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Demand for M2 in an Emerging-Market Economy: An Error-Correction Model for Malaysia

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Abstract

This paper analyses demand for M2 in Malaysia from August 1973 to December 1995 under both the closed- and open-economy framework. Based on the cointegration and weak-exogeneity test results, short-run dynamic error-correction models are specified and estimated. The results indicate that the demand is for *real* M2. Both the long- and short-run models are well-specified and are fairly stable. The long-run income elasticity is close to one with the opportunity cost variables carrying the expected signs. The external events have some influence on the stability.

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Contents

Page

Tables

Figures

I. Introduction

Demand for money plays a major role in macroeconomic analysis, especially in selecting appropriate monetary policy actions. Consequently, a steady stream of theoretical and empirical research has been carried out worldwide over the past several decades (see Sriram (1999b)). The interest on developing countries has heightened in recent years, triggered primarily by the concern among central banks and researchers on the impact of the movement toward flexible exchange rate regime, globalization of capital markets, ongoing domestic financial liberalization and innovation, and country-specific issues.

The extensive literature underscores two major points relevant to modeling and estimating the demand for money: 1. variable selection and representation; and 2. framework chosen. Failure to provide due consideration to these issues has tended to yield poor results. For the former, proper specification of opportunity cost variables happens to be the most important factor in getting meaningful results. In this regard, careful attention should be paid before deciding: (a) whether a model should include both the own-rate and alternative return on money (including the expected inflation rate); and (b) which data series are selected to represent them? These two decisions depend on the macroeconomic situation and developments in the financial system (including institutional details and the regulatory environment), and degree of openness of the economy. Regarding the latter, the chosen system should be free of theoretical and estimation problems, and should perform well in empirical setting. The error-correction models have shown to meet these criteria.

Taking into consideration of these issues, this paper evaluates the long- and short-run determinants and stability of demand for money in Malaysia. Among other countries, Malaysia is selected for the analysis because it exhibits a number of characteristics as discussed above, which have been motivating research interest. Specifically, 1. it is an upper-middle-income developing country with a per capita GNP of $3,890 in 1995 (World Bank (1997)), and has been one of the fastest growing nations in the world with the real output in terms of GDP expanding at an average rate of 7.3 percent between 1973 and 1995; inflation, during this period, remained on average at about 4.75 percent; 2. it follows a managed-floating exchange rate regime; 3. it has a fairly well-developed financial system; and 4. it has been liberalizing its domestic financial sector over the past three decades, especially after October 1978, and fostering financial innovation (see Bank Negara Malaysia (1994) and Sriram (1999d and 1999e)).

Several papers have analyzed the demand for money (as represented by various narrow and broad aggregates under various framework) in Malaysia over the years.[2] Their

[2] See Aghevli and others (1979), Chung (1981), Semudram (1981), Fischer (1983), Yahya (1984a and 1984b), Spencer and Yahya (1985), Anuar (1986a and 1986b), Habibullah (1986, 1987, and 1988), Ghaffar and Habibullah (1987a, 1987b, and 1987c), Jusoh (1987), Merris (1987), Yusoff (1987), Gupta and Moazzami (1989 and 1990), Habibulla (1990), Habibullah
(continued...)

objectives and approaches differed (see Sriram (1999a), pp. 150-62). It appears that the selection of variables and analytical framework chosen form the two overriding factors accounting for these differences. This paper will make a systematic attempt to evaluate the demand for M2 using monthly data from August 1973 to December 1995. Notably, it will consider the pertinent financial system issues before deciding which variables are to be included and how to represent them in the model. Initially it applies a closed-economy framework. Since Malaysia is a small open economy, it reformulates the model allowing possibilities for currency substitution. Upon examining the data characteristics of time series, it chooses the error-correction framework for analysis and evaluates whether the closed- or open-economy framework is better suited for Malaysia. In accomplishing its task, the paper employs a step by step procedure and methodology in undertaking the cointegration and error-correction analysis for estimating money demand.

The results indicate that both the long- and short- run models are well specified. The demand for M2 is for *real* balances and is almost stable throughout the study period. The long-run income elasticity is close to one and the opportunity cost variables carry the expected signs. The external events do exert some influence on demand for real M2.Their direct impact, however, appears to be small as domestic interest rates are sufficiently flexible to deter these events significantly affecting the stability.

II. Financial System Development

Understanding the financial system is essential in formulating appropriate money demand function. It indicates: (1) whether there are alternative assets available in the economy to hold money; (2) how liquid the money and capital markets are; (3) whether the interest rates are controlled by the authorities or determined by the market forces; (4) how fast the financial innovation is taking place in the economy; (5) whether a country can influence the exchange rates; among others. It further helps in selecting appropriate opportunity cost variables to be included in the formulation.

Malaysia has a fairly well-developed financial system among developing countries.[3] It has a sophisticated structure consisting of banking institutions, nonbank financial intermediaries, and a network of money, exchange, and capital markets. The banking institutions have been the primary sources of funding in the economy. Their assets increased from RM7.5 billion in 1970 (61.7 percent of GDP) to RM515.8 billion at the end of 1995 (235.8 percent of GDP), achieved primarily through rapid build-up of the branch network, widening the range of instruments and services, acceleration of credit activities, and

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and Ghaffar (1991), Tseng and Corker (1991), Teng (1993), Merican and others (1994), Dekle and Pradhan (1997), and Tan (1997).

[3] Refer to Bank Negara Malaysia (1994) and Sriram (1999d and 1999e) concerning further details presented in this section.

intermediation of significant capital inflows. Since the 1980s, the capital market has also been evolving rapidly offering a broad range of funding and investment vehicles to the financial system. The market has sufficient liquidity with total net funds raised increasing from a mere RM405 million in 1970 to RM20.3 billion in 1995. The country has an active money market offering a variety of monetary instruments and providing short-term funding for banking institutions.[4] A string of institutional and policy measures provided impetus for the financial system to grow (as further explained in Section IV below).

The developments in the financial system are reflected in the growth of various money measures. M1, narrow money, amounted to RM51.9 billion in 1995, stayed almost at 20 percent of GDP during the 1973-95 period. The broader monetary aggregates grew more rapidly with increased availability of interest-bearing instruments provided by the banking institutions. In specific, M2 rose from RM10.0 billion in 1975 (44.7 percent of GDP) to RM198.9 billion in 1995 (90.9 percent of GDP), and M3 went up from RM11.3 billion (50.7 percent of GDP) in 1975 to RM271.9 billion (124.3 percent of GDP) in 1995.[5]

III. MODEL FRAMEWORK

There is a diverse spectrum of money demand theories emphasizing the transactions, speculative, precautionary or utility considerations. These theories implicitly address a broad range of hypotheses. One significant aspect, however, is that they share common important elements (variables) among almost all of them. In general, they bring forth relationship between the quantity of money demanded and a set of few important economic variables linking money to the real sector of the economy (see Judd and Scadding (1982), p. 993). What sets apart among these theories is that although they consider similar variables to explain the demand for money, they frequently differ in the specific role assigned to each. Consequently one consensus that emerges from the literature is that the empirical work is motivated by a blend of theories.

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[4] Such as bankers' acceptance, negotiable certificates of deposit, Cagamas bonds, floating-rate certificates of deposit, Bank Negara bills, Malaysian Treasury bills, fixed-rate certificates of deposit, Government investment certificate, and so on.

[5] For M2, the quasi-money includes private sector fixed and savings deposits with BNM and commercial banks (excluding Bank Islam Malaysia Berhad), holdings of negotiable certificates deposits (NCDs), and the Central Bank Certificates; and for M3, the broad quasi money consists of private sector savings and fixed deposits placed with BNM, commercial banks (including Bank Islam Malaysia Berhad), finance companies, merchant banks and discount houses, and private sector holdings of NCDs and Central Bank Certificates but excludes placements among these institutions (see Bank Negara Malaysia, 1996, *Quarterly Bulletin* (First Quarter)).

The general specification begins with the following functional relationship for the long-term demand for money:

$$\frac{M}{P} = f\,(S, OC) \tag{1}$$

where the demand for real balances M/P is a function of the chosen scale variable (S) to represent the economic activity and the opportunity cost of holding money (OC). M stands for the selected monetary aggregate in nominal term and P for the price. Like in theoretical models, the empirical models generally specify the money demand as a function of real balances (see Laidler (1993)). Using the real money balance as the dependent variable will also mean that price homogeneity is explicitly imposed into the model. Additionally, there are less severe econometric problems associated with using real rather than nominal balances as the dependent variable (see Boughton (1981) and Johansen (1992)).[6]

IV. Variable Selection and Formulation of Closed-Economy Model

As the model specification hinges upon the variables included under the realm of general framework as shown in equation (1), the first subsection presents relevant discussion underlying the selection and representation of variables included in the closed-economy model. The next subsection shows the final formulation chosen for estimation.

A. Variable Selection

There exists extensive discussion in the literature regarding whether the narrow or broad money is stable. Studies on developing countries indicated that the models on narrow money worked better reflecting the weak banking system and low level of financial sector development. However, as the boundaries of narrow money shift over time to accommodate the new instruments created as a result of the evolving financial system and institutional framework, arguments have been raised in favor of using broad money in the empirical estimation. The measure was hypothesized to yield a stable money demand function and was considered a preferable measure with which to evaluate the long-run economic impact of the change in monetary policy (see Laidler (1993) and Hafer and Jansen (1991)).

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[6] A number of papers have used nominal balances instead (see, for example, Miller (1991) and Dekle and Pradhan (1997)). However, Sriram (1999a) finds out that a nominal M2 model shows very low income elasticity and incorrect sign for own-rate of money. Additionally, the price variable carries a coefficient of three instead of one as the theory suggests.

As the broad monetary aggregates witnessed significant growth during the 1973-95 period, this paper employs M2 as the relevant measure for Malaysia.[7] It is selected over M3 because of data limitations. Slight adjustment is made for this series to take into account the changes introduced by the BNM in data presentation. Prior to January 1989, the monetary aggregates were computed under "old banking format." This effectively creates a break in the series. The modified series is called as *M2A*.[8]

The index of industrial production (1990=100) will be used as the scale variable. It is chosen mainly because monthly data are available only for this measure in Malaysia. And, consumer price index (CPI) is selected as the price variable.

The selection of opportunity cost variables is one of the most important aspects of modeling the demand for money. To begin with, the opportunity cost involves the own rate and the rate of return on alternative assets to money. [9] As quasi-money represents a sizeable portion of M2 (74 percent in 1995) which pays explicit interest; and term deposits (especially of the three-month maturity), to a certain extent, form the major portion of liabilities of commercial banks, finance companies, and merchant banks (see Bank Negara Malaysia, *Monthly Bulletin*), the yield on three-month time deposits with the commercial banks is taken as the representative own rate of money (*TD3R*).

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[7] It is especially important for Malaysia for two reasons: first, the financial system is fairly well-developed with liberalization and innovation taking place during the study period; and second, the nominal magnitudes of monetary aggregates increased remarkably (although the inflation, on an average, was only 4.75 percent during the 1973-95 period) signaling that the growth is related to the financial deepening process and not due to the inflation.

[8]Refer to Ericsson, Hendry, and Tran (1994) for a similar approach; first the growth rate between the values of M2 in December 1987 and in December 1988 is computed as logarithmic differences. This measure is divided by 12 to obtain the average monthly growth rate for 1988. It is applied over the December 1988 value of M2 to obtain the incremental value for January 1989, which is then added to the December 1988 observation to get an estimated value for M2 for January 1989. Using the ratio between the estimated and actual value of M2 for January 1989, the entire series for January 1989-December 1995 is adjusted. This way we obtain a consistent set of series for the entire period of study from August 1973 to December 1995.

[9]Many studies have omitted the own-rate of money with an argument that the checkable deposits consisted solely of demand deposits with an explicit yield of zero or having an unvarying rate that can be conveniently ignored (see Laidler (1993)), the recent studies indicate that the own-rate of money is extremely important in money demand studies. Its omission often leads to break down of the estimated money demand function, especially when the financial innovation occurs in the economy (see Ericsson (1998)).

There are a number of choices to represent the yields on assets alternative to money. Under the portfolio balance approach, they include yields on both the financial and real assets.[10] The yields on financial assets are proxied by some relevant interest rates and the return on real assets by the expected inflation rate. Discount rate on three-month government securities (*TB3MR*) is used as the representative alternative rate of return because the market for it is sufficiently liquid in Malaysia and data are readily available. The expected inflation rate is proxied by the actual inflation rate following Honohan (1994). The annualized rate (*INF_A*) is computed by the expression $(\ln CPI_t - \ln CPI_{t-1}) * 12$.

There are wide ranging discussions in the literature (see Sriram (1999b)) regarding inclusion of the returns on both the real and financial assets in the argument of the money demand function. Since recent studies show that moderate inflation levels can exert significant influence on demand for money (see Baba, Hendry, and Starr (1988)) and the level of nominal interest rates may not fully incorporate the expected inflation rate (see Laidler and Parkin (1975)) both variables are included in the model.

A dummy variable is needed to represent the status of interest rate regime in the economy. Although the financial and capital markets have been steadily liberalized since the inception of BNM, the pace accelerated beginning from October 1978. Major objectives for these reform measures are enhancing efficiency of the financial system through greater reliance on market forces as well as improving the effectiveness of monetary policy. Major efforts were directed at liberalizing interest rates, boosting competition in the financial system, leveling the playing field for different groups of financial institutions, undertaking institutional reforms, strengthening and streamlining the supervisory framework of banking institutions and capital markets, and promoting growth and deepening in the financial and capital markets. Since Malaysia introduced certain discrete policy changes in addition to carrying out a steady pace of reform over decades, a dummy variable *DINTS* will be introduced to take into account the status of the interest rate regime in the country.[11]

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[10] Under the open-economy framework, the portfolio should also include the foreign assets as will be explained in the next section.

[11] In Malaysia, two major policy changes which were explicitly introduced had significant impact on the way interest rates, especially the deposit rates, were determined. The first one implemented in October 1978 was aimed at freeing the interest rate regime from the administrative control of the government. It provided substantial freedom to commercial banks in determining the interest rates. The second measure was brought in to suspend the market determination of interest rates during the tight liquidity period of October 1985-January 1987. Consequently, *DINTS* will have a value of zero for August 1973-September 1978 and for October 1985-January 1987 to represent the presence of market controls, and a value of one for periods October 1978-September 1985 and February 1987-December 1995 to denote the liberal interest rate regime.

An impulse dummy (*dummy9401*) is additionally added for January 1994 because government introduced temporary control measures beginning from this period to sap excess liquidity from the banking system caused by the heavy capital inflows. This variable will take a value of one for January 1994 and zero for the rest of the periods.

B. Model Formulation

There is consensus in the literature that the money demand function is estimated in log-linear form. The monetary aggregates and the scale variable enter in logarithms. The interest rates enter as levels. Similarly, the expected inflation is shown in levels because it is possible for this variable to be negative thereby ruling out logarithm. The model to be estimated can be formulated as follows:

$$LRM2A = \alpha_1 + \alpha_2 LIP90 + \alpha_3 TD3R + \alpha_4 TB3MR + \alpha_5 INF\_A + \varepsilon \tag{2}$$

where *LRM2A* = ln (*M2A/CPI*);
LIP90 = ln (industrial production index);
TD3R = interest on three-month time deposits at commercial banks;
TB3MR = discount rate on three-month treasury bills; and
INF_A = annualized inflation rate.

The model will also include dummy variables *DINTS* and *dummy9401* to indicate the interest rate and policy regime changes respectively.

Expected signs of coefficients

The scale variable (*LIP90*) represents the transactions or wealth effects. In either case, it is positively related to the real demand for money. The coefficient of the three-month commercial bank deposit rate (*TD3R*) is expected to be positive since it represents the own rate of money (and hence, higher the return on money, less the incentive to hold assets alternative for money). Conversely, higher the returns on alternative assets, lower the incentive to hold money, and therefore, the coefficient of the discount rate on three-month Treasury bill (*TB3MR*) is expected to be negative. The expected inflation (*INF_A*), generally, affects the demand for money negatively. Agents prefer to hold real assets as inflation hedges rather than holding money in periods of rising inflation.[12] To summarize, the expected signs of coefficients are as follows: *LIP90* and *TD3R* > 0; and *TB3MR* and *INF_A* < 0.

[12] It is possible that inflation may have a positive relationship with demand for money because when it is expected to rise, agents could increase the money holdings expecting their planned nominal expenditures to move up (see Jusoh (1987)). Consequently, it becomes an empirical issue, but overwhelmingly many studies direct to a negative relationship.

V. Variable Selection and Formulation of Open-Economy Model

A. Introduction

In an open-economy context, the closed-economy version is augmented by variables exerting foreign influence.[13] One major difference is that the portfolio balance of the agents now can include foreign assets as well. Therefore, the return on holding foreign assets should be additionally included as the opportunity cost of holding money. Based on the currency substitution literature, these variables are generally foreign interest rates and the expected depreciation of the domestic currency.[14]

B. Variable Selection

The eurodollar rate (London interbank offered rate (LIBOR)) is the most commonly employed measure in the literature.[15] For the Malaysian situation, yields on the U.S. treasury securities could be possible candidates for the following reasons: (1) United States is one of the three major trading partners for Malaysia; (2) nearly 80 percent of the Malaysian trade is denominated in U.S. dollars; (3) Malaysia has been one of the active Asian countries in purchasing and selling U.S. long-term debt securities (see U.S. Department of Treasury (1997)); and (4) the government securities market, as shown in the International Monetary Fund (1994), has the second largest turnover (just behind the global foreign exchange market) with the U.S. government securities showing the largest average daily transaction volume (exceeding any other government securities). Among a range of securities, the three-month treasury bill can be better suited because like other U.S. treasury securities it possesses desirable characteristics such as high liquidity and being considered as risk free; in addition, its maturity structure will be in line with those of own-rate of money and the return on alternative for money as previously selected in the closed-economy model.

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[13] See Sriram (1999a, Chapter IV) for a list of studies on a number of countries addressing the open-economy type money demand function.

[14] The direct currency substitution literature focuses on exchange rate variable, whereas the capital mobility or indirect currency substitution literature centers its attention on foreign investment variable (see McKinnon (1982), Cuddington (1983), Giovannini and Turtelboom (1993), and Leventakis (1993)).

[15] Alternatively, the short-term interest rates prevailing in major industrial countries are taken either individually (Arize, Spalding, and Umezulike (1991)) or as weighted average (see Arango and Nadiri (1981), Darrat (1986), and Arize (1994)).

Although the currency substitution literature addresses the expected rate of depreciation as the relevant foreign exchange variable, it is really an empirical issue.[16] To begin with, this paper also follows a similar approach. The annualized expected rate of depreciation (*DEPR*) is calculated as $[\ln(e_t) - \ln(e_{t-1})]*12$ where e_t is defined as number of U.S. dollars per unit of ringgit.[17] In this formulation, a negative value signals depreciation of ringgit against U.S. dollar. It will enter in level rather than in logarithm as it can be negative.

C. Model Formulation

Taking into account arguments presented in subsection B above, the open-economy framework can be formulated as follows:

$$LRM2A = \alpha_1 + \alpha_2 LIP90 + \alpha_3 TD3R + \alpha_4 TB3MR + \alpha_5 INF\_A + \alpha_6 USTB3MR + \alpha_7 DEPR + \varepsilon \quad (3)$$

where *LRM2A* = ln (*M2A*/*CPI*);
LIP90 = ln (industrial production index);
TD3R = interest on three-month time deposits at commercial banks;
TB3MR = discount rate on three-month treasury bills;
INF_A = annualized inflation rate;
USTB3MR = yield on three-month U.S. treasury bill;[18]
DEPR = annualized exchange rate depreciation; and
ε = error-term.

[16] For example, other choices are nominal or real effective exchange rates, nominal or real exchange rates, weighted average nominal exchange rates, net foreign interest rate, uncovered interest parity, and so on (see Sriram (1999a)).

[17] *DEPR* is calculated from the actual spot market prices because of the reasons specified below. In the case of industrial countries, the expected spot exchange rates are usually proxied by the forward rates as the market forces are assumed to drive the forward exchange rates to be equal to the expected future spot exchange rates (see Isard (1992)). This is not option for Malaysia as long time series data are not readily available. Furthermore, although forward markets have been operating in the country for sometime, they have been employed only on a limited scale for commercial and financial transactions. Additionally, government sets some cap for the maximum amount for each transaction. Therefore, the absence of active forward markets for foreign currencies implies that one cannot use the forward premium to proxy exchange rate depreciation (see Arize (1994)). Consequently, the actual spot exchange rates are used to calculate the expected depreciation (as in Leventakis (1993)).

[18] As many studies base their analyses on LIBOR, an attempt will be made in Section VII.C to substitute this variable in place of the yield on three-month U.S. treasury bill.

Like in the closed-economy formulation, the model will include seasonal dummies and the dummy variable *DINTS* to indicate the status of interest rate regime in the economy. The model will not incorporate *dummy9401* since the additional variables that are included (*USTB3MR* and *DEPR*) should effectively incorporate the foreign influence.

Expected signs of coefficients

Apart from those employed in the context of closed-economy model, the expected signs of the additional variables—*USTB3MR* and *DEPR* are as follows:

- Increase in foreign interest rates potentially induce the domestic residents to increase their holdings of foreign assets which will be financed by drawing down domestic money holdings. Hence, the foreign interest rates are expected to exert negative influence on the domestic money demand (see Arize (1992)). Therefore, the coefficient for *USTB3MR* is expected to be negative; and

- The expected exchange rate depreciation will also have a negative relationship with real M2. An increase in expected depreciation implies that the expected returns from holding foreign money increases, and hence, agents would substitute the domestic currency for foreign currency (see Simmons (1992)).[19] To summarize, the expected signs of coefficients for the following variables are as follows: *LIP90* and *TD3R* > 0; *TB3MR* and *INF_A* < 0; *USTB3MR* < 0; and *DEPR* < or > 0 (but preferably negative).

VI. Data Issues

The paper applies monthly data from August 1973 to December 1995 (269 observations). August 1973 is chosen as the starting period for two reasons: first, Malaysia began to float the ringgit on June 21, 1973, and hence the entire sample period falls within the managed-floating regime; and second, by August 1, 1973, interest rate ceilings for all commercial bank deposits with maturities exceeding one year were lifted, finance companies were allowed to freely set interest rates for deposits, and the discount rates on Treasury bills were determined by the open tender in the money market (see Teng (1993)). All data series are seasonally unadjusted. They are also preferable for the unit root tests and cointegration analysis as the seasonal-adjustment filters have adverse effects on the power of the unit root and cointegration tests (see Ghysels (1990) and Davidson and MacKinnon (1993)

[19] However, Tan (1997) envisages the possibility of obtaining both negative and positive relationship. The impact can be negative if the domestic currency depreciation leads public to anticipate a further depreciation, prompting them to demand more foreign currency against domestic currency. On the other hand, a positive impact can result if a depreciation heightens expectation that the domestic currency would rebound, thus inducing people to hold more domestic money.

respectively). In order to pick up the unaccounted seasonal effects, seasonal dummies will be introduced.

The data sources for the monetary aggregates, industrial production index, and discount rate on three-month treasury bills are various issues of BNM, *Monthly Bulletin* and *Quarterly Bulletin*; for the consumer price index and period-average nominal foreign exchange rate of the ringgit against the U.S. dollar (*XR_AVG*), the IMF, *International Financial Statistics (IFS)* database (line numbers *64* and *rf* respectively); for the three-month commercial bank time-deposit rates, BNM, *Monthly Bulletin* and *Quarterly Bulletin* and the IMF, *IFS* line *54860l*; and for yields on the three-month U.S. treasury bill and LIBOR on three-month U.S. dollar deposits is the IMF, *IFS* (lines *11160c* and *11160ldd* respectively).

VII. Estimation

An error-correction approach is followed for the analysis. This type of formulation is a dynamic error-correction representation in which the long-run equilibrium relationship between money and its determinants is embedded in an equation that captures short-run variation and dynamics. The impetus came from the findings that in modeling the demand for money, due consideration be given not only in selecting appropriate theoretical set up and empirical make up, but also in specifying the proper dynamic structure.

Since a necessary condition for the existence of long-run relationship (when nonstationary time series are involved) is the presence of cointegration vector, this section estimates the models as shown in equations (2) and (3) by the cointegration techniques. The objective is to form and estimate well-specified models that could satisfy a number of modeling criteria as suggested by Hendry and Richard (1983). Once the cointegration relationships are found, weak exogeneity tests are carried out to see whether the models can be reduced from system formulations to single equations to analyze the short-run dynamic adjustment behavior of variables. However, before proceeding to the cointegration analyses, Subsection A examines the unit root characteristics of relevant time series.

A. Unit Root Tests

In this paper, Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) tests are applied. Among the DF tests, τ_μ and $\tau\tau$ are used. As seasonally unadjusted data are used, the tests are redone by including monthly seasonal dummies. The ADF test is conducted by both including and excluding seasonal dummies. With 269 observations, the lag length is calculated as 15 using the Schwert's criterion (Schwert (1989)). For each variable, the order of integration is confirmed by Dickey and Pantula (1987) sequential approach. The tests are, therefore, begun with an assumption that the order of integration is at most two. The results presented in Table 1 indicate that *LRM2A, TD3R, TB3MR, XR_AVG, USTB3MR,* and *LIBOR3M* are I(1); and *LIP90, INF_A,* and *DEPR* are I(0). In order to observe any drifts or breaks that may bias the unit root test results, time series employed in the analysis are plotted

Table 1. Results of Unit Root Tests 1/

	Augmented Dickey-Fuller Test							
	Constant		Constant + Seasonal		Constant + Trend		Constant + Trend + Seasonal	
	Test statistic	Lag length	Test statistic	Lag length	Test statistic	Lag length	Test statistic	Lag length
LRM2A	-1.0091	15	-0.9944	15	-2.4507	15	-2.2557	15
LIP90	0.8324	15	0.8130	15	-7.2344 **	0	-5.9794 **	0
TD3R	-2.4727	15	-2.3556	15	-2.4675	15	-2.3504	15
TB3MR	-2.4360	15	-2.3727	15	-3.0701	15	-2.9639	15
INF_A	-12.8850 **	0	-13.0980 **	0	-12.8860 **	0	-13.1060 **	0
XR_AVG	-1.5655	15	-1.5132	15	-1.9204	15	-1.8725	15
DEPR	-12.2180 **	0	-11.8170 **	0	-12.1950 **	0	-11.7930 **	0
USTB3MR	-1.7494	15	-1.7309	15	-2.0071	15	-1.9759	15
LIBOR3M	-1.8527	15	-1.8092	15	-2.0961	15	-2.0613	15
DLRM2A	-16.0970 **	0	-16.3300 **	0	-16.1050 **	0	-16.3410 **	0
DLIP90	-28.0360 **	0	-27.6040 **	0	-28.0020 **	0	-27.5710 **	0
DTD3R	-13.8850 **	0	-13.7170 **	0	-13.8570 **	0	-13.6890 **	0
DTB3MR	-11.1230 **	0	-10.5940 **	0	-11.1060 **	0	-10.5750 **	0
DINF_A	-22.3500 **	0	-24.1390 **	0	-22.0370 **	0	-24.0890 **	0
DXR_AVG	-12.0720 **	0	-11.6800 **	0	-12.0500 **	0	-11.6570 **	0
DDEPR	-23.4530 **	0	-22.9180 **	0	-23.4100 **	0	-22.8720 **	0
DUSTB3MR	-11.6990 **	0	-11.3820 **	0	-11.6780 **	0	-11.3610 **	0
DLIBOR3M	-11.8290 **	0	-11.4740 **	0	-11.8060 **	0	-11.4510 **	0
DDLRM2A	-29.5500 **	0	-29.0250 **	0	-29.4910 **	0	-28.9650 **	0
DDLIP90	-39.3690 **	0	-37.4260 **	0	-39.2900 **	0	-37.3480 **	0
DDTD3R	-28.4070 **	0	-28.0320 **	0	-28.3500 **	0	-27.9740 **	0
DDTB3MR	-23.0640 **	0	-22.0480 **	0	-23.0190 **	0	-22.0030 **	0
DDINF_A	-29.8780 **	0	-31.4230 **	0	-29.8190 **	0	-31.3580 **	0
DDXR_AVG	-23.2260 **	0	-22.7160 **	0	-23.1830 **	0	-22.6710 **	0
DDDEPR	-32.2340 **	0	-31.6030 **	0	-32.1730 **	0	-31.5400 **	0
DDUSTB3MR	-19.2690 **	0	-18.7500 **	0	-19.2300 **	0	-18.7100 **	0
DDLIBOR3M	-19.1600 **	0	-18.5380 **	0	-19.1230 **	0	-18.5000 **	0
	Dickey Fuller Test							
LRM2A	-0.1570	...	-0.1179	...	-1.3711	...	-1.2158	...
LIP90	-0.6650	...	-0.4095	...	-7.1959 **	...	-6.0021 **	...
TD3R	-1.5403	...	-1.4731	...	-1.5426	...	-1.4756	...
TB3MR	-1.5556	...	-1.5074	...	-1.7215	...	-1.6509	...
INF_A	-11.9530 **	...	-11.7100 **	...	-12.2590 **	...	-12.0780 **	...
XR_AVG	-1.7889	...	-1.7184	...	-1.9635	...	-1.8902	...
DEPR	-12.9980 **	...	-12.6690 **	...	-12.9800 **	...	-12.6500 **	...
USTB3MR	-1.8817	...	-1.8276	...	-2.0813	...	-2.0221	...
LIBOR3M	-1.9557	...	-1.8899	...	-2.1947	...	-2.1337	...
DLRM2A	-16.4490 **	...	-16.6320 **	...	-16.4170 **	...	-16.5990 **	...
DLIP90	-28.8900 **	...	-28.6200 **	...	-28.8570 **	...	-28.5880 **	...
DTD3R	-14.3240 **	...	-14.1160 **	...	-14.3000 **	...	-14.0920 **	...
DTB3MR	-11.5040 **	...	-10.9990 **	...	-11.4820 **	...	-12.2750 **	...
DINF_A	-23.4520 **	...	-24.6000 **	...	-23.4100 **	...	-24.5530 **	...
DXR_AVG	-12.8360 **	...	-12.5150 **	...	-12.8180 **	...	-12.4960 **	...
DDEPR	-25.1760 **	...	-24.7440 **	...	-25.1300 **	...	-24.6970 **	...
DUSTB3MR	-12.6120 **	...	-12.2990 **	...	-12.5880 **	...	-12.2750 **	...
DLIBOR3M	-11.9290 **	...	-11.5710 **	...	-11.9070 **	...	-11.5480 **	...
DDLRM2A	-29.9970 **	...	-29.4770 **	...	-29.9420 **	...	-29.4200 **	...
DDLIP90	-40.5000 **	...	-38.6410 **	...	-40.4240 **	...	-38.5660 **	...
DDTD3R	-29.2260 **	...	-28.7920 **	...	-29.1710 **	...	-28.7360 **	...
DDTB3MR	-23.6210 **	...	-22.7520 **	...	-23.5770 **	...	-22.0790 **	...
DDINF_A	-30.6730 **	...	-31.5050 **	...	-30.6150 **	...	-31.4430 **	...
DDXR_AVG	-24.9260 **	...	-24.5310 **	...	-24.8800 **	...	-24.4840 **	...
DDDEPR	-35.6810 **	...	-35.1410 **	...	-35.6120 **	...	-35.0690 **	...
DDUSTB3MR	-20.5990 **	...	-20.1640 **	...	-20.5600 **	...	-20.1250 **	...
DDLIBOR3M	-19.4060 **	...	-18.7970 **	...	-19.3690 **	...	-18.7590 **	...

1/ ** and * indicate the rejection of unit roots at 1 percent and 5 percent significance level respectively.

in Figure 1. There are apparently no noticeable breaks thereby confirming the conclusions from the unit root tests.

B. Closed-Economy Model

Cointegration tests

As unit root tests show that the variables are either I(0) or I(1), the cointegration technique is appropriate to estimate the long-run demand for money. This paper applies the method developed by Johansen (1988) and Johansen and Juselius (1990). Variables *LRM2A*, *LIP90*, *INF_A*, *TD3R*, and *TB3MR* are entered as endogenous variables in that order. Dummy variables *DINTS* and *dummy9401*, a constant, and seasonal dummies are also introduced. Since monthly data are used, the analysis is begun with 12 lags. To find a model with the appropriate lag length and to avoid overparameterization, the test is repeated by sequentially reducing one lag at a time until the lag length reaches one. Multivariate tests are undertaken for each run by setting lags for error autocorrelation as 12 and autoregressive conditional heteroscedasticity (ARCH) as 3. The normality test is also conducted.

The cointegration test results are provided in Table 2. They indicate that both trace and maximal eigenvalue tests reject zero in favor or at least one cointegration vector. The results are significant at 1 percent level, even when the critical values are adjusted for degrees of freedom (see Osterwald-Lenum (1992)). The eigenvalue associated with the first vector is certainly dominant over those corresponding to other vectors, thereby confirming that there exists a unique cointegrating vector in the model. In order to find out whether it represents the demand for real M2, β' matrix containing the parameters of the cointegration vectors are examined. The rows of the β' matrix correspond to the standardized coefficients of the variables entering into the respective cointegrating vector. The coefficients are normalized with a value of one along the principal diagonal of the matrix. For example, the first row corresponds to the significant cointegrating vector identified above in which LRM2A is normalized as one. It can be written in an equation form as follows:

$$LRM2A = 1.0358 * LIP90 + 4.8841 * TD3R - 5.3908 * TB3MR - 4.7452 * INF\_A \quad (4)$$

Based on the signs and magnitudes of the estimated coefficients, the unique cointegration vector as shown in the form of equation (4) can be interpreted as the long-run demand for real M2. The graphical result not shown here confirms that the cointegration vector is fairly stationary. To evaluate the goodness of the cointegration results, a series of standard diagnostic test is conducted in PcFiml 9.0. The error-autocorrelations are carefully examined. And, the model is found to be free of estimation problems.

Discussion on the coefficients of the money demand equation

Results shown in equation (4) indicate that the long-run income elasticity is very close to one (1.0358) in accord with the quantity theory of money. Other variables also

Table 2. Cointegration and Weak-Exogeneity Test Results

Cointegration test 1/					
Eigenvalues	0.1773	0.0645	0.0528	0.0396	0.0024
Null hypotheses 2/	r = 0	r <= 1	r <= 2	r <= 3	r <= 4
λ trace 3/	96.5700 **	44.0600	26.1200	11.5400	0.6590
Adjusted for degrees of freedom 4/	91.1900 **	41.6000	24.6600	10.8900	0.6222
95 percent critical values	68.5000	47.2000	29.7000	15.4000	3.8000
λ max 3/	52.5100 **	17.9400	14.5900	10.8800	0.6590
Adjusted for degrees of freedom 4/	49.5900 **	16.9400	13.7700	10.2700	0.6222
95 percent critical values	33.5000	27.1000	21.0000	14.1000	3.8000
	Standardized Eigenvectors β'				
	LRM2A	LIP90	INF_A	TD3R	TB3MR
	1.0000	-1.0358	4.7452	-4.8841	5.3908
	-0.8082	1.0000	0.2512	6.2053	-10.5530
	-3.4848	3.0011	1.0000	3.8469	29.9600
	0.0603	-0.0558	0.0197	1.0000	0.1286
	-0.0214	0.1521	0.1237	-0.0907	1.0000
	Standardized Adjustment Coefficients α				
	LRM2A	LIP90	INF_A	TD3R	TB3MR
ΔLRM2A	-0.0092	-0.0026	0.0025	-0.0195	0.0080
ΔLIP90	0.0277	-0.1032	-0.0059	-0.1109	0.0134
ΔINF_A	-0.0966	-0.0465	-0.0052	-0.0231	-0.0249
ΔTD3R	0.0019	-0.0016	0.0006	-0.0191	-0.0012
ΔTB3MR	0.0005	0.0031	-0.0004	-0.0114	-0.0001
Weak-exogeneity test 5/					
Variables	ΔLRM2A	ΔLIP90	ΔINF_A	ΔTD3R	ΔTB3MR
$\alpha_1 = 0$	$\chi^2(1) = 4.3889$ [0.0362]*				
$\alpha_2 = 0$	$\chi^2(1) = 2.7048$ [0.1000]				
$\alpha_3 = 0$	$\chi^2(1) = 24.106$ [0.0000]**				
$\alpha_4 = 0$	$\chi^2(1) = 2.7048$ [0.1000]				
$\alpha_5 = 0$	$\chi^2(1) = 0.5118$ [0.4744]				

1/ The system includes 3 lags for each variable, a constant, seasonal dummies, and dummy variables *DINTS* and *dummy9401*. The estimation period is 1973:8-1995:12 (269 observations).

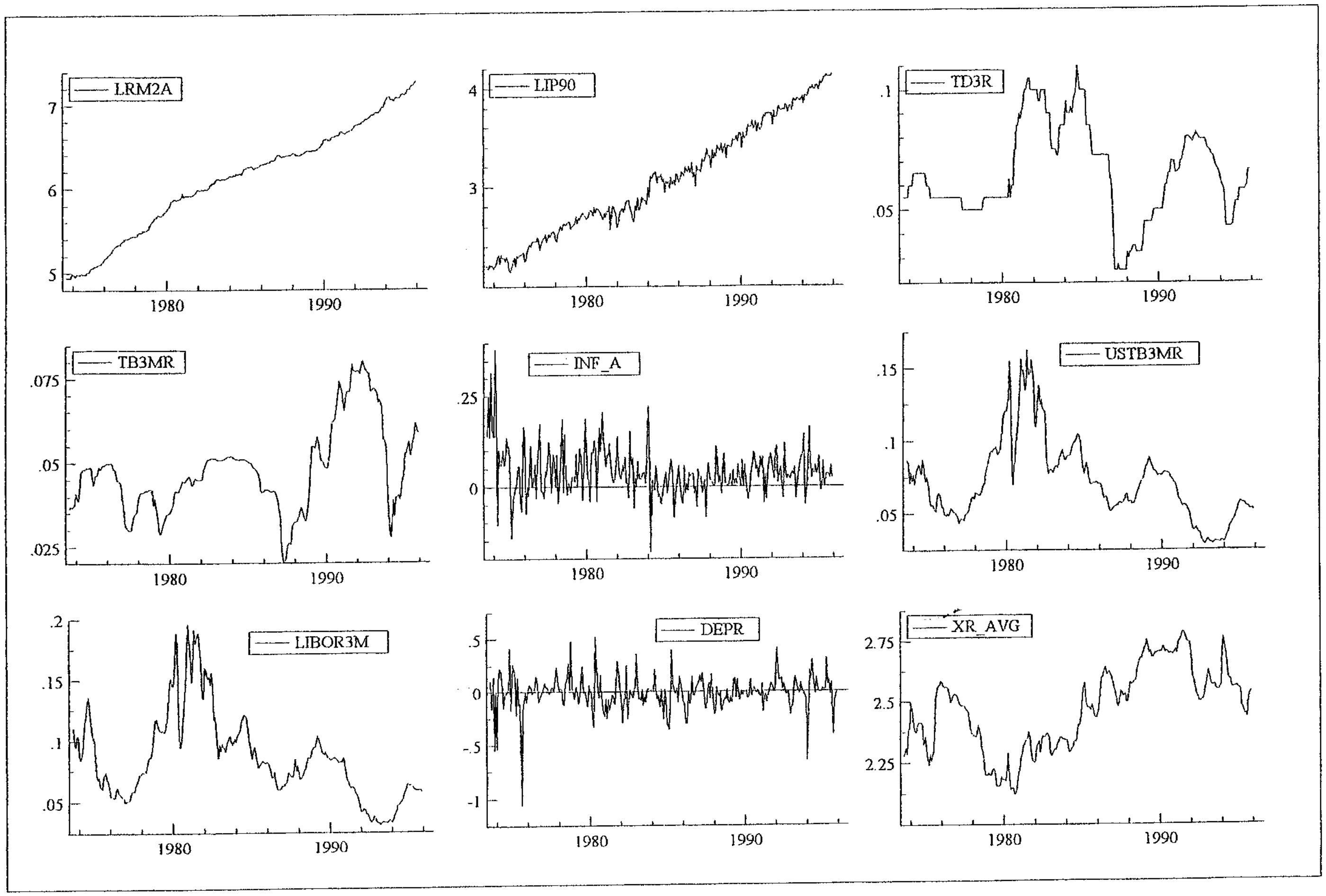
2/ r stands for the number of ranks.

3/ ** indicates the significance at 1 percent level.

4/ As per Reimers (1992).

5/ ** and * indicate that the null hypothesis of weak-exogeneity is rejected at 1 percent and 5 percent significance level respectively. The probability of getting any number exceeding the χ^2 value shown above is less than the figure presented within the squared brackets.

Figure 1. Graphical Presentation of Various Time Series Used in the Cointegration Analysis



behave in the manner the money demand theory suggests. In specific, the long-run demand for real M2 is positively affected by the own-rate of return (*TD3R*) and negatively related to both the alternative return for money (*TB3MR*) and the expected inflation (*INF_A*). The coefficients of these variables carry the expected magnitudes. The restricted cointegration test does not reject the hypothesis of the coefficients of *TD3R* and *TB3MR* being equal but with opposite sign.[20]

In case of Malaysia, as the financial system is fairly well-developed and institutions are well in place, like the results on industrial countries seem to suggest the income elasticity of money has come close to one. In contrast, the earlier papers derived the income elasticity of greater than 1.5 for Malaysia (see Sriram (1999c), Table 9). The differences among various studies could be due to model set up, variables included, frequency of observations, and the estimation periods and techniques applied. However, one of the major reasons for obtaining high income elasticity is model misspecification, especially omitting relevant opportunity cost variables.[21]

As mentioned above, the opportunity cost variables shown in equation (4) also behave in the manner as suggested by theory. The coefficient of the own-rate of money (*TD3R*) is positive and of alternative return (*TB3MR*) and of expected inflation (*INF_A*) are negative. To be specific, the semi-elasticity of *TD3R* is 4.8841 and of *TB3MR* is -5.3908. Like in many developing countries the impact of the expected inflation has been much more pronounced in Malaysia on the demand for money supporting the general consensus that agents sway away from money holdings to real assets when the inflation is expected to rise.

The results concerning the sign of the coefficients of the interest rates corroborate the findings of Tan (1997), who included similar own-rate of and the alternative return on money as in our study, but obtained slightly different coefficients (0.027 and -0.061 respectively). The higher coefficient in absolute term for the alternative return on money may be due to the fact that the expected inflation is not included as an explanatory variable, and hence, its effect is picked up by the former. The additional opportunity cost variable introduced to take into account of the foreign influence seems to be unimportant. Both Tseng and Corker (1991) and Dekle and Pradhan (1997) applied the net interest rate measure and obtained the semi-elasticities of -1.65 and -0.068 respectively. These results are not directly comparable with

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[20] Given the findings we could have used a variable called net interest rate for opportunity cost in the form of *TB3MR* minus *TD3R* as some studies have done (see Dekle and Pradhan (1997)). Since a well-specified formulation has already been obtained, analysis was not conducted to further explore this representation; however, it should be noted that the preliminary attempts do indicate that this measure is negatively related to *LRM2A*.

[21] It is typically the case in many studies where the own-rate of money is altogether ignored or expected inflation is not taken into account. The omitted opportunity cost variables could be highly correlated with money, and hence, the scale variable apparently is picking up their effects causing the income elasticity to significantly exceed one.

ours. However, it should be pointed out that these studies arrived at the estimates of 1.63 and 1.56 for income elasticity respectively (which may effectively be reflecting the omission of inflation as an additional explanatory variable in the estimation).

Discussion on adjustment coefficients (α)

In general α matrix contains weights with which cointegrating vectors enter the equations in the system. Each nonzero column of the matrix also measures the speed of the short-run response to disequilibrium occurring in various equations of endogenous variables entered in the system. For example, the coefficients in the first column of α in Table 2 measure the feedback effects of the lagged disequilibrium in the cointegrating vector onto the variables in the vector autoregression (VAR). In specific, the first term in α represents the speed at which *LRM2A*, the dependent variable in the first equation of the VAR moves toward restoring the long-run equilibrium; and the second term, shows how fast *LIP90* responds to the short-run disequilibrium in the cointegration vector. In specific, -0.0092 is the estimated feedback coefficient for the money equation. The negative coefficient implies that lagged excess money induces smaller holdings of current money. Its numerical value implies slow adjustment of remaining equilibrium (approximately 0.9 percent in the first month).[22] It is apparent from the table that most of the adjustments are taking place in the equations for *LRM2A*, *LIP90*, and *INF_A*. However, weak exogeneity tests indicate (as will be discussed later) that adjustments are primarily carried out via *LRM2A* and *INF_A*. Significant corrections do not take place in the equations for *TD3R* and *TB3MR* as marked by the coefficients of these equations being close to zero.

Tests for parameter constancy

In order to ensure the robustness of test results, parameters have been evaluated for their stability throughout the study period. To accomplish this task, the cointegration test is redone using the recursive estimation method with the initial data set to contain 135 observations. This effectively breaks the number of data points into one half and allow the test to commence from late-1984. As the economy has been undergoing a number of changes including major liberalization of interest rates from October 1978, beginning the initialization around the mid-1980s will leave sufficient number of data points to examine whether the demand for real M2 has remained stable over a long period of time. To this effort, the following parameter constancy tests are carried out: residual sum of squares, one-step residuals, and chow tests. The chow tests further include one-step chow test and break-point

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[22] Ericsson and Sharma (1996) provide estimates from a number of studies examining the demand for money in various countries. The adjustment in case of Malaysia seems to be rather slow in comparison with these estimates probably because relatively there are fewer alternatives for money, although more financial instruments have been introduced in the 1980s and 1990s. In comparison, Tan (1997) obtained the α coefficient of -0.247 for *LRM2A* using the quarterly data for 1973-91.

and forecast chow tests (Ndown and Nup chow tests respectively). The results are shown in Figure 2 and Table 3.

The diagnostic tests shown in Table 3 indicate no problem with autocorrelation. The parameter constancy tests as shown in Figure 2 shows a minor outlier in 1995. There are a few outliers for *rTD3R* during the 1985-87 period and a few minor ones for *rTB3MR* over several periods between 1987 and 1995. The 1up chow test corroborates with the analysis from 1up residuals test confirming that *LRM2A* shows considerable stability throughout the study period except for a break in June 1995. This measure coincides with a policy measure introduced by the government to liberalize the domestic capital markets. The 1up chow test for the entire system magnifies the results from all variables and it appears that there is a major instability for March 1987. It is basically reflecting the measures that have been introduced to liberalize the domestic banking sector, capital markets, and foreign exchange during the end-1986 and the first two months of 1987 (see Sriram (1999e), Table A1).

It is evident that this paper has obtained a well-specified model of demand for real M2 in Malaysia in terms of sign and coefficients and from the diagnostic and parameter constancy test results. The model produces relatively stable function of long-run demand for money. The system as a whole, however, shows some sign of instability arising from the impact of the policy measures introduced during the 1985-87 period which affect *TD3R* and *TB3MR*. The capital inflows/outflows episode of the 1993-95 period shows some instabilities on *TB3MR* because of the efforts of the government to manage the exchange rate.[23] To the extent these two variables prove to be weakly exogenous, the short-run error-correction model should produce a stable money demand function.

Weak-exogeneity tests

The weak-exogeneity tests permit one to draw inferences from the cointegration relationship that is obtained earlier to examine whether the short-run demand for money could be modeled in a simpler setting. Since one cointegrating relationship has been identified, the weak exogeneity tests are evaluated under the assumption of rank (r) = 1. The test statistics will be asymptotically distributed as $\chi^2(1)$ if weak exogeneity of a given variable for the cointegrating sector is valid. The null hypothesis is the existence of weak exogeneity. It is usually examined by restricting the particular α equals zero (in general terms, weak exogeneity involves testing whether or not the corresponding row of α is zero (see Johansen (1992)). If the null hypothesis is not rejected, disequilibrium in the

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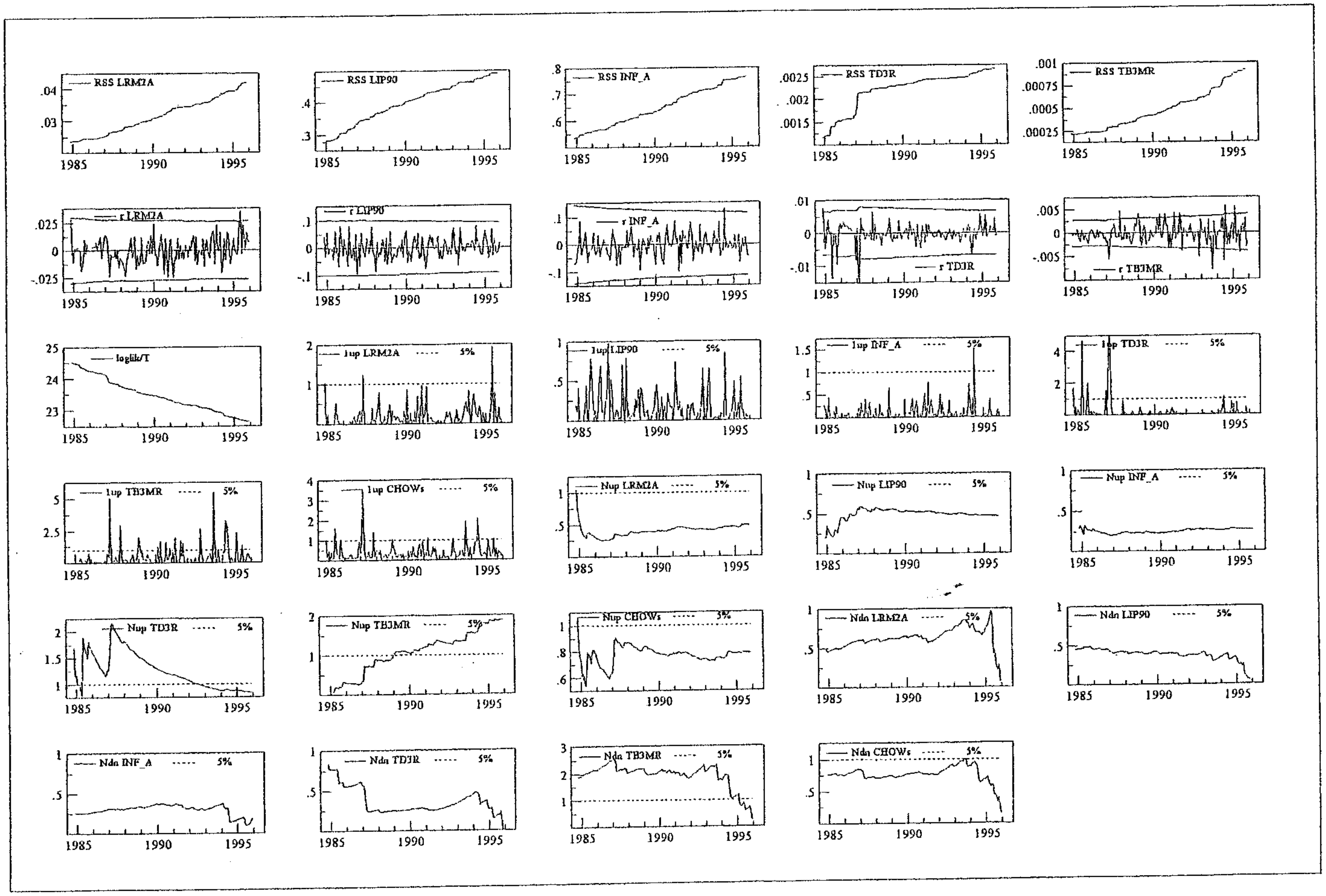
[23] BNM influences the exchange rate in the following three ways in Malaysia: it makes direct purchases or sales of U.S. dollars in the currency markets; influences interest rates by issuing government bills and holding a daily tender of funds in which banks are required to make offers; and imposes regulatory measures, for instance, increasing the statutory reserve requirement (see Morgan Guaranty Trust Company (1996)).

Table 3. Closed-Economy Formulation: Diagnostic Test Results For Cointegration Analysis

```
Cointegration analysis 1973 (8) to 1995 (12)

    eigenvalue       loglik for rank
                       6045.76   0
      0.177348         6072.02   1
     0.0645092         6080.99   2
     0.0527795         6088.28   3
     0.0396256         6093.72   4
    0.00244679         6094.05   5

Ho:rank=p  -Tlog(1-\mu)    using T-nm   95%  -T\Sum log(.)  using T-nm   95%
 p ==  0        52.51**       49.59**  33.5        96.57**       91.19**  68.5
 p <=  1        17.94         16.94    27.1        44.06         41.6     47.2
 p <=  2        14.59         13.77    21.0        26.12         24.66    29.7
 p <=  3        10.88         10.27    14.1        11.54         10.89    15.4
 p <=  4        0.659         0.6222    3.8        0.659         0.6222    3.8

standardized \beta' eigenvectors
       LRM2A        LIP90        INF_A         TD3R        TB3MR
      1.0000      -1.0358       4.7452      -4.8841       5.3908
    -0.80817       1.0000      0.25123       6.2053      -10.553
     -3.4848       3.0011       1.0000       3.8469       29.960
    0.060259    -0.055787     0.019656       1.0000      0.12860
   -0.021413      0.15208      0.12370    -0.090688       1.0000

standardized \alpha coefficients
 LRM2A        -0.0091917  -0.0026475   0.0025016   -0.019506   0.0080117
 LIP90          0.027689    -0.10315  -0.0059037    -0.11093    0.013391
 INF_A         -0.096605   -0.046516  -0.0051895   -0.023131   -0.024924
 TD3R          0.0019162  -0.0016254  0.00063134   -0.019070  -0.0011954
 TB3MR        0.00051494   0.0030547 -0.00037831   -0.011394 -0.00010602

long-run matrix Po=\alpha*\beta', rank 5
                   LRM2A        LIP90        INF_A         TD3R        TB3MR
 LRM2A         -0.017117     0.016687    -0.041173     0.017856     0.058838
 LIP90           0.12465     -0.14132     0.099050     -0.91015       1.0600
 INF_A         -0.041788     0.035470     -0.47883      0.14235     -0.21329
 TD3R       -9.3844e-005 -0.00083339    0.0087930    -0.035978     0.042750
 TB3MR        -0.0013198    0.0020055    0.0025956    0.0036004    -0.042364

Number of lags used in the analysis: 3
Variables entered unrestricted:
 Seasonal_6 Seasonal_7  Seasonal Seasonal_8 Seasonal_9 Seasonal_10
 Seasonal_1  Constant Seasonal_4 Seasonal_2 Seasonal_5 Seasonal_3
     DINTS dummy9401


LRM2A   :Portmanteau 12 lags=   8.6415
LIP90   :Portmanteau 12 lags=   23.123
INF_A   :Portmanteau 12 lags=   14.173
TD3R    :Portmanteau 12 lags=   15.125
TB3MR   :Portmanteau 12 lags=   6.4554
LRM2A   :AR 1-12 F(12,228) =    0.75201 [0.6993]
LIP90   :AR 1-12 F(12,228) =     1.7895 [0.0509]
INF_A   :AR 1-12 F(12,228) =     1.6324 [0.0838]
TD3R    :AR 1-12 F(12,228) =     1.4113 [0.1616]
TB3MR   :AR 1-12 F(12,228) =    0.48458 [0.9226]
LRM2A   :Normality Chi^2(2)=     3.5005 [0.1737]
LIP90   :Normality Chi^2(2)=     20.802 [0.0000] **
INF_A   :Normality Chi^2(2)=     39.311 [0.0000] **
TD3R    :Normality Chi^2(2)=     91.303 [0.0000] **
TB3MR   :Normality Chi^2(2)=     34.597 [0.0000] **
LRM2A   :ARCH 3   F( 3,234) =    1.7438 [0.1588]
LIP90   :ARCH 3   F( 3,234) =    3.3433 [0.0200] *
INF_A   :ARCH 3   F( 3,234) =    8.5907 [0.0000] **
TD3R    :ARCH 3   F( 3,234) =    3.6893 [0.0126] *
TB3MR   :ARCH 3   F( 3,234) =    2.4724 [0.0624]
LRM2A   :Xi^2     F(30,209) =   0.96803 [0.5190]
LIP90   :Xi^2     F(30,209) =   0.98096 [0.5001]
INF_A   :Xi^2     F(30,209) =    2.8183 [0.0000] **
TD3R    :Xi^2     F(30,209) =    1.5409 [0.0431] *
TB3MR   :Xi^2     F(30,209) =    2.0123 [0.0024] **
LRM2A   :Xi*Xj    F(135,104) =   0.92083 [0.6754]
LIP90   :Xi*Xj    F(135,104) =    1.0833 [0.3359]
INF_A   :Xi*Xj    F(135,104) =     1.637 [0.0044] **
TD3R    :Xi*Xj    F(135,104) =    1.4367 [0.0267] *
TB3MR   :Xi*Xj    F(135,104) =   0.95794 [0.5951]
Vector portmanteau 12 lags=   260.36
Vector AR 1-12 F(300,883) =     1.1043 [0.1416]
Vector normality Chi^2(10)=    192.29 [0.0000] **
Vector  Xi^2    F(450,2680) =    1.2118 [0.0030] **
Vector  Xi*Xj  F(2025,1426) =     1.1613 [0.0012] **
```

Figure 2. Closed-Economy Formulation: Parameter Constancy Tests for Cointegration Analysis



cointegrating relationship does not feed back onto that variable; but any disequilibrium of a given variable will have impact on the cointegrating relationship.

The results presented in Table 2 show that the weak exogeneity is rejected for *LRM2A* and *INF_A* at 5 percent and 1 percent significance level respectively. Therefore, a short-run model can be designed with a system of two equations, one with *LRM2A* and another with *INF_A* by considering *LIP90*, *TD3R*, and *TB3MR* as weakly exogenous. However, since the cointegration relationship is found to be representing the demand for money, alternatively, we can go to a single equation framework involving $\Delta LRM2A$ as the endogenous variable. The error-correction model (ECM) designed under the single equation set up for $\Delta LRM2A$ is the focal point in the next subsection.

Short-run model

The short-run model provides information concerning how adjustments are taking place among various variables to restore the equilibrium to the long-run level in response to short-term disturbances in demand for money. Essentially it is an ECM which contains an error-correction (EC) term to ensure that the long-run relationship is satisfied. The EC is calculated from the cointegrating vector representing the *LRM2A* equation. The specification of the ECM will be based on the unit root characteristics of the variables and the lag length applied in the cointegration analysis as will be discussed below. In general, the short-run model will have the I(0) representation of variables both on the left-hand side (LHS) and on the right-hand side (RHS) of the equation. Since the variables are either I(0) or I(1), the RHS will contain variables expressed in terms of first differences (except for the EC term which will be in level). As one lag of a difference term equals second lag of the level, the number of lags in the short-run model is usually one less than what applied in the cointegration tests. Since original data are seasonally unadjusted, seasonal dummies are also entered.

This subsection begins with estimating the unrestricted model in PcFiml 9.0. The model will then be reduced to a parsimonious form following the general-to-specific modeling criteria. The reduction process is monitored by the "model progress" procedure to make sure that the model finally obtained is not worse off from any previously specified ones. Both the unrestricted and the parsimonious models will be examined for their characteristics and behavior. The parameter stability tests will also be performed.

Unrestricted model

Based on the weak exogeneity tests, a single equation unrestricted reduced form (URF) model is formulated to analyze the short-run dynamics for $\Delta LRM2A$. It will contain $\Delta LRM2A$ on the LHS and first differences in *LRM2A*, *LIP90*, *INF_A*, *TD3R*, and *TB3MR* with each variable having two lags to match the lag length of three in the cointegration test. The RHS will also include an EC term (*cl_ecm_a_1*) calculated as *LRM2A* minus the estimated *LRM2A* in time t-1 (from the cointegration vector as shown in equation (3) above). In economic term, it represents excess money in the previous period. In connection with the dummy variable employed to represent the interest rate liberalization in the cointegration test, a first difference of *DINTS* is created which is called as *DDINTS* is introduced. Similarly, the impulse dummy *dummy9401* is also added. Since the seasonally unadjusted data are originally used, seasonal dummies are employed as well. The URF model looks as follows:

$$\begin{aligned}\Delta LRM2A_t = {} & \alpha_0 + \alpha_1 \Delta LRM2A_{t-1} + \alpha_2 \Delta LRM2A_{t-2} + \alpha_3 \Delta LIP90_{t-1} + \alpha_4 \Delta LIP90_{t-2} + \\ & \alpha_5 \Delta INF\_A_{t-1} + \alpha_6 \Delta INF\_A_{t-2} + \alpha_7 \Delta TD3R_{t-1} + \alpha_8 \Delta TD3R_{t-2} + \\ & \alpha_9 \Delta TB3MR_{t-1} + \alpha_{10} \Delta TB3MR_{t-2} + \alpha_{11} EC + \alpha_{12} DDINTS + \alpha_{13} dummy9401 + \\ & \theta_j SD_j + e_t \end{aligned} \tag{5}$$

where *SD* stands for dummy variables. Other variables are as defined previously.

Since all variables are I(0), the above model can be estimated by the OLS. The results shown in Table 4 indicate that constant, $\Delta TD3R_{t-2}$ and seasonal variable (except for one) are significant at 1 percent level; and $\Delta LRM2A_{t-1}$, $\Delta TD3R_{t-1}$, $\Delta TB3MR_{t-1}$, EC (*cl_ecm_a_1),* and *dummy9401* are at 5 percent level. All other variables including *DDINTS* found to be irrelevant. The error-correction term is negative validating the significance of the cointegration relationship. A significant EC term carrying a negative sign conveys two pieces of information: first, agents have corrected in the current period a proportion of previous disequilibrium in money balances (see Rose (1985)); second, it assures that the cointegration relationship established previously is valid as per Granger's Representation Theorem (see Engle and Granger (1987)). The negative sign specifically implies that a fall in excess money in the last period will result in higher level of desired money holdings in the current period. In other words, it is essential for the existing disequilibrium to be reduced over time. The diagnostic tests show no problem with autocorrelation, normality, ARCH, and heteroscedasticity (see Table 4).[24] The parameter constancy tests as shown in Figure 3 do not identify major problem with the stability of the ECM except for one minor break in the middle of 1995 as in the case of cointegration test.

Restricted model

The URF model is reduced into a parsimonious one by following the general-to-specific principles and by applying full-information maximum likelihood (FIML) technique. The results are shown in Table 4. All the significant variables in the unrestricted analysis are found likewise in the parsimonious model as well. The interesting aspect is that the policy measures introduced in January 1994 as explained before prove to be important in the short

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[24] The variables in equation (5) are identified in Table 4 as follows: Δ is replaced by "D", and lag lengths t-1 and t-2 are shown as suffix "_1" and "_2" respectively. For example, $\Delta LRM2A_{t-1}$ will be presented as *DLRM2A_1*. The EC term is shown as cl_ecm_a_1.

Table 4. Closed-Economy Formulation: Results of Short-Run Models

EQ(3) Estimating the unrestricted reduced form by OLS (using MDATAM2p.in7)
The present sample is: 1973 (8) to 1995 (12)

URF Equation 1 for DLRM2A

Variable	Coefficient	Std.Error	t-value	t-prob
DLRM2A_1	-0.15504	0.069476	-2.232	0.0266
DLRM2A_2	0.067016	0.069781	0.960	0.3378
Constant	0.052668	0.013274	3.968	0.0001
DLIP90_1	-0.017183	0.018002	-0.955	0.3408
DLIP90_2	0.010570	0.017869	0.592	0.5547
DINF_A_1	0.0043984	0.018926	0.232	0.8164
DINF_A_2	0.020501	0.014367	1.427	0.1549
DTD3R_1	0.56868	0.24624	2.309	0.0218
DTD3R_2	0.70694	0.25318	2.792	0.0056
DTB3MR_1	-0.94773	0.39998	-2.369	0.0186
DTB3MR_2	-0.24168	0.38568	-0.627	0.5315
cl_ecm_a_1	-0.0089821	0.0042188	-2.129	0.0342
DDINTS	0.0083747	0.0077756	1.077	0.2825
dummy9401	0.032771	0.013777	2.379	0.0181
Seasonal	-0.0085121	0.0043288	-1.966	0.0504
Seasonal_1	-0.014152	0.0044447	-3.184	0.0016
Seasonal_2	-0.020275	0.0044378	-4.569	0.0000
Seasonal_3	-0.014880	0.0046196	-3.221	0.0015
Seasonal_4	-0.024716	0.0045050	-5.486	0.0000
Seasonal_5	-0.014452	0.0040391	-3.578	0.0004
Seasonal_6	-0.022181	0.0041220	-5.381	0.0000
Seasonal_7	-0.014934	0.0041557	-3.594	0.0004
Seasonal_8	-0.016002	0.0041231	-3.881	0.0001
Seasonal_9	-0.016972	0.0040228	-4.219	0.0000
Seasonal_10	-0.019727	0.0040893	-4.824	0.0000

\sigma = 0.0132033 RSS = 0.04253568176

standard deviations of URF residuals
DLRM2A
0.013203

loglik = 1177.1606 log|\Omega| = -8.75212 |\Omega| = 0.000158125 T = 269
log|Y'Y/T| = -8.13724
R^2(LR) = 0.459296 R^2(LM) = 0.459296

F-test on all regressors except unrestricted, F(25,244) = 8.2905 [0.0000] **
No variables entered unrestricted.

F-tests on retained regressors, F(1, 244)

DLRM2A_1	4.97999 [0.0266] *		DLRM2A_2	0.922322 [0.3378]	
Constant	15.7424 [0.0001] **		DLIP90_1	0.911082 [0.3408]	
DLIP90_2	0.349923 [0.5547]		DINF_A_1	0.0540082 [0.8164]	
DINF_A_2	2.03620 [0.1549]		DTD3R_1	5.33366 [0.0218]	*
DTD3R_2	7.79669 [0.0056]	**	DTB3MR_1	5.61410 [0.0186]	*
DTB3MR_2	0.392681 [0.5315]		cl_ecm_a_1	4.53299 [0.0342]	*
DDINTS	1.16004 [0.2825]		dummy9401	5.65834 [0.0181]	*
Seasonal	3.86664 [0.0504]		Seasonal_1	10.1375 [0.0016]	**
Seasonal_2	20.8723 [0.0000]	**	Seasonal_3	10.3747 [0.0015]	**
Seasonal_4	30.1014 [0.0000]	**	Seasonal_5	12.8031 [0.0004]	**
Seasonal_6	28.9559 [0.0000]	**	Seasonal_7	12.9144 [0.0004]	**
Seasonal_8	15.0622 [0.0001]	**	Seasonal_9	17.7992 [0.0000]	**
Seasonal_10	23.2715 [0.0000]	**			

correlation of actual and fitted
DLRM2A
0.51902

DLRM2A :Portmanteau 12 lags= 8.42
DLRM2A :AR 1-12 F(12,232) = 0.78959 [0.6610]
DLRM2A :Normality Chi^2(2)= 3.1742 [0.2045]
DLRM2A :ARCH 3 F(3,238) = 1.7283 [0.1618]
DLRM2A :Xi^2 F(36,207) = 1.097 [0.3352]

Vector portmanteau 12 lags= 8.0191
Vector AR 1-12 F(12,232) = 0.78959 [0.6610]
Vector normality Chi^2(2)= 3.1742 [0.2045]
Vector Xi^2 F(36,207) = 1.097 [0.3352]

Parsimonious model

EQ(12) Estimating the model by FIML (using MDATAM2p.in7)
The present sample is: 1973 (8) to 1995 (12)

Equation 1 for DLRM2A

Variable	Coefficient	Std.Error	t-value	t-prob	HCSE
DLRM2A_1	-0.20735	0.066342	-3.125	0.0020	0.082331
Constant	0.046836	0.010182	4.600	0.0000	0.012129
DTD3R_1	0.53811	0.24126	2.230	0.0266	0.25857
DTD3R_2	0.67257	0.24510	2.744	0.0065	0.27500
DTB3MR_1	-1.1921	0.38073	-3.131	0.0019	0.34183
cl_ecm_a_1	-0.0078362	0.0029967	-2.615	0.0095	0.0035210
Seasonal_1	-0.0090838	0.0034885	-2.604	0.0098	0.0042481
Seasonal_2	-0.015885	0.0034805	-4.564	0.0000	0.0034626
Seasonal_3	-0.014746	0.0038035	-3.877	0.0001	0.0048738
Seasonal_4	-0.021071	0.0036598	-5.757	0.0000	0.0032820
Seasonal_5	-0.011906	0.0036326	-3.278	0.0012	0.0038634
Seasonal_6	-0.018340	0.0035065	-5.230	0.0000	0.0034599
Seasonal_7	-0.013126	0.0035652	-3.682	0.0003	0.0034528
Seasonal_8	-0.012208	0.0034775	-3.511	0.0005	0.0031147
Seasonal_9	-0.014206	0.0035197	-4.036	0.0001	0.0036611
Seasonal_10	-0.016359	0.0036260	-4.512	0.0000	0.0036151
dummy9401	0.027478	0.013677	2.009	0.0456	0.0035898

\sigma = 0.0132738

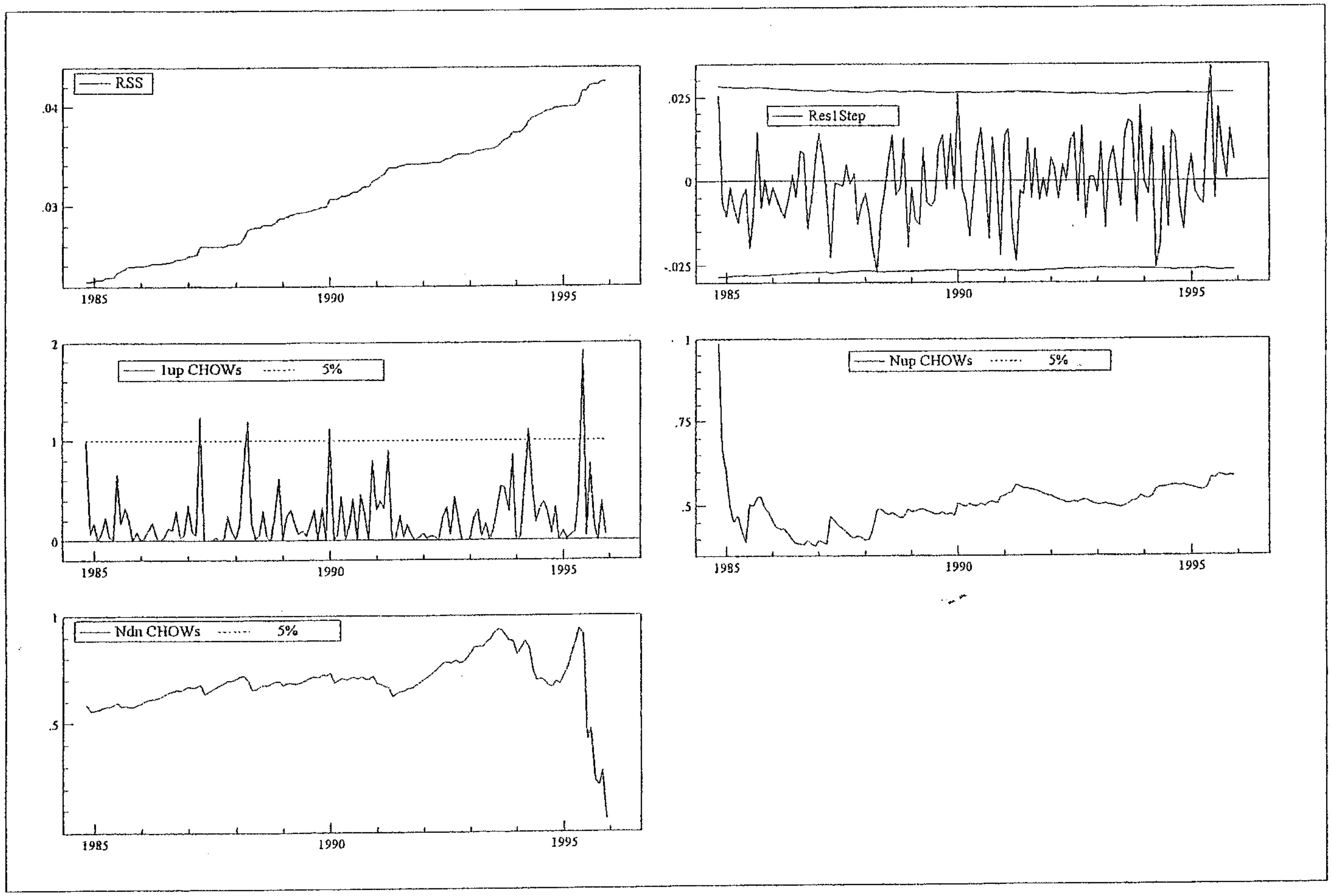
loglik = 1171.3879 log|\Omega| = -8.7092 |\Omega| = 0.00016506 T = 269
LR test of over-identifying restrictions: Chi^2(8) = 11.5453 [0.1727]

correlation of residuals

	DLRM2A
DLRM2A	1.0000

DLRM2A :Portmanteau 12 lags= 12.462
DLRM2A :AR 1-12 F(12,232) = 1.6631 [0.0760]
DLRM2A :Normality Chi^2(2)= 3.7512 [0.1533]
DLRM2A :ARCH 3 F(3,238) = 1.3248 [0.2669]
DLRM2A :Xi^2 F(36,207) = 1.056 [0.3920]
Vector portmanteau 12 lags= 12.012
Vector AR 1-12 F(12,240) = 0.97657 [0.4719]
Vector normality Chi^2(2)= 3.7512 [0.1533]
Vector Xi^2 F(36,215) = 1.0968 [0.3349]

Figure 3. Closed-Economy Formulation: Parameter Constancy Tests for Short-Run Unrestricted Reduced Form Model



run; but the status of interest rate regime in the economy as reflected by *DDINTS* is not. The diagnostic tests also reveal no problem with error autocorrelation, ARCH, normality, and heteroscedasticity. The parameter constancy tests show almost stable function (see Figure 4).

Conclusion

This paper follows a systematic approach to model the demand for real M2 in Malaysia. The relevant macroeconomic situation and the status of financial system development have been carefully studied before selecting appropriate variables to be included in the function. The unit root tests indicate that the cointegration technique such as Johansen (1988) and Johansen and Juselius (1990) can be applied to evaluate the long-run characteristics of the money demand function. Based on the cointegration and weak exogeneity test results, appropriate ECM is set up to evaluate the short-run properties.

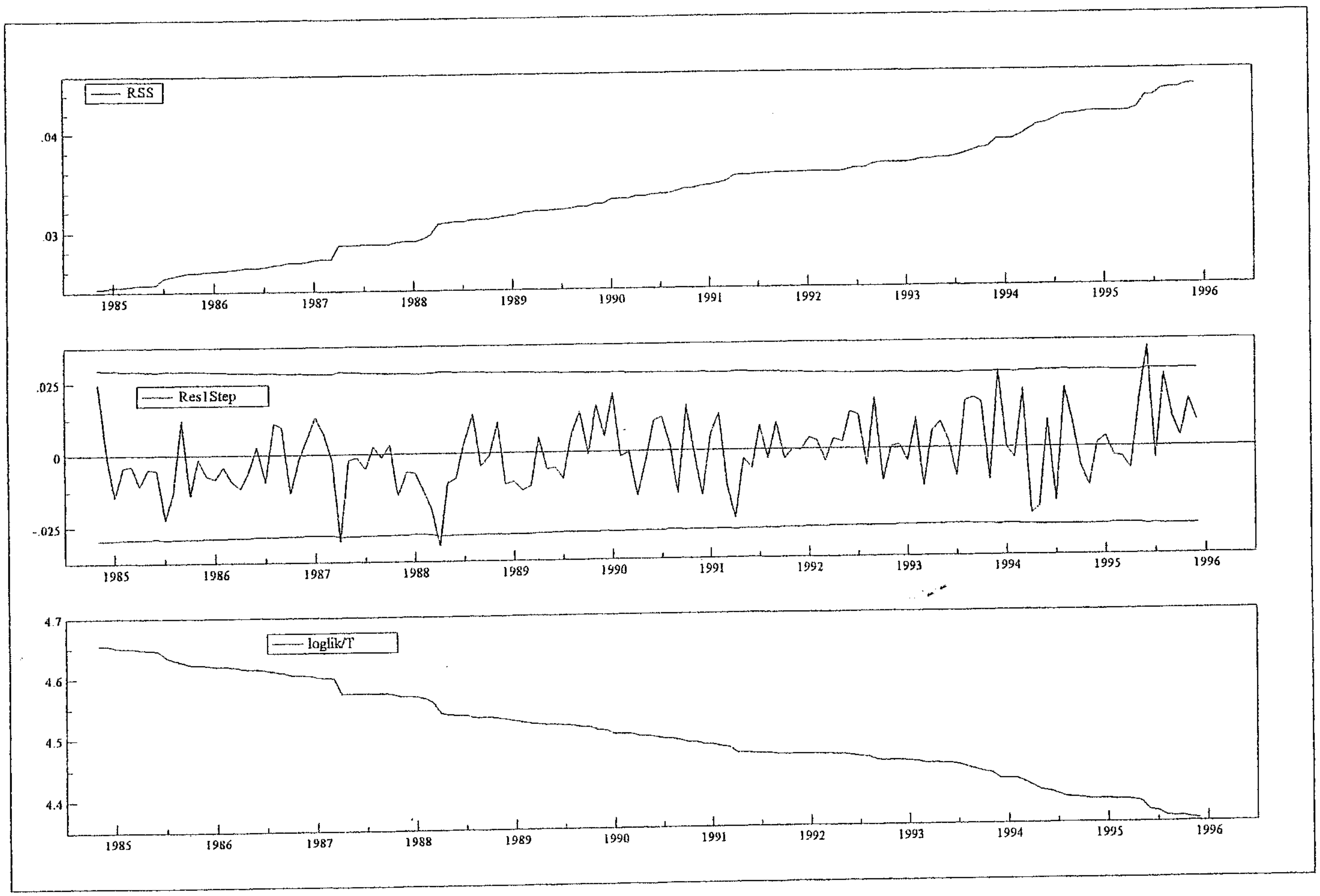
The cointegration test results indicate that the model is well specified with the income elasticity being close to one and the opportunity cost variables exhibiting correct signs and acceptable magnitudes. The ECM shows a significant error-correction term carrying a negative sign thereby indicating a valid cointegration relationship. The important finding is that both in the long- and short-run the demand for real M2 appears to be almost stable providing justification for the monetary authorities to target broad money including M2.

Although the money demand function seems to be stable, the cointegration system as a whole including the interest rate measures (own-rate and alternative return) shows some vulnerability during the 1985-87 and 1993-95 periods. Interestingly these periods also coincide with significant changes in the economy (like the recession/recovery in the former period and significant capital inflows to Malaysia in the latter period) and policy measures taken in response to these events to influence the financial system and exchange rates. Apparently, these issues do not appear to affect the stability of real M2. Most importantly, the short-run ECM shows that the chosen interest rates adequately reflect the prevailing interest rate regimes in the economy and the external events do exert some influence on the stability.

The specific findings of the model are as follows:

- in order to have a well-specified money demand model, it is necessary to include an array of opportunity cost variables that should reflect the status of macroeconomic development (especially the inflation levels), and degree of financial development in the economy. In specific, when a country like Malaysia: (a) exhibits a significant degree of financial innovation; (b) has to a certain extent freedom from government control in interest rate determination; and (c) has reasonably well-developed capital markets, it is extremely important to introduce the own rate of money and alternative return on money. Furthermore, when a country experiences low- to medium-level of inflation on average, it becomes even more important to include the expected inflation variable in the argument (as the nominal interest rate may not fully reflect

Figure 4. Closed-Economy Formulation: Parameter Constancy Tests for Short-Run Parsimonious Model



the expected inflation and agents could diversify their portfolio in the economy by acquiring real assets).

- explicit consideration of the status of interest rate regime in the country is not important because the opportunity cost variables adequately incorporate the prevailing status.
- the institutional changes and policy measures introduced in the financial system by the government affect the opportunity cost variables but not money.
- since the demand function for real M2 is almost stable in Malaysia over a long-period of time, the monetary authorities can use M2 for monetary targeting. It is possible that the broader monetary aggregates such as M3 may provide a more stable function; additionally since the external factors appear to influence the demand for M2 in the short run, an open economy type model can also be attempted.

C. Open-Economy Model

Introduction

The analysis will begin with the specification as shown in equation (3) above, which is reproduced as shown below:

$$LRM2A = \alpha_1 + \alpha_2 LIP90 + \alpha_3 TD3R + \alpha_4 TB3MR + \alpha_5 INF\_A + \alpha_6 USTB3MR + \alpha_7 DEPR + \varepsilon \quad (3)$$

where	*LRM2A*	= ln (*M2A/CPI*);
	LIP90	= ln (industrial production index);
	TD3R	= interest on three-month time deposits at commercial banks;
	TB3MR	= discount rate on three-month treasury bills;
	INF_A	= annualized inflation rate;
	USTB3MR	= yield on three-month U.S. treasury bill;
	DEPR	= annualized exchange rate depreciation; and
	ε	= error-term.

As explained before, the model will include seasonal dummies and the interest rate regime dummy (*DINTS*). The sequence of steps followed in analyzing the long- and short-run properties of the model will be similar to what was carried out in reference to the closed-economy model. Therefore, as far as possible, instead of repeating the methodology or technical details, only the results are presented and discussed in this subsection. The next part addresses issues concerning the selection of appropriate foreign interest rates applied in the analysis.

Variable selection

The Section V.B discussed a number of potential candidates to represent the foreign interest rates but narrowed the choices down to two instruments — yield on three-month U.S. treasury bills (*USTB3MR*) and three-month U.S. dollar LIBOR (*LIBOR3M*). To make a choice between these two, a simple correlation analysis is carried out in lines of the uncovered interest parity (UIP) concept. Ignoring the risk characteristics, the UIP approximates the interest rate differential between the foreign and domestic interest rates with the expected depreciation of domestic currency (*DEPR*). To test whether the UIP holds and if does not (which is very typical in the empirical analysis), we will find out which interest rate differential will have a stronger correlation with *DEPR*. *TB3MR* will be used as the domestic interest rate in both cases.[25]

Figure 5 presents data concerning both sets of interest rate differential and expected exchange rate depreciation. The top panel plots all three time series in order to observe their movements over the study period. The next two panels present the cross plots of each interest rate differential measure with *DEPR*. All these panels reveal no apparent evidence for the UIP relationship. There are also low correlation coefficients of -0.1183 and -0.1234 with *DEPR* for *ID_LIBOR* and *ID_USTB3MR* respectively. As there is no clear cut favorite in selecting one of these two variables, *USTB3MR* is selected as the foreign interest rate variable.

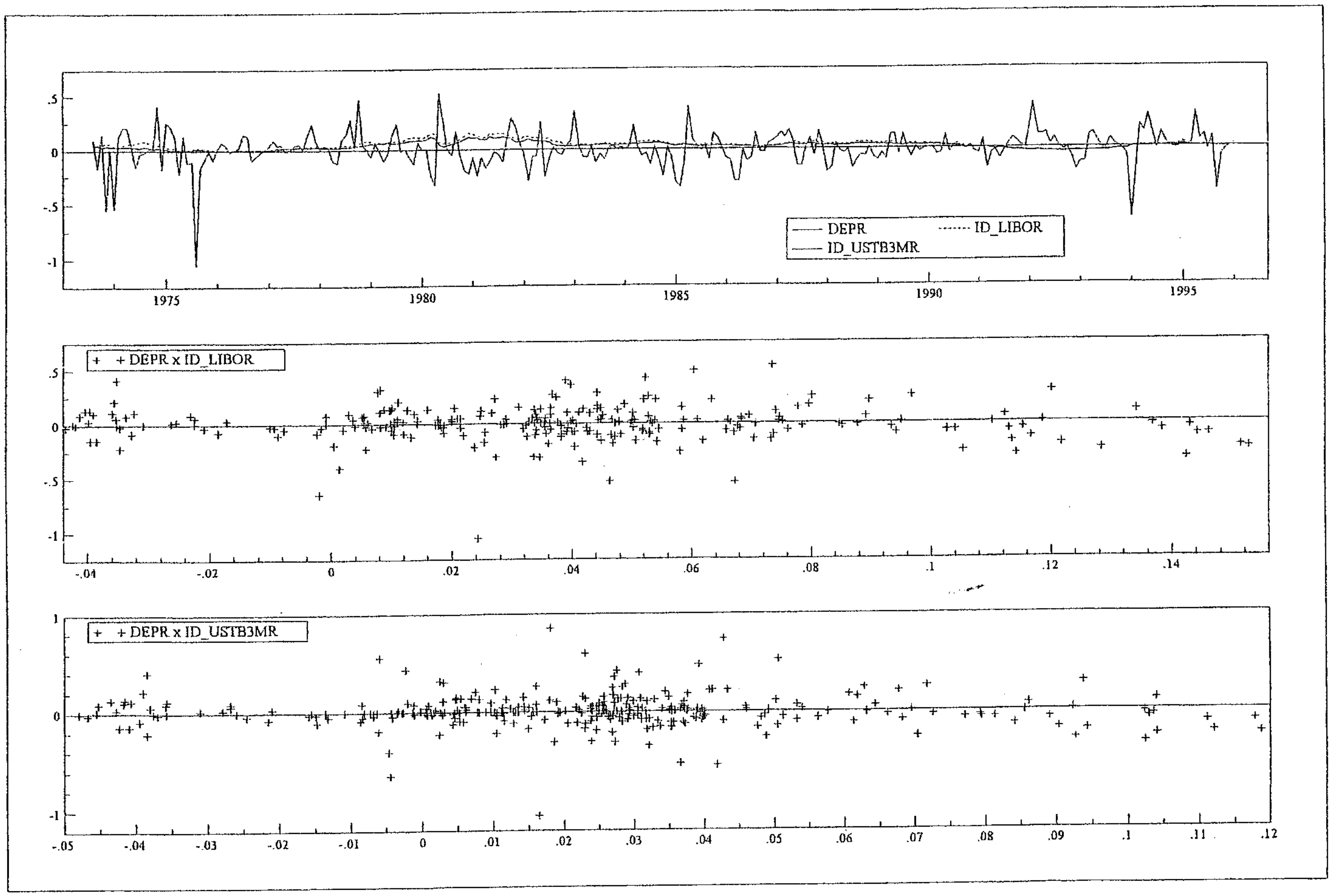
Cointegration tests

The model underlying equation (3) taken as the starting point for the cointegration analysis. *LRM2A*, *LIP90*, *INF_A*, *TD3R*, *TB3MR*, *USTB3MR*, and *DEPR* are entered as endogenous variables. Seasonal dummies and the interest rate regime dummy (*DINTS*) are also added. The model with 3 lags is found to be the most appropriate one. Although multiple cointegration vectors are obtained, none of them represent formulation which could be interpreted as demand for money. Hence, *LIBOR3M* is attempted in place of *USTB3MR*, but obtained almost similar results.

Failure to obtain satisfactory results directs the research toward a number of variations, of which, the formulation that incorporates the nominal exchange rate alone (*XR_AVG*) in place of *USTB3MR* and *DEPR* gives an appropriate long-term open-economy relationship. The test signifies a single unique cointegration vector that appears to be stationary. The relationship is significant at 99 percent level by both the trace and maximal eigenvalue criteria even when they are adjusted for the degrees of freedom. The

[25] The variable names for the interest rate differentials are as follows: *ID_LIBOR* (defined as *LIBOR3M-TB3MR*) and *ID_USTB3MR* (calculated as *USTB3MR-TB3MR*).

Figure 5. Open-Economy Version of Demand for Real M2: Relationship Between Expected Exchange Rate Depreciation and Interest Rate Differential



cointegration test results are shown in Table 5. The relevant first row of the β' matrix can be written in an equation form as follows:

$$LRM2A = 1.1302 * LIP90 + 2.5095 * TD3R - 1.8342 * TB3MR - 4.8911 * INF\_A - 0.5811 * XR\_AVG \quad (6)$$

The coefficients of all variables carry the expected signs. Their magnitudes are also acceptable. The important finding is that the introduction of the foreign exchange rate variable takes away some of the effects from *TD3R* and *TB3MR* as noticed in the closed-economy formulation. This makes intuitive sense because Malaysia follows managed-floating of ringgit and one way the BNM accomplishes this task is by its actions in the treasury bill market.[26] In this process, exchange rates indirectly affect the interest rate structure for various money market instruments in the country. Consequently, the variables *TD3R* and *TB3MR* when included alone without *XR_AVG* as in the closed-economy formulation they incorporated the foreign influence. The open-economy formulation provides additional information regarding the size of the direct effect of the changes in the exchange rates on demand for real M2, which appears to be small. As in the closed-economy model, the restricted cointegration test does not reject the hypothesis that ignoring the signs, the coefficients of *TD3R* and *TB3MR* are the same; more interestingly the test also does not reject the sum of coefficients *TB3MR* and *XR_AVG* being different from for *TD3R* in absolute terms. These results imply that both the own rate and the alternative returns are exercising almost equal influences on the demand for real M2 in Malaysia.

The coefficient of *INF_A* is almost similar as in the closed-economy model and is the dominant variable in the open-economy framework suggesting that the large period-to-period fluctuation in this variable prompts agents to respond more strongly to the changes in this variable. The income elasticity is slightly larger (1.1302) than in the closed-economy model implying that the model may be missing some additional opportunity cost variables. However, considering the fact that the equation (3) fails to provide satisfactory results and in the open-economy situation there may be many other factors exerting influence on the demand for money, the coefficient for *LIP90* is judged to be reasonable. It should also be noted that the income elasticity we obtained is far below than what Dekle and Pradhan (1997) and Tan (1997) reported for Malaysia.

Our model is well specified. The diagnostic tests reveal that the model is relatively free of statistical problems, and the parameter constancy tests exhibit almost stable function for *LRM2A* and for the system as a whole (as discussed below). The α coefficients show that the adjustments in response to the short-run disequilibrium mainly come from *INF_A*, *LIP90*, *XR_AVG*, and *LRM2A* in that order. But further tests indicate both *LIP90* and *XR_AVG* are

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[26] See Morgan Guaranty Trust Company (1996).

Table 5. Cointegration and Weak-Exogeneity Test Results for the Open-Economy Formulation of Demand for Real M2

Cointegration test 1/						
Eigenvalues	0.1837	0.1168	0.0592	0.0345	0.0212	0.0024
Null hypotheses 2/	r = 0	r <= 1	r <= 2	r <= 3	r <= 4	r <= 5
λ trace 3/	120.3000 **	65.7200	32.3100	15.8800	6.4370	0.6593
Adjusted for degrees of freedom 4/	112.3000 **	61.3200	30.1500	14.8200	6.0060	0.6152
95 percent critical values	94.2000	68.5000	47.2000	29.7000	15.4000	3.8000
λ max 3/	54.6000 **	33.4100	16.4300	9.4480	5.7780	0.6593
Adjusted for degrees of freedom 4/	50.9500 **	31.1700	15.3300	8.8150	5.3910	0.6152
95 percent critical values	39.4000	33.5000	27.1000	21.0000	14.1000	3.8000

Standardized Eigenvectors β′

LRM2A	LIP90	INF_A	TD3R	TB3MR	XR_AVG
1.0000	-1.1302	4.8911	-2.5095	1.8342	0.5811
-1.4011	1.0000	-5.3147	69.8630	-117.9100	8.6071
-3.0160	3.3730	1.0000	18.2000	-18.8160	0.0524
0.1946	-0.2059	0.0177	1.0000	3.2005	-0.0273
-0.0263	-0.0083	-0.0343	-0.3914	1.0000	0.1112
0.2747	-1.7688	-1.1895	-1.3583	7.2286	1.0000

Standardized Adjustment Coefficients α

	LRM2A	LIP90	INF_A	TD3R	TB3MR	XR_AVG
ΔLRM2A	-0.0112	-0.0015	0.0023	0.0046	0.0196	-0.0010
ΔLIP90	0.0256	-0.0034	-0.0324	-0.0117	0.0887	-0.0016
ΔINF_A	-0.0855	0.0031	-0.0159	-0.0041	0.0728	0.0032
ΔTD3R	0.0009	-0.0008	0.0004	-0.0049	0.0029	0.0001
ΔTB3MR	0.0006	0.0002	0.0001	-0.0069	-0.0020	0.0000
ΔXR_AVG	-0.0202	-0.0032	-0.0082	0.0011	-0.1931	0.0000

Weak-exogeneity test 5/

Variables	ΔLRM2A	ΔLIP90	ΔINF_A	ΔTD3R	ΔTB3MR	ΔXR_AVG
$\alpha_1 = 0$	$\chi^2(1) = 5.8822$ [0.0153]*					
$\alpha_2 = 0$	$\chi^2(1) = 2.4587$ [0.1169]					
$\alpha_3 = 0$	$\chi^2(1) = 17.852$ [0.0000]**					
$\alpha_4 = 0$	$\chi^2(1) = 0.3943$ [0.5301]					
$\alpha_5 = 0$	$\chi^2(1) = 0.6496$ [0.4203]					
$\alpha_6 = 0$	$\chi^2(1) = 3.3294$ [0.0681]					

1/ The system includes 3 lags for each variable, a constant, seasonal dummies, and the dummy variable *DINTS*. The estimation period is 1973:8-1995:12 (269 observations).

2/ r stands for the number of ranks.

3/ ** indicates the significance at 1 percent level.

4/ As per Reimers (1992).

5/ ** and * indicate that the null hypothesis of weak-exogeneity is rejected at 1 percent and 5 percent significance level respectively. The probability of getting any number exceeding the χ^2 value shown above is less than the figure presented within the squared brackets.

weakly exogenous, and hence, *INF_A* and *LRM2A* are responsible in bringing the system back toward equilibrium. The coefficient for $\Delta LRM2A$ (-0.0112) is much larger than in the closed-economy model (-0.0092) indicating that the adjustments are taken place at a more rapid pace due to increased alternatives for M2.

The standard diagnostic test reveals an apparent problem of autocorrelation for *LIP90* at 12 lags at 1 percent level, but it disappears at 14 lags.[27] However, as *LIP90* is found to be weakly exogenous (as discussed below) we treat this issue not a serious one. As in the closed-economy model, *LRM2A* shows normality (see Figure 6). The parameter constancy tests indicate that the model is mostly stable. Due to the capital inflow issues as discussed in detail in the closed-economy situation, there are a few outliers during the 1993-95 period for the 1up residuals of *LRM2A* (see Figure 7). Similar to the closed-economy model, *TD3R* exhibits some instability during the 1985-87 period and *TB3MR* in January 1994. Additionally, *XR_AVG* also shows a similar outlier for January 1994. These outliers are in response to the government's action to take charge of the capital inflows problem as discussed previously. For the system as a whole, as indicated by the 1up chow test, the January 1994 marks a major break. There is a minor break occurring in March 1987. These breaks are primarily associated with the variables *TD3R*, *TB3MR*, and *XR_AVG*. To the extent, these variables are found to be weakly exogenous, the short-run model should produce a stable framework.

The tests indicate that *LIP90*, *TD3R*, *TB3MR*, and *XR_AVG* are weakly exogenous. Both *LRM2A* and *INF_A* are not weakly exogenous (see Table 5). Therefore, for the short-run ECM, we could go for a system containing two equations one each for $\Delta LRM2A$ and *INF_A*, but have instead opted for a single equation framework since the cointegration tests identify a unique vector that represents the demand for real M2.

Short-run model

The ECM will have $\Delta LRM2A$ on the LHS and two lags each of the following six variables on the RHS: $\Delta LRM2A$, $\Delta LIP90$, ΔINF_A, $\Delta TD3R$, $\Delta TB3MR$, and ΔXR_AVG; in addition, RHS will have the error-correction term (EC) computed from the cointegration vector obtained above.[28] In addition, seasonal dummies and interest rate regime dummy *DDINTS* are added. The formulation will look as follows:

---

[27] See Sriram (1999a), Appendix XI.

[28] These variables are referred to as *DLRM2A*, *DLIP90*, *DINF_A*, *DTD3R*, *DTB3MR*, *DXR_AVG*, and *op_ecm_1* respectively in PcFiml 9.0.

Figure 6. Open-Economy Version of Demand for Real M2: Graphical Analysis of Diagnostic Test Results

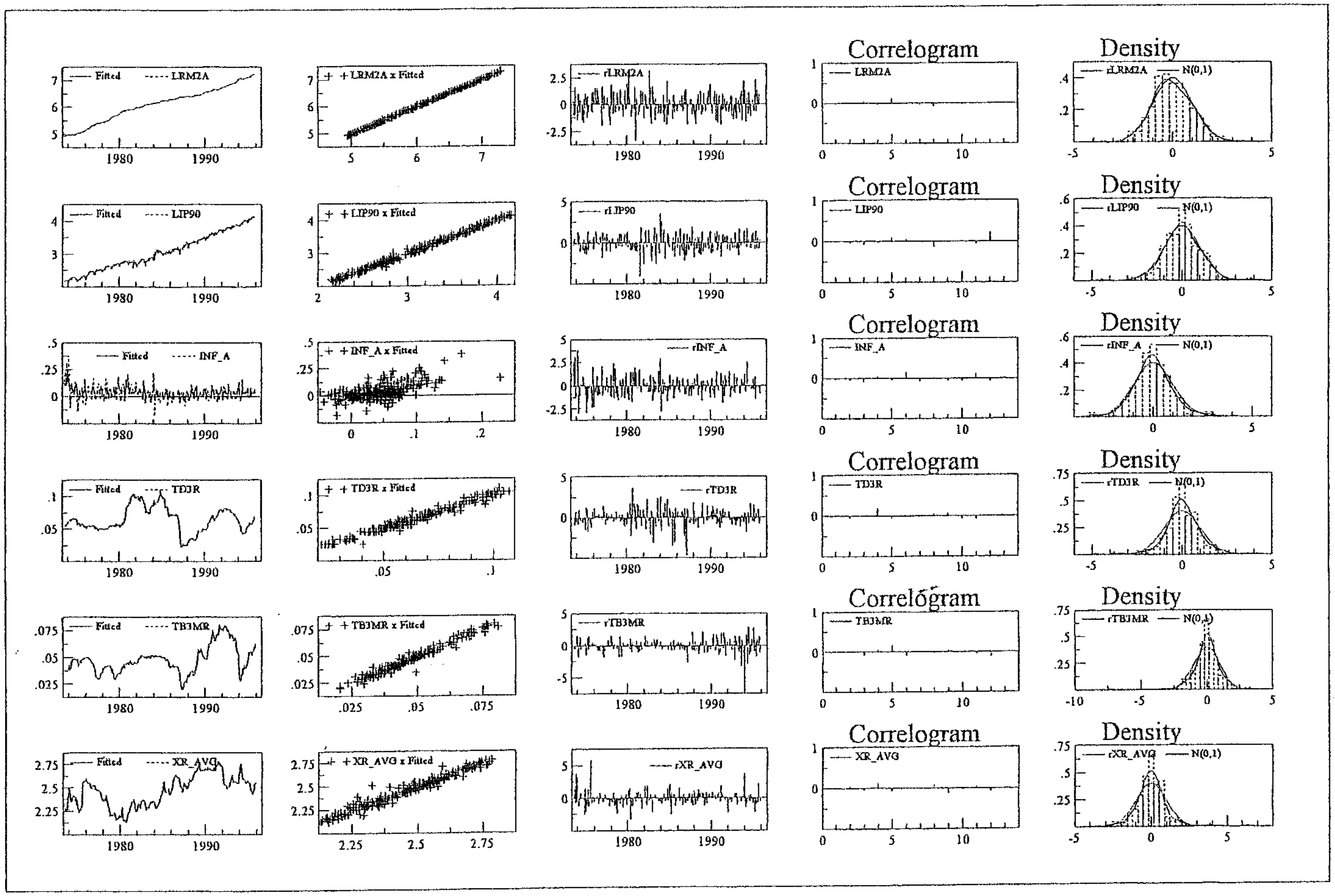
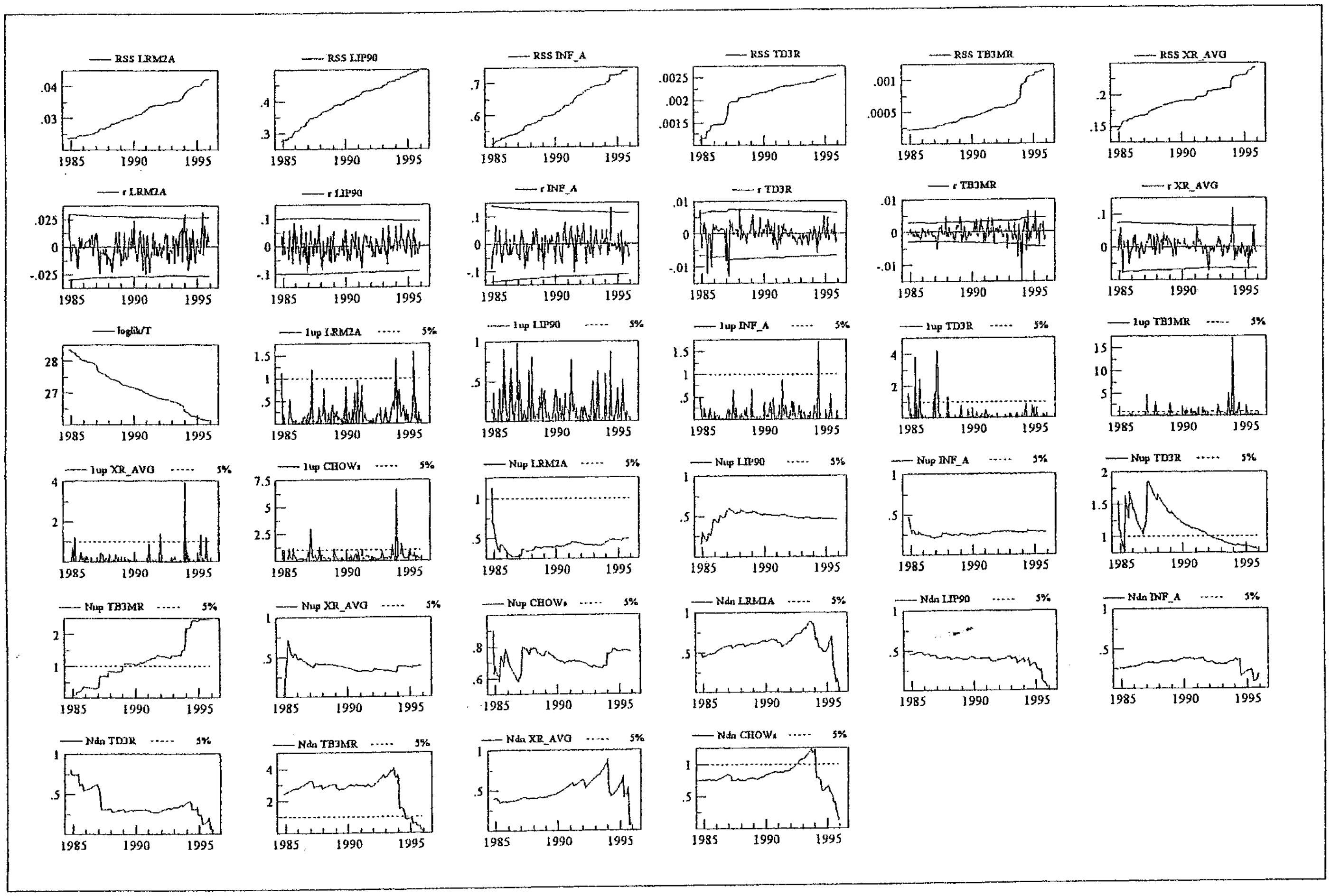


Figure 7. Open-Economy Version of Demand for Real M2: Parameter Constancy Tests for the Cointegration Analysis



$$\Delta LRM2A_t = \alpha_0 + \alpha_1 \Delta LRM2A_{t-1} + \alpha_2 \Delta LRM2A_{t-2} + \alpha_3 \Delta LIP90_{t-1} + \alpha_4 \Delta LIP90_{t-2} + \alpha_5 \Delta INF\_A_{t-1} + \alpha_6 \Delta INF\_A_{t-2} + \alpha_7 \Delta TD3R_{t-1} + \alpha_8 \Delta TD3R_{t-2} + \alpha_9 \Delta TB3MR_{t-1} + \alpha_{10} \Delta TB3MR_{t-2} + \alpha_{11} \Delta XR\_AVG_{t-1} + \alpha_{12} \Delta XR\_AVG_{t-2} + \alpha_{13} EC + \alpha_{14} DDINTS + \theta_j SD_j + e_t \quad (7)$$

The OLS results for URF model as shown in Table 6 indicate that $\Delta TD3R_{t-2}$, $\Delta TB3MR_{t-1}$, and EC are significant at 1 percent level; $\Delta LRM2A_{t-1}$ and $\Delta TD3R_{t-1}$ at 5 percent level; and all but one seasonal dummies and constant at 1 percent level. Other variables do not seem to be important. The diagnostic tests reveal no problem with autocorrelation, normality, ARCH, and heteroscedasticity (see Table 7). The parameter constancy tests confirm that the model is mostly stable (see Figure 8).

By following the general-to-specific approach, a parsimonious ECM is obtained. During the reduction process, the models are estimated by the FIML technique and the results are shown in Table 7. The significant variables are the same as in the URF model. They also carry coefficients with the expected signs. The error-correction term is negative and significant confirming the validity of the cointegration relationship established earlier. Most importantly, the model appears to be stable with 1up residuals are within the two standard deviation on either end of the mean (Figure 9). The diagnostic tests reveal no statistical problem at all (see Table 7). Interestingly, the dummy variable *DDINTS* is found to be unimportant.

Conclusion

This paper has developed a well-specified open-economy formulation. The cointegration test identifies one unique vector that represents demand for money which is significant at 99 percent level. The variable that exercises the foreign influence is found to be average nominal exchange rate (of ringgit against the U.S. dollar). However, its direct impact appears to be small because the domestic interest rate variables are indirectly incorporating the foreign influence on the demand for real M2 due to the government's efforts in managing the exchange rate. The parameter constancy tests indicate that the system as a whole shows signs of structural break during January 1994 as a result of measures taken to stem capital inflows. But the function for real M2 appears to be fairly stable.

The short-run formulation produces a stable ECM. With a valid error-correction term, it confirms the existence of cointegration relationship as well. The model is free of statistical problems and structural instability. The important finding is that the exchange rate variable is insignificant in the short run. Only the domestic opportunity cost variables seem to matter.

Table 6. Open-Economy Formulation: Short-Run ECM Results

Variable	Coefficient	t-value
Unrestricted equation		
$\Delta LRM2A_{t\_1}$	-0.1543	-2.1950
$\Delta LRM2A_{t\_2}$	0.0365	0.5170
$\Delta LIP90_{t\_1}$	-0.0186	-1.0240
$\Delta LIP90_{t\_2}$	0.0100	0.5550
ΔINF_A_{t-1}	0.0145	0.7600
ΔINF_A_{t-2}	0.0241	1.6590
$\Delta TD3R_{t-1}$	0.5861	2.3450
$\Delta TD3R_{t-2}$	0.7328	2.8550
$\Delta TB3MR_{t-1}$	-1.0727	-2.6510
$\Delta TB3MR_{t-2}$	-0.3139	-0.8020
ΔXR_AVG_{t-1}	-0.0134	-0.5250
ΔXR_AVG_{t-2}	-0.0024	-0.0950
EC	-0.0111	-2.6780
Constant	0.0719	4.0410
Seasonal	-0.0065	-1.4990
Seasonal_1	-0.0126	-2.7920
Seasonal_2	-0.0190	-4.2090
Seasonal_3	-0.0142	-3.0320
Seasonal_4	-0.0246	-5.4150
Seasonal_5	-0.0145	-3.5670
Seasonal_6	-0.0221	-5.3140
Seasonal_7	-0.0145	-3.4730
Seasonal_8	-0.0158	-3.8000
Seasonal_9	-0.0166	-4.0780
Seasonal_10	-0.0196	-4.7390
DDINTS	0.0080	1.0160
$\sigma = 0.0132848$		
Parsimonious model		
$\Delta LRM2A_{t\_1}$	-0.2023	-3.0620
$\Delta TD3R_{t-1}$	0.5368	2.2250
$\Delta TD3R_{t-2}$	0.6560	2.6770
$\Delta TB3MR_{t-1}$	-1.2666	-3.3190
EC	-0.0086	-2.9670
Constant	0.0598	4.5260
Seasonal_1	-0.0096	-2.7550
Seasonal_2	-0.0163	-4.6900
Seasonal_3	-0.0157	-4.1140
Seasonal_4	-0.0219	-5.9880
Seasonal_5	-0.0125	-3.4430
Seasonal_6	-0.0191	-5.4440
Seasonal_7	-0.0139	-3.8850
Seasonal_8	-0.0130	-3.7300
Seasonal_9	-0.0150	-4.2610
Seasonal_10	-0.0173	-4.7600
$\sigma = 0.0132797$		

Note: σ refers to standard error of the regression.

Table 7. Open-Economy Version of Demand for Real M2: Diagnostic Test Results for ECM

```
EQ( 3) Estimating the unrestricted reduced form by OLS  (using MDATAM2p.in7)
The present sample is:  1973 (8) to 1995 (12)

URF Equation 1 for DLRM2A
Variable      Coefficient     Std.Error  t-value  t-prob
DLRM2A_1         -0.15434      0.070318   -2.195  0.0291
DLRM2A_2         0.036488      0.070521    0.517  0.6053
DLIP90_1        -0.018612      0.018170   -1.024  0.3067
DLIP90_2         0.010000      0.018005    0.555  0.5791
DINF_A_1         0.014532      0.019131    0.760  0.4482
DINF_A_2         0.024119      0.014541    1.659  0.0985
DTD3R_1           0.58614       0.24994    2.345  0.0198
DTD3R_2           0.73280       0.25670    2.855  0.0047
DTB3MR_1          -1.0727       0.40469   -2.651  0.0086
DTB3MR_2         -0.31386       0.39149   -0.802  0.4235
DXR_AVG_1       -0.013415      0.025556   -0.525  0.6001
DXR_AVG_2      -0.0024397      0.025667   -0.095  0.9244
op_ecm_1        -0.011143     0.0041602   -2.678  0.0079
Seasonal_1      -0.012648     0.0045301   -2.792  0.0057
Seasonal_2      -0.018992     0.0045121   -4.209  0.0000
Seasonal_3      -0.014159     0.0046701   -3.032  0.0027
Seasonal_4      -0.024598     0.0045425   -5.415  0.0000
Seasonal_5      -0.014535     0.0040746   -3.567  0.0004
Seasonal_6      -0.022098     0.0041585   -5.314  0.0000
Seasonal_7      -0.014527     0.0041831   -3.473  0.0006
Seasonal_8      -0.015777     0.0041514   -3.800  0.0002
Seasonal_9      -0.016553     0.0040589   -4.078  0.0001
Seasonal_10     -0.019580     0.0041314   -4.739  0.0000
Constant         0.071851      0.017778    4.041  0.0001
Seasonal       -0.0065122     0.0043438   -1.499  0.1351
DDINTS          0.0079767     0.0078531    1.016  0.3108

\sigma = 0.0132848   RSS = 0.04288622153
standard deviations of URF residuals
        DLRM2A
      0.013285

loglik = 1176.0567  log|\Omega| = -8.74392  |\Omega| = 0.000159428  T = 269
log|Y'Y/T| = -8.13724
R^2(LR) = 0.45484  R^2(LM) = 0.45484
F-test on all regressors except unrestricted, F(26,243) = 7.7977 [0.0000] **
No variables entered unrestricted.

F-tests on retained regressors, F(1, 243)
   DLRM2A_1     4.81775 [0.0291] *    DLRM2A_2     0.267714 [0.6053]
   DLIP90_1     1.04922 [0.3067]      DLIP90_2     0.308477 [0.5791]
   DINF_A_1    0.577022 [0.4482]      DINF_A_2      2.75118 [0.0985]
    DTD3R_1     5.49970 [0.0198] *     DTD3R_2      8.14946 [0.0047] **
   DTB3MR_1     7.02569 [0.0086] **   DTB3MR_2     0.642731 [0.4235]
  DXR_AVG_1    0.275550 [0.6001]     DXR_AVG_2   0.00903423 [0.9244]
   op_ecm_1     7.17429 [0.0079] ** Seasonal_1      7.79475 [0.0057] **
 Seasonal_2     17.7162 [0.0000] ** Seasonal_3      9.19264 [0.0027] **
 Seasonal_4     29.3224 [0.0000] ** Seasonal_5      12.7253 [0.0004] **
 Seasonal_6     28.2380 [0.0000] ** Seasonal_7      12.0598 [0.0006] **
 Seasonal_8     14.4427 [0.0002] ** Seasonal_9      16.6313 [0.0001] **
Seasonal_10     22.4619 [0.0000] **   Constant      16.3336 [0.0001] **
   Seasonal     2.24754 [0.1351]        DDINTS      1.03174 [0.3108]

correlation of actual and fitted
        DLRM2A
       0.51319

DLRM2A  :Portmanteau 12 lags=   7.2367
DLRM2A  :AR 1-12 F(12,231) =   0.91147 [0.5361]
DLRM2A  :Normality Chi^2(2)=    3.3709 [0.1854]
DLRM2A  :ARCH 3  F( 3,237) =     1.721 [0.1633]
DLRM2A  :Xi^2    F(39,203) =    1.0959 [0.3340]
Vector portmanteau 12 lags=   6.913
Vector AR 1-12 F(12,231) =    0.91147 [0.5361]
Vector normality Chi^2( 2)=    3.3709 [0.1854]
Vector  Xi^2   F(39,203) =     1.0959 [0.3340]

Parsimonious model

EQ( 6) Estimating the model by FIML  (using MDATAM2p.in7)
The present sample is:  1973 (8) to 1995 (12)

Equation 1 for DLRM2A
Variable      Coefficient     Std.Error  t-value  t-prob         HCSE
DLRM2A_1         -0.20232      0.066075   -3.062  0.0024     0.082516
DTD3R_1           0.53682       0.24130    2.225  0.0270      0.25838
DTB3MR_1          -1.2666       0.38158   -3.319  0.0010      0.33852
op_ecm_1       -0.0086475     0.0029141   -2.967  0.0033    0.0034031
Seasonal_1     -0.0095755     0.0034758   -2.755  0.0063    0.0042393
Seasonal_2      -0.016286     0.0034724   -4.690  0.0000    0.0034253
Seasonal_3      -0.015664     0.0038079   -4.114  0.0001    0.0048069
Seasonal_4      -0.021892     0.0036561   -5.988  0.0000    0.0032214
Seasonal_5      -0.012535     0.0036404   -3.443  0.0007    0.0037899
Seasonal_6      -0.019072     0.0035030   -5.444  0.0000    0.0034969
Seasonal_7      -0.013886     0.0035744   -3.885  0.0001    0.0034356
Seasonal_8      -0.012966     0.0034763   -3.730  0.0002    0.0030857
Seasonal_9      -0.015001     0.0035202   -4.261  0.0000    0.0036622
Seasonal_10     -0.017286     0.0036312   -4.760  0.0000    0.0035963
Constant         0.059832      0.013219    4.526  0.0000     0.015498
DTD3R_2           0.65603       0.24508    2.677  0.0079      0.27705

\sigma = 0.0132797

loglik = 1170.736  log|\Omega| = -8.70436  |\Omega| = 0.000165862  T = 269
LR test of over-identifying restrictions: Chi^2(10) = 10.6414 [0.3861]
correlation of residuals
                   DLRM2A
 DLRM2A            1.0000

DLRM2A  :Portmanteau 12 lags=   10.609
DLRM2A  :AR 1-12 F(12,231) =    1.6736 [0.0736]
DLRM2A  :Normality Chi^2(2)=    3.1855 [0.2034]
DLRM2A  :ARCH 3  F( 3,237) =    1.4394 [0.2320]
DLRM2A  :Xi^2    F(39,203) =    1.0547 [0.3928]
Vector portmanteau 12 lags=   10.261
Vector AR 1-12 F(12,241) =    0.84056 [0.6085]
Vector normality Chi^2( 2)=    3.1855 [0.2034]
Vector  Xi^2   F(39,213) =     1.1066 [0.3185]
```

Figure 8. Open-Economy Version of Demand for Real M2: Short-Run Unrestricted Reduced Form Model—Parameter Constancy Tests

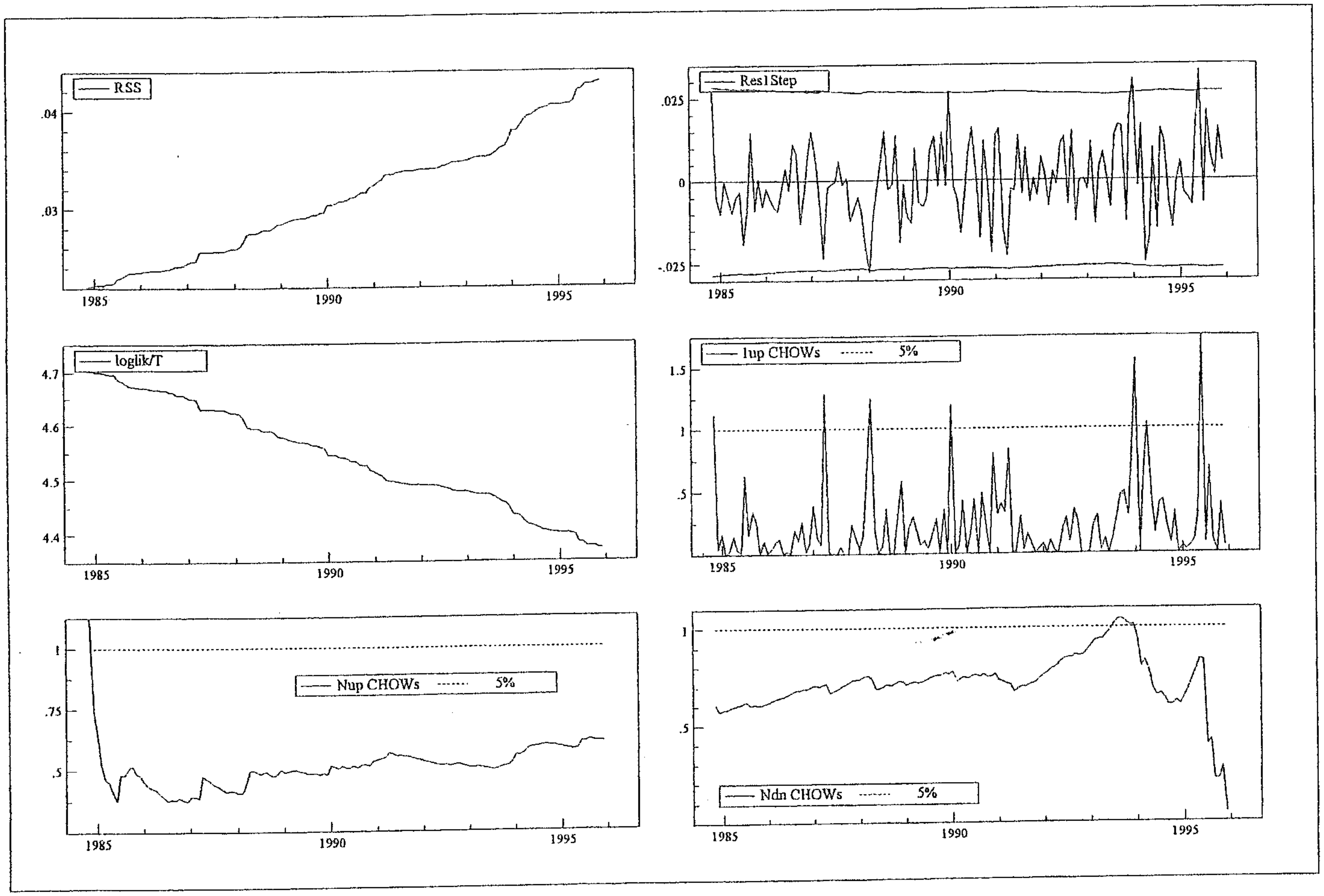
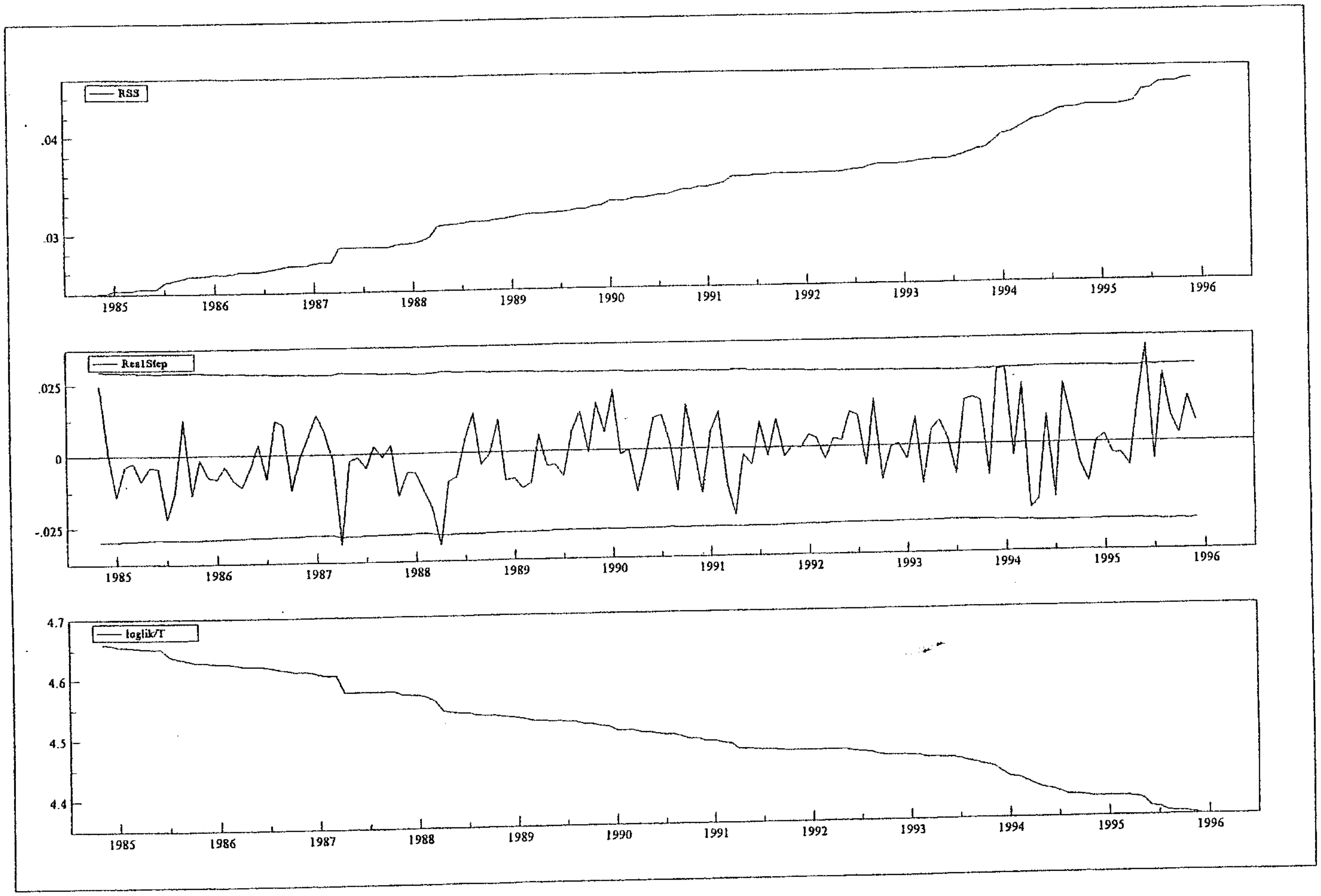


Figure 9. Open-Economy Version of Demand for Real M2: Short-Run Parsimonious ECM—Parameter Constancy Tests



VIII. Conclusion

Judd and Scadding (1982, p. 993) state "a stable demand function for money means that the quantity of money is predictably related to a small set of key variables linking money to the real sector of the economy." Judging by this principle, this paper has made a successful attempt in obtaining a stable demand function for M2 in Malaysia, in which the demand happens to be for *real* M2.

The paper has carefully studied developments in the macroeconomic situation and the financial system, and identified only few but highly relevant variables exercising influence on real M2 under both the closed- and open-economy formulations. Importantly, it has analyzed the time series characteristics of data thoroughly before selecting the appropriate estimation techniques to evaluate the long- and short-run characteristics. Due consideration has also been given on institutional details and government policy measures that have impact on the determinants and the stability of real M2.

The results suggest that both the long- and short-run models are well specified. The demand for M2 is for *real* balances and is fairly stable. The long-run income elasticity is close to one and the opportunity cost variables carry the expected signs. The external events do exert some influence on demand for real M2. Their direct impact, however, appears to be small as domestic interest rates are sufficiently flexible to deter these events significantly affecting the stability.

The important contribution of this paper comes from the use of monthly observations. No other known previous work on Malaysia has applied monthly data. The model based on the high-frequency data is useful because it is capable of identifying the impact of any measures taken by the governments or events taking place in the economy on the long- and short-run stability of demand for money. A stable function will in turn help the authorities in effectively conducting the monetary policy.

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