggests the following test statistic,

$$SSRD = T\,(SSR^c - SSR^u) \tag{26}$$

where T is the sample size and SSR^c and SSR^u are respectively the sums of squared residuals of the constrained and uncontrained systems. Gallant and Jorgenson[24] prove that the test statistic SSRD is distributed asymptotically as a Chi-square with q degrees of freedom under the null hypothesis, where q is the number of constraints imposed. The matrix S in the objective function should be the same for both the constrained and unconstrained systems since the test statistic is not valid otherwise.

IV Empirical Results

The preceeding MRE model was tested using quarterly data for Malaysia from 1968Q1 through 1985 Q4, obtained from Bank Negara Quarterly Review, an official publication of the central bank of Malaysia. The foreign money supply series were proxied by using the M1 index of 21 developed countries listed in the IMF Financial Statistics and Supplementary issues. Foreign interest rates were taken as the London Inter-Bank rates, also obtained from the IMF Financial Statistics.

One major problem encountered was that only annual GDP data for Malaysia are available. Since the annual series contain less than 30 observations, and since the estimation and testing procedures are valid only for large samples, it was not possible to test the MRE model using annual data. Therefore a way of approximating quarterly GDP was required. Following a method outlined by Chow and Lin[25] and refined and tested by Wilcox,[26] we approximated the quarterly GDP series based on the annual GDP series and its relationship with some related variables.

All data used in the estimation were seasonally adjusted using the U.S. Census 11 procedure. The four systems of equations estimated (A through D) are:

(A) $$M_t = Z_{1t-1}\,\tau_1 + u_t$$

$$MF_t = Z_{2t-1}\,\tau_2 + v_t$$
$$y_t = \sum_{j=o}^{N} \alpha_j\,(M_{t-j} - Z_{1t-j-1}\,\tau_1) + \sum_{j=o}^{N} \beta_j\,(MF_{t-j} - Z_{2t-j-1}\,\tau_2) + \varepsilon_t$$

(B) $$M_t = Z_{1t-1}\,\tau_1 + u_t$$

$$MF_t = Z_{2t-1}\tau_2 + v_t$$

$$y_t = \sum_{j=o}^{N} \alpha_j (M_{t-j} - Z_{1t-j-1}\,\tau_1^{*}) + \sum_{j=o}^{N} \beta_j (MF_{t-j} - Z_{2t-j-1}\,\tau_2^{*})$$

$$+ \sum_{j=o}^{N} \delta_j Z_{1t-j-1}\tau_1^{*} + \sum_{j=o}^{N} \phi_j Z_{2t-j-1}\,\tau_2^{*} + \varepsilon_t$$

(C) $$M_t = Z_{1t-1}\,\tau_1 + u_t$$

$$MF_t = Z_{2t-1}\,\tau_2 + v_t$$

$$y_t = \sum_{j=o}^{N} \alpha_j (M_{t-j} - Z_{1t-j-1}\,\tau_1) + \sum_{j=o}^{N} \beta_j (MF_{t-j} - Z_{2t-j-1}\,\tau_2)$$

$$+ \sum_{j=o}^{N} \delta_j Z_{1t-j-1}\,\tau_1 + \sum_{j=o}^{N} \phi_j Z_{2t-j-1}\,\tau_2 + \varepsilon_t$$

(D) $$M_t = Z_{1t-1}\,\tau_1 + u_t$$

$$MF_t = Z_{2t-1}\,\tau_2 + v_t$$

$$y_t = \sum_{j=o}^{N} \alpha_j (M_{t-j} - Z_{1t-j-1}\,\tau_1^{*}) + \sum_{j=o}^{N} \beta_j (MF_{t-j} - Z_{2t-j-1}\,\tau_2^{*}) + \varepsilon_t$$

Each system consists of three equations: the domestic money supply forecasting equation, the foreign money supply forecasting equation, and the output equation. Model (A) is a standard MRE model since it assumes rational expectations ($\tau = \tau^*$) and the neutrality of money ($\delta=\phi=o$). Model (B) assumes that expectations are not formed rationally ($\tau \neq \tau^*$) and nonneutrality of money since both saved $\phi \neq 0$. Model (c) has rational expectations ($\tau = \tau^*$) but noneutrality of money ($\delta,\phi\neq 0$) while Model (D) assumes expectations are not formed rationally ($\tau \neq \tau^*$) and neutriality of money (δ=ϕ=o). The variables in the vectors Z_1 and Z_2 in the forecasting equations were determined by using the Granger casuality test. The final forms of the forecasting equations are

$$M_t = \tau_{10} + \tau_{11} M_{t-1} + \tau_{12} M_{t-2} + \tau_{13} R_{t-1} + \tau_{14} R_{t-2} + u_t$$

$$MF_t = \tau_{20} + \tau_{21} MF_{t-1} + \tau_{22} MF_{t-2} + \tau_{23} RF_{t-1} + \tau_{24} RF_{t-2} + v_t$$

where M is the domestic money supply, R the domestic interest rate, MF the foreign money supply, and RF the foreign interest rate.

The dependent variable of the output equation is the deviation from the natural level of output. It was derived by first regressing the real quarterly GDP on a time trend, yielding

$$GDP_t = \underset{(0.0178)}{3.1625} + \underset{(0.0004)}{0.0192}\ TIME \qquad R^2 = 0.967$$

where GDP is our estimate of quarterly real GDP and TIME is a time trend.[27] Figures in parentheses are standard errors of the estimates. The residuals in this equation were assumed to be the deviation of output from its natural level.

To ensure that the errors of the output equation are, in fact, white noise, we assumed a fourth order autoregressive error structure. The autocorrelation coefficients are denoted as r_1, r_2, r_3, and r_4 in the tables below. The Box-Ljung statistics for the first 18 observations are also shown. In every case the null hypothesis of white noise errors could not be rejected.

Since specifications of the lagged effects of anticipated and unanticipated money supply changes could affect the test results, various lag lengths were used. The following results were obtained using a lag length of 8 quarters.

Table 1 Tests of MRE Model

Systems with lag length N = 8	Test Statistics $T(SSR^c - SSR^u)$
Joint Hypothesis	
$H_o : \tau_{1i} = \tau_{1i}^*, \tau_{2i} = \tau_{2i}^*$	33.548
	(0.24)
$\delta_j = 0, \phi_j = 0$	
Neutrality Hypothesis	
$H_o : \alpha_j = 0, \beta_j = 0$	32.485
	(0.02)
Rationality Hypothesis	
$H_o : \tau_{1i} = \tau_{1i}^*, \tau_{2i} = \tau_{2i}^*$	13.489
	(0.41)

Note : Figures in parentheses are approximate marginal significance levels.

Table 1 shows that neither the joint nor the rationality hypotheses could be rejected at the 5% level. However the neutrality hypothesis is rejected at 2% level of significance. This indicates that a joint test of rationality and neutrality provides little information on the status of individual hypotheses. A rejection of the joint hypothesis may imply the rejection of one but not the other hypothesis. Likewise, if the joint hypothesis is not rejected, it does not follow that the neutrality and rationality hypotheses cannot be rejected when tested individually.

Tables 2 and 3 below present the parameter estimates of the output equations of systems (A) to (D) with a lag length of eight.

Table 2 NL3S Estimation of Output Equations for models A and B.

Lag Length : N = 8

Model (A) Rational Expectations, neutrality of money			Model (B) not rational expectations, nonneutrality of money		
α_0 =	1.11722	(0.39199)*	α_0 =	1.19027	(0.35749)*
α_1 =	0.85693	(0.32863)*	α_1 =	1.47266	(0.84043)
α_2 =	1.27145	(0.51255)*	α_2 =	1.21388	(0.98844)
α_3 =	1.33391	(0.41467)*	α_3 =	1.73719	(0.71916)*
α_4 =	1.17490	(0.39405)*	α_4 =	0.27132	(0.72944)
α_5 =	1.18123	(0.36869)*	α_5 =	0.40194	(0.70045)
α_6 =	1.09560	(0.39462)*	α_6 =	-0.09876	(0.79342)
α_7 =	1.03750	(0.54598)	α_7 =	-0.30028	(0.62354)
β_0 =	-0.14369	(0.12133)	β_0 =	-0.14825	(2.40594)
β_1 =	-0.10856	(0.11177)	β_1 =	1.29756	(3.11799)
β_2 =	-0.18881	(0.13923)	β_2 =	-1.01356	(2.51619)
β_3 =	-0.11635	(0.13213)	β_3 =	3.77963	(2.12316)
β_4 =	-0.14926	(0.15964)	β_4 =	-1.07431	(2.12607)
β_5 =	0.03006	(0.09885)	β_5 =	2.26070	(1.81115)
β_6 =	0.09550	(0.09178	β_6 =	-0.15192	(1.22495)
β_7 =	-0.03824	(0.08154)	β_7 =	-0.26191	(1.32909)
r_1 =	1.12713	(0.35291)*	δ_0 =	-0.05500	(0.07065)
r_2 =	0.28772	(0.55110)	δ_1 =	-0.01432	(0.10912)
r_3 =	-0.68901	(0.42408)	δ_2 =	-0.02988	(0.09057)
r_4 =	0.22214	(0.24809)	δ_3 =	-0.02223	(0.09607)
			δ_4 =	0.03141	(0.10171)
			δ_5 =	0.06806	(0.10039)

		δ_6 = 0.09339	(0.11098)
		δ_7 = 0.06079	(0.08587)
		ϕ_0 = -0.10096	(0.09520)
		ϕ_1 = -0.08976	(0.12472)
		ϕ_2 = -0.15177	(0.14492)
		ϕ_3 = -0.15722	(0.15245)
		ϕ_4 = -0.02957	(0.13804)
		ϕ_5 = -0.03854	(0.14230)
		ϕ_6 = -0.00751	(0.11773)
		ϕ_7 = 0.04117	(0.11011)
		r_1 = 1.59745	(0.24576)*
		r_2 = -0.50527	(0.50410)
		r_3 = -0.49515	(0.48145)
		r_4 = 0.29973	(0.23221)
R^2	0.892	0.966	
Box-Ljung	22.990	9.860	
Mar. Sig	0.191	0.937	

Notes : Figures in parentheses are standard errors.

* indicates significance at the 5% level.

Mar. Sig. denotes the marginal significance level for the Box-Ljung statistics.

Table 3 NL3S Estimation of Output Equations for systems C and D

Lag Length : N = 8

Model (C) rational expectations, nonueutrality of money			System (D) Not rational expectations neutrality of money	
α_0 =	0.68511	(0.27917)*	α_0 =	0.66863 (0.13163)*
α_1 =	0.11200	(0.67088)	α_1 =	0.03960 (0.12492)
α_2 =	0.16179	(0.90767)	α_2 =	0.10396 (0.12394)
α_3 =	0.71322	(0.87643)	α_3 =	0.22772 (0.14121)
α_4 =	0.47430	(0.80399)	α_4 =	0.13579 (0.14871)
α_5 =	0.43782	(0.79760)	α_5 =	0.05664 (0.15280)
α_6 =	0.32437	(0.70320)	α_6 =	0.11118 (0.23539)
α_7 =	0.01775	(0.40745)	α_7 =	0.17351 (0.20873)
β_0 =	2.05455	(1.13381)	β_0 =	-0.01071 (0.01260)
β_1 =	0.13751	(1.26469)	β_1 =	-0.03225 (0.01695)
β_2 =	-0.08002	(0.94935)	β_2 =	-0.03838 (0.01619)*
β_3 =	0.03220	(1.24037)	β_3 =	-0.04248 (0.01695)*
β_4 =	0.29450	(1.21442)	β_4 =	-0.03186 (0.01685)
β_5 =	1.06625	(1.14202)	β_5 =	-0.00439 (0.01639)
β_6 =	-0.31556	(0.95578)	β_6 =	0.00804 (0.02043)
β_7 =	-0.31197	(0.71851)	β_7 =	0.01375 (0.02019)
β_0 =	-0.07611	(0.07831)	r_1 =	1.61118 (0.20880)*
δ_1 =	-0.00949	(0.16152)	r_2 =	-0.50161 (0.40250)
δ_2 =	0.16397	(0.27110)	r_3 =	-0.26317 (0.40249)
δ_3 =	0.14582	(0.35243)	r_4 =	0.11757 (0.23251)
δ_4 =	0.14854	(0.35853)		

δ_5 = 0.26159	(0.32861)	
δ_6 = 0.16926	(0.26221)	
δ_7 = 0.05202	(0.13183)	
ϕ_0 = -0.26703	(0.19756)	
ϕ_1 = -0.30120	(0.27129)	
ϕ_2 = -0.06423	(0.23918)	
ϕ_3 = 0.00551	(0.21378)	
ϕ_4 = -0.09248	(0.19819)	
ϕ_5 = 0.08044	(0.20829)	
ϕ_6 = -0.00234	(0.24011)	
ϕ_7 = 0.18822	(0.20146)	
r_1 = 2.01955	(0.30495)*	
r_2 = -1.48765	(0.68361)*	
r_3 = 0.37956	(0.72532)	
r_4 = 0.05404	(0.35041)	
R^2	0.968	0.956
Box-Ljung	24.650	28.090
Mar. Sig	0.135	0.061

Notes : See Table 2

Although, as Tables 2 and 3 show, none of the coefficients of anticipated money growth are significant, it does not follow that the coefficients are not significant as a group. See, for example, Pindyck and Rubinfeld,[28] Chapter 5.

Our empirical results clearly indicate that the neutrality hypothesis can be rejected with some specifications of the lagged effects of anticipated and unanticipated money supply growth. We are, however, unable to reject the rationality hypothesis. The MRE model which implies that only unanticipated monetary growth has real effects, regardless of the lag length specified, is therefore rejected. It must be emphasised that the MRE model is rejected solely on the basis of the non-neutrality of money. The rational expectations hypothesis itself could not be rejected.

V Concluding Remarks

These results have significant implications for the conduct of monetary policy in Malaysia. They imply that the monetary authority is able to influence levels of output, employment and the rate of inflation through monetary policy as claimed by Malaysia's central bank.[29]

However, even though our results show that money is not neutral in Malaysia, it does not follow that the magnitude and timing of the effects of monetary policy can be determined with any accuracy. Clearly these are crucial considerations when using monetary policy to influence real economic activity. Our results represent the necessary but not the sufficient conditions for using monetary policy as an instrument for economic management.

Furthermore, there are a variety of causes of the non-neutrality of anticipated money growth including an array of market imperfections, which may disappear during economic development. For example, a developing economy such as that of Malaysia is typically characterized by the co-existence of organised and unorganised markets. A 'dual' economy may have a relatively sophisticated monetised market sector along with a traditional non monitized sector. As economic development proceeds one would expect the monetised sector to expand and the non-monetised sector to decline in size. A wider use of money and/or increasing sophistication (depth) of the monetary sector will have real effects on output and employment analogous to moving from a barter to a monetised economy. At the very least, the wider use of money should reduce the transaction costs in market exchanges. Since growth of the money supply reflects in part the growth of the monetised sector of the Malaysian economy it is not surprising that a time series study of output and money growth shows that monetary growth, though anticipated, has real effects.

These observations lead to a natural extension for future studies of developing economies. Conceptually one could disaggregate total money supply growth into a component representing increases in the breadth and depth of the monetry sector and a component representing policy induced anticyclical changes. The first component should (may) be non neutral, while the second, assuming the validity of the usual MRE conclusions, should be neutral. Alternatively, one could make the hypothesis that money becomes "more neutral" as economic development proceeds.

At the very least, our study has demonstrated both the applicability of MRE models to developing economies and has highlighted some of the problems involved in such extensions.

NOTES:

1. See for example, R.J. Barro, (1978) "Unanticipated Money, Output, and the Price Level in the United States", Journal of Political Economy, 86, (1978): 549-80.

W.H. Buiter, (1983) "Real Effects of Anticipated and Unanticipated Money", Journal of Monetary Economics, 11, (1983): 207-24.

R.E. Lucas Jr., "Expectations and the Neutrality of Money", Journal of Economic Theory, 4, (1972): 103-24.

2. N.W. Duck, "Prices, Output and the Balance of Payments in an Open Economy With Rational Expectations", Journal of International Economics, 16, (1984): 59-77.

3. Bank Negara Malaysia Money and Banking in Malaysia, 2nd ed., (Kuala Lumpur: Bank Negara Malaysia, 1984).

4. R.J. Barro, "Unanticipated Money, Output, and the Price Level in the United States", Journal of Political Economy, 86, (1978): 549-80.

R.E. Lucas, "An Equilibrium model of the Business Cycles", Journal of Political Economy 83, (1975): 1113-44.

5. R.E. Lucas Jr., "Expectations and the Neutrality of Money", Journal of Economic Theory, 4, (1975): 103-24.

6. Unless otherwise specified, all variables are in logarithms.

7. Note that the same structural parameters are assumed for for both equations (4) and (5). Allowing for different parameters will not change the results substantively, though the algebra will become more complex.

8. By Walras' Law, excess supply in one market will be offset by excess demand in other markets, hence the random term has to sum to zero.

9. Here we do not make the distinction between temporary and permanent shocks. For a discussion of this, see Barro.

10. X_t can be a scalar or vector. For simplicity it is assumed throughout to be a scalar. The analysis can be extended to the vector case in a straightforward manner.

11. This is in line with previous research. See F.S. Mishkin, A Rational Expectations Approach to Macroeconometrics, (Chicago : University of Chicago Press, 1983).

12. This problem was first pointed out in Sargent T.J.,"The Observational Equivalence of Natural and Unnatural Rate of Theories of Macroeconomics", Journal of Political Economy, 84(3), (1976): 631-40, and has subsequently attracted the attention of may economists. See, for example, B.T. McCallum, "On the Observational Inequivalence of Classical and Keynesian Models", Journal of Political Economy, 87(2), (1979): 395-402; W.E. Weber, "Prior Information and Observational Equivalence Problem", Journal of Political Economy, 89(2), (1981): 411-15; and Buiter.

13. See Weber.

14. See Mishkin.

15. For a discussion of computation methods and algorithms, see Y. Bard, Nonlinear Parameter Estimation, (New York : Academic Press, (1974).

16. Estimators of this type and their statistical properties are discussed in Bard, Y., Nonlinear Parameter Estimation , New York Academic Press, 1974.

17. S.M. Goldfeld, and R.E. Quandt Nonlinear Methods in Econometrics, (Amsterdam: North-Holland, (1972).

18. Since Eq(24) is nonlinear, there may be more than one solution for some values of v, in which case NLFI is not applicable.

19. T. Amemiya, "Nonlinear Regression Models", in Griliches, Z. and Intriligator, M.D. (eds.) Handbook of Econometrics, vol. I. (Amsterdam : North-Holland, (1983)

20. ibid, p. 378.

21. T. Amemiya, "The Maximum Likelihood and the Nonlinear Three-Stage Least Squares Estimator in the General Nonlinear Simultaneous Equation Model", Econometrica, 45, (1977): 955-68.

22. Amemiya. "Nonlinear Regression Models".

23. R.A. Gallant, and D.W Jorgenson, "Statistical Inference for a System of Simultaneous, Nonlinear, Implicit Equations in the Context of Instrumental Variable Estimation", Journal of Econometrics, 11, (1979): 275-302.

24. ibid.

25. G. C. Chow, and A. Lin, "Best Linear Unbiased Interpolation, Distribution, and Extrapolation of Time Series By Related Series", Review of Economics and Statistics, 53, (1971): 372-5.

26. J. A. Wilcox, "Disaggregating Data Using Related Series", Journal of Business and Economic Statistics, 1, (1983): 187-91.

27. see note 16.

28. R.S. Pindyck, and D.L Rubinfeld, . Econometric Models and Economic Forecasts, 2nd Ed., (Singapore : McGraw-Hill, (1981), especially Ch. 5.

29. Bank Negara Malaysia, pp. 389-417.

30. D. L. Schulze, "Monetization in ASEAN, 1970-1984" Singapore Economic Review, 31(2) (1986): 57-66.