CHAPTER IV EMPIRICAL ASSESSMENT

This study proceeds with an empirical assessment of the effectiveness of monetary policy in Malaysia over the period 1973:4-1999:2. The empirical work follows largely that by Friedman and Kuttner. The effectiveness of monetary policy is determined by assessing the statistical significance of the relationships between money (or interest rates) on income and prices. The objective is to find out between the two variables, money supply and interest rates, which variable is better in explaining the movements in income or prices in Malaysia before and after financial reforms. This chapter will first outline the empirical framework. This is followed by the stationarity tests and model specification to the empirical runs. The empirical results of the autoregression tests are then presented and analyzed after which the cointegration work is discussed.

IV.1 Empirical Framework

As in Friedman and Kuttner, this empirical study is broken down into two parts, first is the autoregression tests to find empirical evidence indicating significant relationships between money (however defined) and nominal income, or between money and either real income or prices separately. Second is the test of cointegration, to focus on long run relationships, of movements between money and income or prices as well as between interest rates and income or prices. However, the stationarity test of the variables to be used in the regressions will be conducted before proceeding with the autoregression tests. The autoregression tests apply the least squares method while the cointegration test apply the Engel-Granger method to statistically determine the long run relationship. Money supply M3 is used for the purpose of this exercise instead of M2 because the correlation between M2 and M3 is very high and furthermore, M3 has been the monetary variable relied upon since the mid-80s as the intermediate target. For comparison purposes, the analogous autoregressions is also done in which the financial variable is replaced by the 3-month interbank interest rate and the commercial banks' average lending rate. This differed from Friedman and Kuttner, which used the interest rate on prime 4-6 month commercial paper, the 90-day Treasury bill rate and the difference between these two interest rates. The rate for commercial papers is not used because the development of the market is still shallow. The autoregressions also include the fiscal variable in order to assess whether its presence has any effect on the significance of the financial variables indicated.

The sample range covers the period from the fourth quarter of 1973 to the second quarter of 1999 since data for M3 is only available at the end of 1973. The sample range is also broken down into two sub-periods, from 1973:4 to 1989:4 and 1990:1 to 1999:2. The break point was determined based on several factors:

i) It marked the beginning of the focus on interest rates as the operating target in the conduct of monetary policy.

ii) Based on Chow stability test on money equation, the breakpoint was significant during the third quarter of 1989.

iii) Indication of a sudden sharp uptrend in all three money variables in value terms, reserve money, M1 and M3 (please refer Appendix I). In addition, the volatility of each money variable as measured by their standard deviation was much greater in the second period compared to the first, except for M3 which standard deviation registered a marginal decline in the second period (please refer Appendix III).

iv) The interest rate's standard deviation in the first period was also greater compared to the second period (Appendix III).

IV.2 Stationarity tests and results

Empirical work based on time series data normally assumes that the underlying time series is stationary. However, this assumption needs to be verified as the time series may not be stationary and in fact there may be situation that exemplifies the problem of spurious regression whereby the time series involved exhibit strong trends with high R^2, but the high R^2 observed is actually due to the presence of the trend, and not to a true relationship between the time series.

A stationary series exhibit mean reversion; it fluctuates around a constant long run mean. It has finite variance and has theoretical correlogram that diminishes as lag length increases. On the other hand, a non-stationary series is where there is no long run mean to which the series returns. The variance is time dependent and goes to infinity as time approaches infinity. Theoretical autocorrelation do not decay, but in finite sample, the sample correlogram dies out slowly. Furthermore, if a series must be differenced d times before it becomes stationary, then it contains d unit roots and is said to be integrated of order d, denoted as I (d). Test for stationarity can be done by testing for unit roots.

Suppose Y_t is generated by AR(1) process:

$$Y_t = \rho Y_{t-1} + \varepsilon_t$$

If $|\rho| < 1$, Y_t is I (0). If $\rho = 1$, Y_t is I (1). Therefore, test for stationarity is to test for $\rho = 1$.

Dickey and Fuller[36] considered 3 different regressions to test for the presence of unit root, where $H_o: \rho^* = 0$ (that is there is a unit root):

$$\Delta Y_t = \rho^* Y_{t-1} + \varepsilon_t$$

$$\Delta Y_t = a_0 + \rho^* Y_{t-1} + \varepsilon_t$$

$$\Delta Y_t = a_0 + \rho^* Y_{t-1} + a_1 t + \varepsilon_t$$

The above assumes that the error term is not correlated. If the error term is autocorrelated, the regression has to take on a different form as follows which includes lagged difference terms, which is called the Augmented Dickey Fuller (ADF) test, where $H_o: \rho^{**} = 0$:

$$\Delta Y_t = a_0 + \rho^{**} Y_{t-1} + a_1 t + b_i \Sigma \Delta Y_{t-i} + \varepsilon_t$$

The important coefficient to look at is ρ^{**}, where if the test shows that $\rho^{**} = 0$, it means that a unit root exists in Y i.e. Y is nonstationary.

However, including a trend variable in a simple regression to solve the problem of spurious correlation can be misleading, because the trend in a series can be either deterministic or stochastic. If the trend is stochastic, the common practice of detrending the data by a single trend line will be misleading. Therefore, an assessment needs to be made on the error term, based on two different equations as shown below:

(1) $Y_t = a_0 + a_1 t + \varepsilon_t$

(2) $Y_t - Y_{t-1} = a + \varepsilon_t$

In equation (1), if the error term ε_t is found to be stationary, then it is said to represent a **trend-stationary process** (TSP). In equation (2), if the error term is found to be stationary, then it is said to represent a **difference stationary process** (DSP). In other words, a stationary time series can be modeled as a TS process while a

[36] In Gujarati, Damodar N. Basic Econometrics, Third edition, McGraw Hill, 1995.

nonstationary time series represents a DS process. The practical significance of TSP and DSP is for purposes of long term forecasting, whereby forecast made from a TSP is said to be more reliable while forecast made from a DSP will be unreliable.

Testing for the presence of Unit Roots

The results of the Augmented Dickey-Fuller (ADF) test for unit roots (Ho : Presence of Unit Roots) for the variables to be used in the autoregression tests are as shown below (Table IV.1):

Table IV.1

Variables	**ADF Test Statistic**		**1% Critical Value**	
	Level	**First Difference**	**Level**	**First difference**
ALR	-2.76	-4.00	-3.5	-3.5
3-M INTERBANK IR	-3.71	-	-3.5	-
LNM1	-0.75	-3.88	-3.5	-3.5
LNM3	-1.52	-3.70	-3.5	-3.5
LNRM	-1.15	-3.62	-3.5	-3.5
LNGOV	-2.63	-5.17	-3.5	-3.5
LNCPI	-0.87	-3.73	-3.5	-3.5
LNM3CREDIT	-1.56	-3.85	-3.5	-3.5

Based on the above methodology and ADF statistics, it was found that all variables, with the exception of the 3-month inter-bank interest rate, are integrated of order one. Data covered for the above test is from 1973 fourth quarter to the second quarter of 1999.

IV.3 Model specification

Early work on money-income relationship started with research by Christopher A. Sims (1972, 1980) who also introduced the debatable Granger test. Since then, empirical work of whether money can usefully play a role in the monetary policy process has appropriately focused not just on whether fluctuations of money help predict future fluctuations of income or prices, but on whether they help predict future fluctuations of income that are not already predictable on the basis of fluctuations of income itself. However, in the context of information-variable approach, as long as movements in money do contain information about future movements in income beyond what is already contained in movements in income itself, monetary policy can exploit that information by responding to observed money growth regardless of whether the information it contains reflects true causation, reverse causation based on anticipations, or mutual causation by some independent but unobserved influence[37].

The model specification takes on the following autoregressions of the form outlined below, with the null hypothesis that all of the coefficients on the lagged variable M (defined below), that is all of the β_i, are zero :-

$$\mathbf{Ho}: \beta_i = 0 \quad \forall \text{ i's}$$

(Equation 1) $$\Delta Y_t = \alpha + \sum_{i=0}^{4} \beta_i \Delta M_{t-i} + \sum_{i=0}^{4} \gamma_i \Delta G_{t-i} + \sum_{i=1}^{4} \delta_i \Delta Y_{t-i} + \varepsilon_t$$

where:

ΔY_t — difference of log of nominal or real income measured by GDP

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[37] Op. Cit.

at 1987 prices. Prior to 1987, the series were obtained based on the growth estimates by Tilak and Lee[38]. The nominal income series were determined based on the quarterly change of the consumer price index. For the real income equation and the price equation (Table IV.3 and IV.4), the log of CPI is used and data was re-based to 1994=100.

ΔM_t — difference of log of financial variables indicated (Reserve money, M1, M3 and M3 credit), and difference of 3-month inter-bank rate (average for the month) and the commercial banks average lending rate (end-month).

Data for M3 credit is available from 1980 onwards. Prior to that, data for M2 credit is used.

ΔG_t — difference of log of federal government expenditure (current expenditure plus net development expenditure).

α, β_i, γ_i, and δ_i are coefficients to be estimated; and ε_t is a disturbance term.

The estimated regressions in this study use four lags of each variable. Unlike Friedman and Kuttner which begins with **i=1** for M and G variables, for the purpose of this study, **i** begins with **0** because given that the data used are quarterly numbers.

[38] Tilak Abeysinghe and Christopher Lee. ' Best Linear unbiased Interpolation of quarterly GDP: The case for Malaysia'. Fourth Malaysian Econometric Conference, October 1996.

M and G for period **t** is also assumed to be correlated and have impact on Y during period **t** .

IV.4 Results of Autoregression Test and Interpretation

Table IV.2 presents the results based on equation in which the variable whose movement is to be explained is nominal income (nominal GDP) as below. Although it was not explained by Friedman and Kuttner how the F-statistics is obtained, in this study, the F-statistics is obtained from the Wald test which tests for the null hypothesis that the all of the coefficients of the financial variables indicated is zero. The autoregression equation takes on the following form:

(Equation 2)

$$\Delta Y_t = \alpha + \beta_0 \Delta M_t + \beta_1 \Delta M_{t-1} + \beta_2 \Delta M_{t-2} + \beta_3 \Delta M_{t-3} + \beta_4 \Delta M_{t-4}$$
$$+ \gamma_0 \Delta G_t + \gamma_1 \Delta G_{t-1} + \gamma_2 \Delta G_{t-2} + \gamma_3 \Delta G_{t-3} + \gamma_4 \Delta G_{t-4}$$
$$+ \delta_1 \Delta Y_{t-1} + \delta_2 \Delta Y_{t-2} + \delta_3 \Delta Y_{t-3} + \delta_4 \Delta Y_{t-4} + \varepsilon_t$$

Table IV.2 - F-statistics for Variables in Nominal Income Equations

	1973:4-1989:4		1990:1-1999:2		1973:4-1999:2	
	F-stat	Prob.	F-stat	Prob.	F-stat	Prob.
A. Three-variable System (Nominal Income, Fiscal variable and Financial Variable)						
ΔALR	3.462	0.009	5.723	0.001	2.874	0.019
ΔIR	0.595	0.704	4.332	0.006	1.535	0.188
ΔLN(RM)	0.318	0.899	5.540	0.002	2.367	0.046
ΔLN(M1)	2.824	0.027	3.012	0.031	3.297	0.009
ΔLN(M3)	1.083	0.382	0.936	0.476	2.489	0.038
ΔLN(M3CREDIT)	0.702	0.625	4.218	0.007	1.431	0.222

B. Two variable System (Nominal Income and Financial Variable)

ΔALR	3.694	0.006	3.207	0.021	3.235	0.010
ΔIR	1.777	0.135	2.463	0.057	2.598	0.031
ΔLN(RM)	1.326	0.269	5.872	0.001	3.070	0.013
ΔLN(M1)	3.647	0.007	2.696	0.041	4.451	0.001
ΔLN(M3)	1.556	0.190	2.217	0.081	2.002	0.086
ΔLN(M3CREDIT)	0.918	0.477	3.918	0.008	1.580	0.174

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From the above Table, the last four lines in the upper portion present F-statistics for tests, across different time periods based on equation 2. The lower portion of the table shows the F-statistics based on analogous equations excluding the government spending variable.

For the sample spanning the last quarter of 1973 to the end of 1989, the result showed that only the average lending rate is statistically significant at the 1% level while M1 is significant at the 5% level, even when excluding the presence of fiscal variable. The other financial variables are highly insignificant and hence empirically do not contain information to movements in income. The F-statistics for the second sub-period showed that only M3 is not significant while the other financial variables are significant at the 1% level. Of interest is the improvement in the inter-bank interest rate which registered a highly significance position during the second sub period compared to the first. This augurs well for the variable as it gains importance in the 1990s as an operating target in the conduct of monetary policy. However, excluding the presence of fiscal variable, only reserve money and M3 credit seemed to be significant the 1% level while the average lending rate and M1 is significant at less than 5%. For the overall sample period, M1, average lending rate and M1 are significant at the 1% with or without the presence of Government which implied that on statistical grounds, they are important determinants to movements in nominal income. Nevertheless, M3 showed significance at the 5% level with the presence of fiscal variable and 10% significance level without the presence of fiscal variable in the regression.

Table IV.3 presents the results based on equation in which the variable whose movement is to be explained is real income (real GDP). The regression equation to be estimated is as in equation 3:

(Equation 3)

$$\Delta Y_t = \alpha + \beta_0 \Delta M_t + \beta_1 \Delta M_{t-1} + \beta_2 \Delta M_{t-2} + \beta_3 \Delta M_{t-3} + \beta_4 \Delta M_{t-4}$$
$$+ \gamma_0 \Delta G_t + \gamma_1 \Delta G_{t-1} + \gamma_2 \Delta G_{t-2} + \gamma_3 \Delta G_{t-3} + \gamma_4 \Delta G_{t-4}$$
$$+ \gamma^*_0 \Delta P_t + \gamma^*_1 \Delta P_{t-1} + \gamma^*_2 \Delta P_{t-2} + \gamma^*_3 \Delta P_{t-3} + \gamma^*_4 \Delta P_{t-4}$$
$$+ \delta_1 \Delta Y_{t-1} + \delta_2 \Delta Y_{t-2} + \delta_3 \Delta Y_{t-3} + \delta_4 \Delta Y_{t-4} + \varepsilon_t$$

Table IV.3 - F-statistics for Variables in Real Income Equations

	1973:4-1989:4		1990:1-1999:2		1973:4-1999:2	
	F-stat	Prob.	F-stat	Prob.	F-stat	Prob.
A. Four-variable System (Real Income, Price Index, Fiscal variable and Financial Variable)						
ΔALR	0.882	0.502	2.946	0.041	3.721	0.004
ΔIR	3.420	0.011	3.350	0.026	3.506	0.006
ΔLN(RM)	1.305	0.281	3.884	0.015	5.571	0.000
ΔLN(M1)	3.942	0.005	2.044	0.121	4.174	0.002
ΔLN(M3)	1.520	0.205	0.681	0.644	1.610	0.167
ΔLN(CREDIT)	1.857	0.124	1.243	0.330	2.334	0.050

B. Three variable System (Real Income, Price Index, and Financial Variable)

ΔALR	1.311	0.276	3.104	0.028	4.500	0.001
ΔIR	3.603	0.008	1.816	0.149	4.900	0.000
ΔLN(RM)	1.41	0.239	5.105	0.003	7.755	0.000
ΔLN(M1)	5.004	0.000	3.515	0.017	6.737	0.000
ΔLN(M3)	0.827	0.537	1.771	0.159	1.607	0.167
ΔLN(CREDIT)	1.136	0.355	1.629	0.192	104.5	0.231

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During the overall sample period, the F-statistics for variables in the real income equation indicate that among the financial variables used, M3 showed that it is not significant even at the 10% level, while interest rates and reserve money are significant at the 1% level. During the first sub-period, only inter-bank interest rate and M1 showed significance at the 1% level. This result is also consistent without the presence of fiscal variable. However, during the second sub-period, M1 and M3 turned out to be statistically poor variables in explaining the movement in real income. The inter-bank interest rate, on the other hand, showed a favorable result throughout the sample period while the average lending rate only showed significance (at the 5% level) in the second sub-period.

Table IV.4 presents the results based on equation in which the variable whose movement is to be explained is price. The regression equation to be estimated is as in equation 4:

(Equation 4)

$$\Delta P_t = \alpha + \beta_0 \Delta M_t + \beta_1 \Delta M_{t-1} + \beta_2 \Delta M_{t-2} + \beta_3 \Delta M_{t-3} + \beta_4 \Delta M_{t-4}$$

$$+ \gamma_0 \Delta G_t + \gamma_1 \Delta G_{t-1} + \gamma_2 \Delta G_{t-2} + \gamma_3 \Delta G_{t-3} + \gamma_4 \Delta G_{t-4}$$

$$+ \gamma^*_1 \Delta P_{t-1} + \gamma^*_2 \Delta P_{t-2} + \gamma^*_3 \Delta P_{t-3} + \gamma^*_4 \Delta P_{t-4}$$

$$+ \delta_0 \Delta Y_t + \delta_1 \Delta Y_{t-1} + \delta_2 \Delta Y_{t-2} + \delta_3 \Delta Y_{t-3}$$

$$+ \delta_4 \Delta Y_{t-4} + \varepsilon_t$$

Table IV.4 - F-statistics for Variables in Price Equations

	1973:4-1989:4		1990:1-1999:2		1973:4-1999:2	
	F-stat	Prob.	F-stat	Prob.	F-stat	Prob.
A. Four-variable System (Real Income, Price Index, Fiscal variable and Financial Variable)						
ΔALR	0.503	0.771	0.563	0.727	0.750	0.588
ΔIR	2.253	0.068	2.583	0.063	3.455	0.007
ΔLN(RM)	0.724	0.609	0.932	0.483	1.177	0.328
ΔLN(M1)	0.954	0.457	1.117	0.386	0.821	0.538
ΔLN(M3)	0.984	0.440	0.152	0.977	0.551	0.737
ΔLN(CREDIT)	2.042	0.093	0.435	0.818	2.030	0.084
B. Three variable System (Real Income, Price Index, and Financial Variable)						
ΔALR	0.286	0.918	1.282	0.305	0.493	0.781
ΔIR	1.367	0.254	1.662	0.184	3.052	0.014
ΔLN(RM)	1.724	0.148	0.624	0.683	0.708	0.619
ΔLN(M1)	1.908	0.111	0.959	0.463	0.891	0.491
ΔLN(M3)	2.662	0.034	0.269	0.925	1.190	0.321
ΔLN(CREDIT)	2.966	0.021	0.774	0.578	2.961	0.016

Based on the F-statistics, the inter-bank interest rate and M3 credit variables showed significance at the 1% and 10% level respectively during the overall sample period. The statistics also showed same importance, albeit at different significance level, in the first sub-period. It is interesting to note that during the second sub-period, only the inter-bank interest rate can be said to be able to explain the movement in the price variable at less than 10% level. These results highlight the poor performance of the money variables in explaining the movement in prices in the country.

IV.5 Cointegration : money-income and money-price relationships

The above empirical tests focus on short run relationships between the growth rate of money or financial variables indicated to the growth rate of income or prices. The above tests were conducted after determining their integrated series. However, in the practical conduct of monetary policy, it is important to determine the long run relationship between the level of money and the level of income or prices.

It was determined above that the variables money, income and prices are non-stationary at the level form. The fact that money, income and prices are individually non-stationary need not imply that the ratio of one to other is also non-stationary. In statistical terms, two series are cointegrated whenever they are individually integrated yet there exist a linear combination of the two that is stationary. A stationary money:income ratio therefore means that money and income are cointegrated in logarithms[39]. For example, if the logarithms of money and income are each individually integrated but jointly obey a simple equilibrium relationship of the form

$$m = \alpha + \beta y$$

[39] Friedman and Kuttner

ıa the deviations of *m* and *y* are stationary, then the two variables are cointegrated 'or any nonzeo value of coefficient β) in that either *y* or *m* will tend to adjust, so as to estore the equilibrium relationship in the above equation after any realized listurbance. Alternatively, if any disturbance producing a deviation from above equation is equally likely to increase or to decrease from each period's realized value, then y and m have no tendency to return to an equilibrium relationship, and hence, are not cointegrated[40].

For the purpose of checking the cointegration between real money and real income or prices for Malaysia during the sample period from the fourth quarter of 1973 to the second quarter of 1999, the following steps were taken:

i) Run the above equation in logarithm form and determine its residuals.

ii) Test for stationarity on the residuals using the Augmented Dickey Fuller unit root test.

The summary results are as shown in Table IV.5 :

Table IV.5

Equations	***ADF Test Statistics***	***1% / 5% critical value***
Real M1 and real GDP	-3.087	-2.587
Real M3 and real GDP	-2.993	-2.587
Int. rate (3-m) and real GDP	-3.111	-2.587
M1 and CPI	-2.449	-2.587/-1.943
M3 and CPI	-2.491	-2.587/-1.943
Int. rate (3-m) and CPI	-3.110	-2.587

[40] Op. Cit.

Based on the above ADF statistics, except for the paired variables between money and prices, the residuals for other equations particularly on money with real GDP and the interest rates with GDP and prices are stationary at the 1%. As such, it can be concluded that on statistical grounds, there seems to be a long run relationship between money supply M1 and M3 with income. However, although the result for M1 is consistent with earlier results on the autoregression test where M1 emerged as the most important variable that contains information on the movement of income throughout the period under review, it is surprising that money supply M3 is inherently cointegrated with income and yet does not provide information to movement in income. On the other hand, interest rates showed a consistent result in both the autoregression test as well as the test for cointegration. In earlier autoregression tests, the interbank interest rate is significant at the 1% level with respect to its influence on real income in the 1990s and likewise in the test for cointegration, the 3-month inter-bank rate showed a favorable result. Testing for cointegration confirmed that statistically, there exist a long run relationship between interest rates and income as well as between interest rates and prices in Malaysia.

In conclusion, the findings from the above empirical investigation showed some interesting results on the significance of monetary aggregates and interest rates in influencing the movement in income and prices over the past two decades. One positive finding that emerged from the empirical analysis was the outstanding effect of interest rates on income and prices. On the contrary, the cointegration test showed evidence of no long run relationship between the monetary aggregates and prices. The insignificance of broad money M3 with respect to prices questions its usefulness and reliability as an intermediate target.

APPENDIX III

Sample period 1973:4 - 1989:4

	ALR	IR3M	M1GR	M3GR	RMGR
Mean	10.66852	6.816951	11.51506	16.66121	10.69182
Median	10.25000	6.410000	12.67835	16.54284	11.41347
Maximum	12.99000	11.75000	21.01252	29.98779	28.57510
Minimum	8.700000	2.630000	-5.448879	4.768805	-3.264755
Std. Dev.	**1.296201**	**2.356045**	**6.447035**	**6.675267**	**6.914723**
Skewness	0.226019	0.213963	-0.708568	0.160794	0.196269
Kurtosis	1.547083	2.189785	2.789300	2.443017	2.572244
Jarque-Bera	5.884739	2.133907	5.217201	1.051358	0.856696
Probability	0.052741	0.344055	0.073638	0.591154	0.651584
Observations	61	61	61	61	61

Sample period 1990:1 - 1999:2

	ALR	IR3M	M1GR	M3GR	RMGR
Mean	9.787895	7.070342	12.23573	17.27953	14.90395
Median	9.715000	7.280000	12.23680	18.92076	22.20001
Maximum	13.51000	11.07000	37.49683	29.00622	43.45191
Minimum	8.240000	3.270000	-17.02071	2.725089	-56.35778
Std. Dev.	**1.167958**	**1.492835**	**12.49999**	**6.097029**	**25.32433**
Skewness	1.487994	0.219367	-0.522100	-0.856304	-1.663612
Kurtosis	5.749321	4.527625	3.712217	3.368746	4.918897
Jarque-Bera	25.99085	3.999701	2.529541	4.859245	23.35827
Probability	0.000002	0.135356	0.282304	0.088070	0.000008
Observations	38	38	38	38	38

CHAPTER IV EMPIRICAL ASSESSMENT

This study proceeds with an empirical assessment of the effectiveness of monetary policy in Malaysia over the period 1973:4-1999:2. The empirical work follows largely that by Friedman and Kuttner. The effectiveness of monetary policy is determined by assessing the statistical significance of the relationships between money (or interest rates) on income and prices. The objective is to find out between the two variables, money supply and interest rates, which variable is better in explaining the movements in income or prices in Malaysia before and after financial reforms. This chapter will first outline the empirical framework. This is followed by the stationarity tests and model specification to the empirical runs. The empirical results of the autoregression tests are then presented and analyzed after which the cointegration work is discussed.

IV.1 Empirical Framework

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the first, except for M3 which standard deviation registered a marginal decline in the second period (please refer Appendix III).

iv) The interest rate's standard deviation in the first period was also greater compared to the second period (Appendix III).

IV.2 Stationarity tests and results

Empirical work based on time series data normally assumes that the underlying time series is stationary. However, this assumption needs to be verified as the time series may not be stationary and in fact there may be situation that exemplifies the problem of spurious regression whereby the time series involved exhibit strong trends with high R^2, but the high R^2 observed is actually due to the presence of the trend, and not to a true relationship between the time series.

A stationary series exhibit mean reversion; it fluctuates around a constant long run mean. It has finite variance and has theoretical correlogram that diminishes as lag length increases. On the other hand, a non-stationary series is where there is no long run mean to which the series returns. The variance is time dependent and goes to infinity as time approaches infinity. Theoretical autocorrelation do not decay, but in finite sample, the sample correlogram dies out slowly. Furthermore, if a series must be differenced d times before it becomes stationary, then it contains d unit roots and is said to be integrated of order d, denoted as $I(d)$. Test for stationarity can be done by testing for unit roots.

Suppose Y_t is generated by AR(1) process:

$$Y_t = \rho Y_{t-1} + \varepsilon_t$$

If $|\rho| < 1$, Y_t is $I(0)$. If $\rho = 1$, Y_t is $I(1)$. Therefore, test for stationarity is to test for $\rho = 1$.

Dickey and Fuller[36] considered 3 different regressions to test for the presence of unit root, where $H_o : \rho^* = 0$ (that is there is a unit root):

$$\Delta Y_t = \rho^* Y_{t-1} + \varepsilon_t$$

$$\Delta Y_t = a_0 + \rho^* Y_{t-1} + \varepsilon_t$$

$$\Delta Y_t = a_0 + \rho^* Y_{t-1} + a_1 t + \varepsilon_t$$

The above assumes that the error term is not correlated. If the error term is autocorrelated, the regression has to take on a different form as follows which includes lagged difference terms, which is called the Augmented Dickey Fuller (ADF) test, where $H_o : \rho^{**} = 0$:

$$\Delta Y_t = a_0 + \rho^{**} Y_{t-1} + a_1 t + b_i \Sigma \Delta Y_{t-i} + \varepsilon_t$$

The important coefficient to look at is ρ^{**}, where if the test shows that $\rho^{**} = 0$, it means that a unit root exists in Y i.e. Y is nonstationary.

However, including a trend variable in a simple regression to solve the problem of spurious correlation can be misleading, because the trend in a series can be either deterministic or stochastic. If the trend is stochastic, the common practice of detrending the data by a single trend line will be misleading. Therefore, an assessment needs to be made on the error term, based on two different equations as shown below:

(1) $Y_t = a_0 + a_1 t + \varepsilon_t$

(2) $Y_t - Y_{t-1} = a + \varepsilon_t$

In equation (1), if the error term ε_t is found to be stationary, then it is said to represent a **trend-stationary process** (TSP). In equation (2), if the error term is found to be stationary, then it is said to represent a **difference stationary process** (DSP). In other words, a stationary time series can be modeled as a TS process while a

[36] In Gujarati, Damodar N. Basic Econometrics, Third edition, McGraw Hill, 1995.

nonstationary time series represents a DS process. The practical significance of TSP and DSP is for purposes of long term forecasting, whereby forecast made from a TSP is said to be more reliable while forecast made from a DSP will be unreliable.

Testing for the presence of Unit Roots

The results of the Augmented Dickey-Fuller (ADF) test for unit roots (Ho : Presence of Unit Roots) for the variables to be used in the autoregression tests are as shown below (Table IV.1):

Table IV.1

Variables	**ADF Test Statistic**		**1% Critical Value**	
	Level	**First Difference**	**Level**	**First difference**
ALR	-2.76	-4.00	-3.5	-3.5
3-M INTERBANK IR	-3.71	-	-3.5	-
LNM1	-0.75	-3.88	-3.5	-3.5
LNM3	-1.52	-3.70	-3.5	-3.5
LNRM	-1.15	-3.62	-3.5	-3.5
LNGOV	-2.63	-5.17	-3.5	-3.5
LNCPI	-0.87	-3.73	-3.5	-3.5
LNM3CREDIT	-1.56	-3.85	-3.5	-3.5

Based on the above methodology and ADF statistics, it was found that all variables, with the exception of the 3-month inter-bank interest rate, are integrated of order one. Data covered for the above test is from 1973 fourth quarter to the second quarter of 1999.

I'/.3 Model specification

Early work on money-income relationship started with research by Christopher A. Sims (1972, 1980) who also introduced the debatable Granger test. Since then, empirical work of whether money can usefully play a role in the monetary policy process has appropriately focused not just on whether fluctuations of money help predict future fluctuations of income or prices, but on whether they help predict future fluctuations of income that are not already predictable on the basis of fluctuations of income itself. However, in the context of information-variable approach, as long as movements in money do contain information about future movements in income beyond what is already contained in movements in income itself, monetary policy can exploit that information by responding to observed money growth regardless of whether the information it contains reflects true causation, reverse causation based on anticipations, or mutual causation by some independent but unobserved influence[37].

The model specification takes on the following autoregressions of the form outlined below, with the null hypothesis that all of the coefficients on the lagged variable M (defined below), that is all of the β_i, are zero :-

$$\mathbf{Ho} : \beta_i = 0 \quad \forall \text{ i's}$$

(Equation 1) $$\Delta Y_t = \alpha + \sum_{i=0}^{4} \beta_i \Delta M_{t-i} + \sum_{i=0}^{4} \gamma_i \Delta G_{t-i} + \sum_{i=1}^{4} \delta_i \Delta Y_{t-i} + \varepsilon_t$$

where:

ΔY_t — difference of log of nominal or real income measured by GDP

[37] Op. Cit.

at 1987 prices. Prior to 1987, the series were obtained based on the growth estimates by Tilak and Lee[38]. The nominal income series were determined based on the quarterly change of the consumer price index. For the real income equation and the price equation (Table IV.3 and IV.4), the log of CPI is used and data was re-based to 1994=100.

ΔM_t — difference of log of financial variables indicated (Reserve money, M1, M3 and M3 credit), and difference of 3-month inter-bank rate (average for the month) and the commercial banks average lending rate (end-month).

Data for M3 credit is available from 1980 onwards. Prior to that, data for M2 credit is used.

ΔG_t — difference of log of federal government expenditure (current expenditure plus net development expenditure).

α, β_i, γ_i, and δ_i are coefficients to be estimated; and ε_t is a disturbance term.

The estimated regressions in this study use four lags of each variable. Unlike Friedman and Kuttner which begins with **i=1** for M and G variables, for the purpose of this study, **i** begins with **0** because given that the data used are quarterly numbers,

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[38] Tilak Abeysinghe and Christopher Lee. ' Best Linear unbiased Interpolation of quarterly GDP: The case for Malaysia'. Fourth Malaysian Econometric Conference, October 1996.

M and G for period **t** is also assumed to be correlated and have impact on Y during period **t**.

IV.4 Results of Autoregression Test and Interpretation

Table IV.2 presents the results based on equation in which the variable whose movement is to be explained is nominal income (nominal GDP) as below. Although it was not explained by Friedman and Kuttner how the F-statistics is obtained, in this study, the F-statistics is obtained from the Wald test which tests for the null hypothesis that the all of the coefficients of the financial variables indicated is zero. The autoregression equation takes on the following form:

(Equation 2)

$$\Delta Y_t = \alpha + \beta_0 \Delta M_t + \beta_1 \Delta M_{t-1} + \beta_2 \Delta M_{t-2} + \beta_3 \Delta M_{t-3} + \beta_4 \Delta M_{t-4}$$
$$+ \gamma_0 \Delta G_t + \gamma_1 \Delta G_{t-1} + \gamma_2 \Delta G_{t-2} + \gamma_3 \Delta G_{t-3} + \gamma_4 \Delta G_{t-4}$$
$$+ \delta_1 \Delta Y_{t-1} + \delta_2 \Delta Y_{t-2} + \delta_3 \Delta Y_{t-3} + \delta_4 \Delta Y_{t-4} + \varepsilon_t$$

Table IV.2 - F-statistics for Variables in Nominal Income Equations

	1973:4-1989:4		1990:1-1999:2		1973:4-1999:2	
	F-stat	Prob.	F-stat	Prob.	F-stat	Prob.
A. Three-variable System (Nominal Income, Fiscal variable and Financial Variable)						
ΔALR	3.462	0.009	5.723	0.001	2.874	0.019
ΔIR	0.595	0.704	4.332	0.006	1.535	0.188
ΔLN(RM)	0.318	0.899	5.540	0.002	2.367	0.046
ΔLN(M1)	2.824	0.027	3.012	0.031	3.297	0.009
ΔLN(M3)	1.083	0.382	0.986	0.476	2.489	0.038
ΔLN(M3CREDIT)	0.702	0.625	4.218	0.007	1.431	0.222

. Two variable System (Nominal Income and Financial Variable)

ALR	3.694	0.006	3.207	0.021	3.235	0.010
IR	1.777	0.135	2.463	0.057	2.598	0.031
LN(RM)	1.326	0.269	5.872	0.001	3.070	0.013
LN(M1)	3.647	0.007	2.696	0.041	4.451	0.001
LN(M3)	1.556	0.190	2.217	0.081	2.002	0.086
LN(M3CREDIT)	0.918	0.477	3.918	0.008	1.580	0.174

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From the above Table, the last four lines in the upper portion present F-statistics for tests, across different time periods based on equation 2. The lower portion of the table shows the F-statistics based on analogous equations excluding the government spending variable.

For the sample spanning the last quarter of 1973 to the end of 1989, the result showed that only the average lending rate is statistically significant at the 1% level while M1 is significant at the 5% level, even when excluding the presence of fiscal variable. The other financial variables are highly insignificant and hence empirically do not contain information to movements in income. The F-statistics for the second sub-period showed that only M3 is not significant while the other financial variables are significant at the 1% level. Of interest is the improvement in the inter-bank interest rate which registered a highly significance position during the second sub period compared to the first. This augurs well for the variable as it gains importance in the 1990s as an operating target in the conduct of monetary policy. However, excluding the presence of fiscal variable, only reserve money and M3 credit seemed to be significant the 1% level while the average lending rate and M1 is significant at less than 5%. For the overall sample period, M1, average lending rate and M1 are significant at the 1% with or without the presence of Government which implied that on statistical grounds, they are important determinants to movements in nominal income. Nevertheless, M3 showed significance at the 5% level with the presence of fiscal variable and 10% significance level without the presence of fiscal variable in the regression.

Table IV.3 presents the results based on equation in which the variable whose movement is to be explained is real income (real GDP). The regression equation to be estimated is as in equation 3:

(Equation 3)

$$\Delta Y_t = \alpha + \beta_0 \Delta M_t + \beta_1 \Delta M_{t-1} + \beta_2 \Delta M_{t-2} + \beta_3 \Delta M_{t-3} + \beta_4 \Delta M_{t-4}$$
$$+ \gamma_0 \Delta G_t + \gamma_1 \Delta G_{t-1} + \gamma_2 \Delta G_{t-2} + \gamma_3 \Delta G_{t-3} + \gamma_4 \Delta G_{t-4}$$
$$+ \gamma^*_0 \Delta P_t + \gamma^*_1 \Delta P_{t-1} + \gamma^*_2 \Delta P_{t-2} + \gamma^*_3 \Delta P_{t-3} + \gamma^*_4 \Delta P_{t-4}$$
$$+ \delta_1 \Delta Y_{t-1} + \delta_2 \Delta Y_{t-2} + \delta_3 \Delta Y_{t-3} + \delta_4 \Delta Y_{t-4} + \varepsilon_t$$

Table IV.3 - F-statistics for Variables in Real Income Equations

	1973:4-1989:4		1990:1-1999:2		1973:4-1999:2	
	F-stat	Prob.	F-stat	Prob.	F-stat	Prob.
A. Four-variable System (Real Income, Price Index, Fiscal variable and Financial Variable)						
ΔALR	0.882	0.502	2.946	0.041	3.721	0.004
ΔIR	3.420	0.011	3.350	0.026	3.506	0.006
ΔLN(RM)	1.305	0.281	3.884	0.015	5.571	0.000
ΔLN(M1)	3.942	0.005	2.044	0.121	4.174	0.002
ΔLN(M3)	1.520	0.205	0.681	0.644	1.610	0.167
ΔLN(CREDIT)	1.857	0.124	1.243	0.330	2.334	0.050

. Three variable System (Real Income, Price Index, and Financial Variable)

ΔALR	1.311	0.276	3.104	0.028	4.500	0.001
ΔIR	3.603	0.008	1.816	0.149	4.900	0.000
ΔLN(RM)	1.41	0.239	5.105	0.003	7.755	0.000
ΔLN(M1)	5.004	0.000	3.515	0.017	6.737	0.000
ΔLN(M3)	0.827	0.537	1.771	0.159	1.607	0.167
ΔLN(CREDIT)	1.136	0.355	1.629	0.192	104.5	0.231

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During the overall sample period, the F-statistics for variables in the real income equation indicate that among the financial variables used, M3 showed that it is not significant even at the 10% level, while interest rates and reserve money are significant at the 1% level. During the first sub-period, only inter-bank interest rate and M1 showed significance at the 1% level. This result is also consistent without the presence of fiscal variable. However, during the second sub-period, M1 and M3 turned out to be statistically poor variables in explaining the movement in real income. The inter-bank interest rate, on the other hand, showed a favorable result throughout the sample period while the average lending rate only showed significance (at the 5% level) in the second sub-period.

Table IV.4 presents the results based on equation in which the variable whose movement is to be explained is price. The regression equation to be estimated is as in equation 4:

(Equation 4)

$$\Delta P_t = \alpha + \beta_0 \Delta M_t + \beta_1 \Delta M_{t-1} + \beta_2 \Delta M_{t-2} + \beta_3 \Delta M_{t-3} + \beta_4 \Delta M_{t-4}$$

$$+ \gamma_0 \Delta G_t + \gamma_1 \Delta G_{t-1} + \gamma_2 \Delta G_{t-2} + \gamma_3 \Delta G_{t-3} + \gamma_4 \Delta G_{t-4}$$

$$+ \gamma^*_1 \Delta P_{t-1} + \gamma^*_2 \Delta P_{t-2} + \gamma^*_3 \Delta P_{t-3} + \gamma^*_4 \Delta P_{t-4}$$

$$+ \delta_0 \Delta Y_t + \delta_1 \Delta Y_{t-1} + \delta_2 \Delta Y_{t-2} + \delta_3 \Delta Y_{t-3}$$

$$+ \delta_4 \Delta Y_{t-4} + \varepsilon_t$$

Table IV.4 - F-statistics for Variables in Price Equations

	1973:4-1989:4		1990:1-1999:2		1973:4-1999:2	
	F-stat	Prob.	F-stat	Prob.	F-stat	Prob.
A. Four-variable System (Real Income, Price Index, Fiscal variable and Financial Variable)						
ΔALR	0.503	0.771	0.563	0.727	0.750	0.588
ΔIR	2.253	0.068	2.583	0.063	3.455	0.007
ΔLN(RM)	0.724	0.609	0.932	0.483	1.177	0.328
ΔLN(M1)	0.954	0.457	1.117	0.386	0.821	0.538
ΔLN(M3)	0.984	0.440	0.152	0.977	0.551	0.737
ΔLN(CREDIT)	2.042	0.093	0.435	0.818	2.030	0.084
B. Three variable System (Real Income, Price Index, and Financial Variable)						
ΔALR	0.286	0.918	1.282	0.305	0.493	0.781
ΔIR	1.367	0.254	1.662	0.184	3.052	0.014
ΔLN(RM)	1.724	0.148	0.624	0.683	0.708	0.619
ΔLN(M1)	1.908	0.111	0.959	0.463	0.891	0.491
ΔLN(M3)	2.662	0.034	0.269	0.925	1.190	0.321
ΔLN(CREDIT)	2.966	0.021	0.774	0.578	2.961	0.016

Based on the F-statistics, the inter-bank interest rate and M3 credit variable showed significance at the 1% and 10% level respectively during the overall sampl period. The statistics also showed same importance, albeit at different significanc vel in the first sub-period. It is interesting to note that during the second sub-period, ıly the inter-bank interest rate can be said to be able to explain the movement in the rice variable at less than 10% level. These results highlight the poor performance of ıe money variables in explaining the movement in prices in the country.

V.5 Cointegration : money-income and money-price relationships

The above empirical tests focus on short run relationships between the growth rate of money or financial variables indicated to the growth rate of income or prices. The above tests were conducted after determining their integrated series. However, in the practical conduct of monetary policy, it is important to determine the long run relationship between the level of money and the level of income or prices.

It was determined above that the variables money, income and prices are non-stationary at the level form. The fact that money, income and prices are individually non-stationary need not imply that the ratio of one to other is also non-stationary. In statistical terms, two series are cointegrated whenever they are individually integrated yet there exist a linear combination of the two that is stationary. A stationary money:income ratio therefore means that money and income are cointegrated in logarithms[39]. For example, if the logarithms of money and income are each individually integrated but jointly obey a simple equilibrium relationship of the form

$$m = \alpha + \beta y$$

[39] Friedman and Kuttner

and the deviations of *m* and *y* are stationary, then the two variables are cointegrated (for any nonzeo value of coefficient β) in that either *y* or *m* will tend to adjust, so as to restore the equilibrium relationship in the above equation after any realized disturbance. Alternatively, if any disturbance producing a deviation from above equation is equally likely to increase or to decrease from each period's realized value, then y and m have no tendency to return to an equilibrium relationship, and hence, are not cointegrated[40].

For the purpose of checking the cointegration between real money and real income or prices for Malaysia during the sample period from the fourth quarter of 1973 to the second quarter of 1999, the following steps were taken:

i) Run the above equation in logarithm form and determine its residuals.

ii) Test for stationarity on the residuals using the Augmented Dickey Fuller unit root test.

The summary results are as shown in Table IV.5 :

Table IV.5

Equations	*ADF Test Statistics*	*1% / 5% critical value*
Real M1 and real GDP	-3.087	-2.587
Real M3 and real GDP	-2.993	-2.587
Int. rate (3-m) and real GDP	-3.111	-2.587
M1 and CPI	-2.449	-2.587/-1.943
M3 and CPI	-2.491	-2.587/-1.943
Int. rate (3-m) and CPI	-3.110	-2.587

[40] Op. Cit.

Based on the above ADF statistics, except for the paired variables between money and prices, the residuals for other equations particularly on money with real GDP and the interest rates with GDP and prices are stationary at the 1%. As such, it can be concluded that on statistical grounds, there seems to be a long run relationship between money supply M1 and M3 with income. However, although the result for M1 is consistent with earlier results on the autoregression test where M1 emerged as the most important variable that contains information on the movement of income throughout the period under review, it is surprising that money supply M3 is inherently cointegrated with income and yet does not provide information to movement in income. On the other hand, interest rates showed a consistent result in both the autoregression test as well as the test for cointegration. In earlier autoregression tests, the interbank interest rate is significant at the 1% level with respect to its influence on real income in the 1990s and likewise in the test for cointegration, the 3-month inter-bank rate showed a favorable result. Testing for cointegration confirmed that statistically, there exist a long run relationship between interest rates and income as well as between interest rates and prices in Malaysia.

In conclusion, the findings from the above empirical investigation showed some interesting results on the significance of monetary aggregates and interest rates in influencing the movement in income and prices over the past two decades. One positive finding that emerged from the empirical analysis was the outstanding effect of interest rates on income and prices. On the contrary, the cointegration test showed evidence of no long run relationship between the monetary aggregates and prices. The insignificance of broad money M3 with respect to prices questions its usefulness and reliability as an intermediate target.