# Money, Interest Rates And Income In The Singapore Economy

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# MONEY, INTEREST RATES AND INCOME IN THE SINGAPORE ECONOMY

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## EXECUTIVE SUMMARY

1 Monetary policy in Singapore centres on the management of the exchange rate. There is no independent policy targets for either interest rates or money supply. This choice of monetary regime is based on the following assumptions:[1]

(a) Money supply is essentially endogenous, or adjusts passively, to economic activity. Changes in money supply thus have a limited impact on economic activity, both in real and nominal terms;

(b) Exchange-rate changes have a major influence on inflation, and not insignificant effects on the international competitiveness of the real sector;

(c) An exchange rate-centred monetary regime in Singapore cannot co-exist with an independent policy on domestic money supply or interest rates; i.e., the active management of the exchange rate implies a loss of domestic monetary autonomy in the context of an open economy.

2 The present paper examines the first of these precepts, item (a). There is good economic reasoning stemming from the extreme openness of the economy, for the view that money supply has little independent influence on economy activity. The dominance of external demand in the economy implies a minimal role for changes in the domestic money supply as an independent stimulus of demand. The heavy reliance on foreign investments also reduces the role of domestically funded capital expenditures. Finally, the high exposure of the monetary sector to capital flow from abroad implies that any excesses in the demand or supply of money would be eliminated with only small changes in interest rates.

3 However, these arguments need to be tested empirically on the data.[2] They are premised on the empirical dimension of economic behaviour including, the degree of wage and price flexibility, the elasticity of aggregate demand to interest rates, and the stability of the money demand relationships. This paper proposes to

[1] See Teh and Shanmugaratnam(1992).

[2] Several other papers have looked at the issues raised by assumptions (a) and (c). For example, see Robinson, E. and Ng, C.H. (1996), on issue (a), and MAS Economics Department (1998), on issue (c).

examine the linkages between monetary aggregates and economic activity in Singapore.

4 The paper begins with a discussion of some methodological issues relating to the money-income relationship. We explain that a consensus has emerged in the theoretical literature for the view that money affects the level of real economic activity over period of one or two years, but that it has no long-run impact on the economy. The empirical literature specifies a somewhat weaker criterion on establishing money-income relationships. Here, the emphasis is on deriving information content, specifically, whether fluctuations in monetary aggregates can help predict future movements of income, that are not already predictable on the basis of past values of income or other readily observable variables.

5 The paper proceeds with a careful empirical investigation of the money-income relationship in Singapore over the period 1976 to 1997 using the empirical criterion. We take into account the statistical properties of the money and income variables. Our objective is to confirm the robustness of results, and in this regard, we estimate a number of different test specifications, which vary across sample periods, conditioning variables used, and lag structure between the income and money variables.

6 Our results confirm that money (the M2 measure) and interest rates have predictive content for future movements in real GDP, though this relationship establishes itself only after a lag of about three to seven quarters. It is important to emphasise that our findings do not provide evidence for the non-neutrality (or otherwise) of monetary aggregates in Singapore. Instead, it suggests the possible use of information in monetary and interest rate variables in predicting future movements in real GDP. In addition, our findings provide a strong basis to proceed with a further study into identifying and quantifying the channels through which monetary impulses impact on key sectors and expenditure categories in the economy.

# 1 METHODOLOGY

1.1 In this section, we consider a number of methodological issues related to the money-income relationship. The theoretical underpinnings of the role of money has had an illustrious history in the literature, and in many ways can be thought of as being at the core of the macroeconomic management debate between the Keynesians and those of the Classical persuasion. If it is at all possible to distil the results of that discussion, it would be that **money affects the level of real economic activity over periods of one or two years, but that it has no long-run impact on the economy, i.e., money is super-neutral in the longer term.** (See for example, M. Espinosa-Vega(1998)). Chart 1 is an attempt to provide a guide to the various strands in the literature on the *'Great Money Debate'.* As the debate in the literature can be somewhat confusing at times, some generalisation and simplification has been adopted.

1.2 The literature summarised in Chart 1 has included a heavy empirical orientation. Indeed, in many instances, empirical regularities have preceded the development of the theoretical constructs. In the remainder of this section, we will discuss some of the major issues pertaining to the empirical studies.

## The Information-Variable Perspective

1.3 The various empirical studies which examine the causality between monetary aggregates and economic activity, differ in their econometric methodologies, and the monetary and activity variables that are used in the tests. Table 1 provides a summary of some of the widely quoted ones and highlights their differences across these dimensions.

# Chart 1
# THE GREAT MONEY DEBATE

**The Basic Transactions Identity**

Fisher (1911): Equation of Exchange
MV≡PY
(Underpinnings in Hume (1752))

## "The Classical Route"

**The Early Quantity Theory (QT) of Money**

- Fisher's assumption that Y, V are exogenous. ⇒ΔM~ΔP
- Pigou (1941): "… money clearly is a veil. It does not comprise any of the essentials of economic life"

**General Equilibrium (GE) Interpretation of the General Theory (GT)**

- Patinkin (1956) broke down the 'classical dichotomy' to integrate real and monetary sectors in a GE f/w
- His model restored the self-equilibrating forces in a market based economy

**The Modern QT**

- Friedman (1956) and Phelps (1967) introduced expectations into Phillips curve, and showed there is no trade trade-off in the long-run
- Lucas (1971) derived a aggregate supply-side 'surprise' function, independent of policy instruments:
  Y - Y* = f [unpredictable money ss shocks and random dd-side shocks]
- Sargent, Wallace (1976) proved the policy ineffectiveness proposition; the inability of macro stabilization policy to achieve pre-determined objectives under RE and new-classical supply curve

**Enhancements to Long-run Superneutrality**

- Dynamic Inconsistency - Kydland and Prescott (1977) showed that the temptation to exploit the Phillips curve will only lead to more inflation under RE. They suggest tying the central banks' hands by committing to a policy rule

## "The Keynesian Route"

**The Keynesian Challenge to the QT**

- Keynes (1936) in the General Theory (GT) argued that $M^d$ is unstable, ∴QT did not have predictive content
- Illustrated the ineffectiveness of monetary policy in a liquidity-trap
- Hicks (1937) interpretation of GT in the IS-LM framework reinforced role of fiscal instruments

**The Inflation-Unemployment Trade-off**

- Phillips (1958) found that Δw was negatively related to unemployment rate in UK using 1861-1957 data
- Macropolicy could exploit this trade-off

**Post-Keynesian Response**

- Derivation of the micro-foundations of coordination failure
- Price rigidity - Ball & Mankiw (1995) on menu costs
- Wage rigidity - Taylor (1980) on staggered contracts
  - Stiglitz and Shapiro (1984) on efficiency wages
- Tobin (1956) and Bernanke and Gertler (1995) work on the credit transmission, allow permanent increases in $M^s$ and inflation to result in permanently lower real interest rates and higher levels of output

**The Unholy Truce**

*Theory*

- Monetary policy has short-run effects but is long-run neutral.
- However, the theoretical debate between 'Classical' and 'Keynesian' economists continues. As Leijonhufvud (1973) notes there is more work to be done: "Keynesian economics had been maligned on the grounds that its theoretical foundations were prosaic at best, non-existent at worst, and clearly inelegant. Its heir apparent, new classical economics, boasted an elegant and technically sweet theory, which passed internal consistency checks with flying colours, but which failed miserably when it came to consistency with observation"

*Policy*

- Taylor (1998), "A general implication of research on credibility, time in consistency, and rational expectations is that money policy should be viewed and conducted as much as possible as a contingency plan, or a policy rule." [Classical stand]
- Blinder (1998), "Rarely does society solve a time-inconsistency problem by rigid pre-commitment … (to a rule). Enlightened discretion is the answer." [Keynesian stand]

**Table 1**
**Selective Summary of Recent Empirical Studies**

| | Friedman & Kuttner (1992) | Bernanke & Blinder (1992) | Feldstein & Stock (1994) | Tallman & Chandra (1996) | Tallman & Chandra (1997) |
|---|---|---|---|---|---|
| | | | | | |
| **(I) Methodology** | | | | | |
| Frequency | Q | M | Q | Q | Q |
| Data | US,1960-90 | US,1959-89 | US,1959-92 | Aust,1976-95 | Aust,1977-96 |
| Different Sample Periods? | ✓ | ✓ | ✓ | N | N |
| Single Equation (# of lags) | 4 | 6 | 3 | 4 | ✓ |
| Var (# of lags) | 4 | 6 | - | 4 | 4 |
| Variance Decomposition (Horizon) | 4,8 | 24 | - | 6,12 | - |
| Cointegration | ✓ | | ✓ | | |
| Other Tests? | N | N | ✓ | ✓ | ✓ |
| | | | | | |
| **(II) Dependent Variables** | | | | | |
| Nominal GDP | ✓ | | ✓ | | |
| Real GDP | ✓ | ✓ | ✓ | ✓ | ✓ |
| Price Level | ✓ | | | | |
| Capacity Utilisation | | ✓ | | | |
| Consumption | | ✓ | | | |
| Durable Goods Orders | | ✓ | | | |
| Employment | | ✓ | | | |
| Housing Starts | | ✓ | | | |
| Personal Income | | ✓ | | | |
| Retail Sales | | ✓ | | | |
| Unemployment Rate | | ✓ | | | |
| | | | | | |
| **(III) Independent Variables** | | | | | |
| Monetary Base | ✓ | | ✓ | ✓ | Y |
| M1 | ✓ | ✓ | ✓ | | |
| M2 | ✓ | ✓ | ✓ | | |
| M3 | | | | ✓ | ✓ |
| Broad Money | | | | ✓ | ✓ |
| Credit | ✓ | | | ✓ | ✓ |
| Federal Funds Rate | | ✓ | ✓ | | |
| Commercial Paper Rate | ✓ | | | | |
| US Treasury Bill Rate | ✓ | ✓ | | ✓ | ✓ |
| US Treasury Bond Rate | | ✓ | | | |
| Spread (Bill & Paper) | ✓ | | | | |
| Spread (Bond & Funds) | | ✓ | | | |
| Spread (Bond & Paper) | | ✓ | ✓ | | |
| Term Structure | | ✓ | ✓ | | |
| Exchange Rate | | | | ✓ | ✓ |
| Government Expenditure | ✓ | | | | |
| Price Level | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | | | | |
| **(IV) Results** | | | | | |
| Does money have information content? | Y | Y | Y | N | N |

Notes: Y - yes, N - No, Q - quarterly, M - monthly

1.4 Most of the empirical studies focus on the information-variable concept in monetary policy analysis (see for example, Kareken, et. al. (1976)). Essentially, this approach specifies that "there be at least some reliable exploitable connection between money and either income or prices, so that observed departures of money from an *ex ante* path bear a systematic implication for income or prices in the future" (Friedman and Kuttner (1992)).[3]

1.5 The econometric estimating and testing procedures require a more precise criterion of information content. Accordingly, the empirical literature has focussed on establishing **whether fluctuations of money help predict future fluctuations of income, that are not already predictable on the basis of fluctuations of income itself or other readily observable variables**. It is important to appreciate that this definition abstracts from issues of 'causality' (see for example, Friedman and Kuttner [1992]). The point is that, as long as money contains information about future income beyond that already contained in income itself, monetary policy can exploit that information, regardless of whether it reflects true causation, reverse causation (based on anticipations, see footnote 3), or joint causation by some independent, unobserved influence.

## Choice of Variables in the Money-Income Relationship

1.6 The next important issue concerns the choice of variables to be used in the testing of the money-income relationship. Table 1 shows that there has been an increasing tendency to examine the effects of money on **real GDP**. The earlier emphasis on **nominal GDP** was closely associated with the nominal GDP targeting objective of monetary policy, which was popular in the late-1980s. However, there was some disillusionment with these targeting rules through the 1980s, reflecting the difficulties encountered in controlling monetary aggregates in a period of rapid financial sector liberalisation and development. The focus more recently has been to

[3] Robert Solow disagrees with the direct connection between the money supply and the price level. "So far as fundamentals are concerned, monetary policy works though its effects on aggregate demand, just like fiscal policy…. The only direct connection I can think of is itself the creation of pop economics. If business people and others become convinced that there is some casual immaculate connection from the money supply to the price level, completely bypassing the real economy, then the news of a monetary-policy action will generate inflationary or disflationary expectations and induce the sorts of actions that will tend to bring the expected outcome…" See Solow and Taylor (1998).

study the money-income relationship as one of the major structural linkages or transmission channels in the economy. Accordingly, our study will focus on the effects of money on real GDP.

1.7 Both the M1 and M2 monetary aggregate have been normally used as the independent variable in empirical studies (see Table 1). We adopt the M2 measure in our study.[4] Another issue in the literature on the money-output relationship is whether the inclusion of interest rates eliminates the predictive content of the monetary aggregate. We examine this possibility by including the benchmark 3-month domestic interbank rate as one of the regressors. In addition, we also include a set of other control variables which are designed to test for robustness of results.

**Econometric Issues**

1.8 There are three important econometric issues to consider – the appropriate specification of the test equation which takes into account the statistical properties of the monetary and income variables, the distinction between short and long run relationships, and the robustness of results. We consider them in turn.

1.9 The applied econometric literature now routinely tests economic time series for the presence of time-varying moments. If confirmed, the correct modelling approach is to use the error correction model (ECM). This framework not only gets around the estimation and hypothesis testing problems posed by the presence of non-stationary variables, but also explicitly recognises that relationships between variables depend on the time horizon under consideration. As we have briefly alluded to above, time horizon considerations are important in analysing the money-income relationship. In particular, the non-neutrality of money in the short-run is predicated on money illusion effects, whereby economic agents are momentarily confused about absolute versus relative price changes. Such confusions are not expected to persist over time, though.

[4] Sensitivity experiments not reported in the paper confirm that results are not significantly changed when other monetary definitions are used.

1.10 The ECM includes the interaction of short-run terms in first-difference form, as well as a consistent[5] long-run relationship, which is specified in the levels. The latter would capture the long-run relationship linking money and real income, and serves to 'anchor' the longer-term movements of the dependent variable to an 'equilibrium' path. In testing for money-income relationship, it is important to **test both the short and long-run linkages** provided for in the ECM.

1.11 Finally, an important objective in the testing of economic relationships concerns the need to establish the robustness of results. In particular, the researcher needs to establish the stability of the partial coefficient between the variable of interest and the independent variable, when there is a change to the set of other variables which are controlled for in the regression. Economic theory does not place *a priori* restrictions as it "…ordinarily does not generate a complete specification of which variables are to be held constant when statistical tests are performed on the relation between the dependent variable and the independent variables of primary interest." (Cooley, T and Le Roy, S.(1981).) In the context of growth regressions, Levine and Renelt (1992) found that only an handful of independent variables from amongst a subset of over 50 variables, which had been found to be correlated to GDP growth in previous studies, were actually robust to alterations in the list of explanatory variables in the test equations.

1.12 Levine and Renelt (1992), propose a procedure to test for robustness, which involves systematically altering the control variable set and deriving a distribution of estimates on the partial coefficient of interest. This distribution is then used as a basis for testing for robustness. The method, which is a modification of the extreme-bounds analysis of Leamer (1983), has a rather heavy requirement on sample size. In this study we instead adopt a more ad hoc approach by progressively increasing the number of variables in the control set, Z (see equation (1) below). At each stage, the relevant hypothesis test will be repeated with a view to establishing if the information content of the monetary aggregates (or interest rates) has declined.

[5] Consistency between the long-run and short-run terms in an ECM are ensured by the Engle-Granger Representation Theorem (see for example Davidson and McKinnon (1993).

1.13 The considerations above motivate an ECM of the following form[6]:

$$\Delta ngdp90_t = a_0 + \sum_{i=1}^{n} b_i \Delta ngdp90_{t-i} + \sum_{i=1,j=1}^{n,k} f_{ji} Z_{j,t-i} + \sum_{i=1}^{n} g_i \Delta neer_{t-i} + \sum_{i=1}^{n} l_i \Delta fmb_{t-i} + \sum_{i=1}^{n} m_i \Delta aintbk3_{t-i} + \sum_{i=1}^{n} q_i ecm_{t-i} + e_t \quad (1)$$

Expected Signs: $\beta_i$ (+), $\gamma_i$ (-), $\lambda_i$ (+), $\mu_i$ (-), $\theta_i$ (-)

Here, *ngdp90* is the real GDP, $Z_j$ is the $j^{th}$ control variable, *neer* is the nominal effective exchange rate defined such that an increase in the index implies an appreciation, *fmb* is M2, *aintbk3* is the nominal 3 month inter-bank rate, and *ecm* is the residual from the cointegrating relationship between the endogenous variables in the model. In our complete set, we have chosen Z = {GDP deflator (always included), nominal effective exchange rate (always included), Government expenditure, non-oil domestic exports, net investment commitments, unemployment rate}. The variables are chosen as our conditioning set because most (except for the unemployment rate) are typically used as explanatory variables in growth regressions and have been found to have explanatory power for real GDP per capita. In addition, the GDP deflator and the nominal effective exchange rate are always included in the regressor list, in the quasi-reduced form specification. We have indicated the expected signs on the variables in equation (1).

1.14 For the data set, we use quarterly observations over the period 1976Q1 to 1998Q1, a total of just under 90 time series data points. The data were seasonally adjusted using the X-11 multiplicative method and where appropriate, expressed in natural logarithms, before differencing.

1.15 The implementation of the estimation and test procedure of the money-income relationship, within the framework of equation (1) involves a number of steps as follows:

[6] The proposed specification remains premised on the finding of unit roots in the variable set.

Step 1
Testing for the presence of unit roots in each (deseasonalised) series.

Step 2
Using the results above, test for the presence of a cointegrating relationship between real GDP and the money aggregates (and/or interest rates). Estimate the long-run relationship.

Step 3
Estimate the ECM as in equation (1) using OLS and the level term from Step 2

Step 4
Test for the information content of money and/or interest rates using the F-test. The null hypothesis is specified thus:

$H_0 : \lambda_1=\ldots\lambda_n=\theta_1=\ldots\theta_n=0$

Step 5
Vary the variables in Z, and repeat steps 2 to 4 above, to ascertain robustness of conclusions.

1.16 We next outline the results from each of these steps.

## 2 EMPIRICAL EVIDENCE ON THE MONEY-INCOME RELATIONSHIP IN SINGAPORE

### Testing for the Presence of Unit Roots

2.1 The presence of unit roots is tested using the Augmented Dickey-Fuller (ADF) test. We adopt the sequential testing methodology suggested by Enders (1995), in which the appropriate deterministic regressor to be included in the test equation is determined even before the test for the presence of unit roots is conducted. Dickey and Fuller(1981) proposed a test for inclusion of constant and/or linear trend terms for the ADF test. The result of this test is summarised in the column 2 of Table 2 for each series (marked with an *). However, there is reason to suggest that the test actually suffers from low power. Note that in almost all cases, the test statistic advises against the inclusion of a constant or trend. We have also conducted the unit root test under different assumptions, by including both constant and trend terms in some of the variables which are known to be highly trended. In this case, the null hypothesis would be that the series is stationary around a deterministic trend.

2.2 Based on this methodology, it is found that **all variables, with the exception of the unemployment rate, are integrated of order one**. Singapore's unemployment rate is found to be stationary, i.e., reverting around a constant term of 2-2.2%. The next step will be to test for the presence of cointegration or a long-run relationship between the variables that are I(1).

**Table 2**
**Results of Augmented Dickey-Fuller Tests**
**($H_0$: Presence of Unit Roots)**

| Variable | Test Equation | ADF Statistic | 5% Critical Value |
|---|---|---|---|
| **NGDP90** | const* | 12.25 | -1.95 |
| | const/trend | 0.001 | -3.46 |
| **NEER** | no const/trend* | 1.59 | -1.95 |
| | const/trend | -2.56 | -3.46 |
| **FMB** | no const/trend* | 6.42 | -1.95 |
| | const/trend | 0.96 | -3.46 |
| **AINTBK3SA** | no const/trend* | -0.44 | -1.95 |
| | const | -2.17 | -2.89 |
| **PGDP90** | no const/trend* | 3.82 | -1.95 |
| | const | -0.02 | -2.89 |
| **NCG90** | no const/trend* | 3.78 | -1.95 |
| | const/trend | -1.29 | -3.46 |
| **NIC** | no const/trend* | 2.94 | -1.95 |
| | const/trend | -1.22 | -3.45 |
| | const | 1.52 | -2.89 |
| **NODX** | no const/trend* | 5.83 | -1.95 |
| | const/trend | -0.93 | -3.46 |
| **UR** | const* | -2.91 | -2.89 |

Notes:

- Statistics in blue are significant at 5% level of confidence.
- * means test equation as chosen by Dickey, Fuller (1981) criteria
- const – include a constant in the test equation
- Test equations: $\Delta y_t = \rho y_{t-1} + \varepsilon_t$
  $\Delta y_t = \mu + \rho y_{t-1} + \varepsilon_t$
  $\Delta y_t = \mu + \rho y_{t-1}\, \beta \text{Trend}_t + \varepsilon_t$

## Testing for Cointegration

2.3 The presence of a cointegrating relationship between the I(1) processes is tested using the Johansen test (Johansen (1992)). Similar to the test for unit roots we have pursued a vigorous testing methodology following Hansen and Juselius (1995) which guides the choice of test equation.

2.4 The most general model that can be estimated for the Johansen test is as follows:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + ... + \Gamma_k \Delta X_{t-k} + \begin{pmatrix} \alpha\beta & \alpha\beta_0 & \alpha\beta_1 \end{pmatrix} \begin{pmatrix} X_{t-1} \\ 1 \\ t \end{pmatrix} + \mu_0 + \mu_1 Trend + \varepsilon_t \qquad (2)$$

2.5 The models that are likely to be relevant for our purposes are as follows:

Model 1

The model does not allow for linear trends in the data. The only deterministic components in the model are the intercepts in the cointegration relations, i.e. $\beta_1=\mu_0=\mu_1=0$, $\beta_0$ is unrestricted.

Model 2

The model allows for linear trends in the data, but it is assumed that there is no trends in the cointegrating relations, i.e. $\beta_1=\mu_1=0$, $\beta_0$, $\mu_0$ are unrestricted.

Model 3

The model allows for linear trends in both the data and the cointegrating relationship, i.e. $\mu_1=0$, $\beta_0$, $\beta_1$, $\mu_0$ are unrestricted.

2.6 Denoting the combination of rank and deterministic components as $M_{ij}$, where i is the rank (i=0,1,…,p), and j is the model (j=1,2,3), the guidelines can be summarised as follows:

> "Starting from the most restrictive model, i.e. $M_{01}$, compare the rank test statistic with the chosen quantile of the corresponding table. If the model is rejected, continue to model $M_{02}$, i.e. keep the rank assumption and change the model of the deterministic components; if $M_{02}$ is rejected, go to $M_{03}$; if this is rejected, go to $M_{11}$, if rejected, go to $M_{12}$, etc., until the first time the null hypothesis is accepted."
> (Hansen and Juselius (1995))

The result of pursuing this test procedure is reported in the 3rd column (labelled 'Model') in Table 3. In all cases, it was found appropriate to include a constant in the cointegrating vector (Model 1). The various combinations of variables that yielded significant long-run relationships[7] are listed in Table 3. The results establish the presence of a long-run relationship between money, interest rates and the real economic activity in a system, which also controls for the influence of the nominal effective exchange rate. The presence of other control variables does not alter this conclusion. As expected, their inclusion as endogenous variables in the system, have the effect of increasing the number of cointegrating variables. [8]

2.7 The results imply that over the long-term in the historical sample space, there was **evidence of a systematic co-movement among M2, interest rates and real economic activity**. This finding underscores the point that **movements in monetary variables cannot be decoupled from underlying real economy activity** in the longer term. However, the evidence in Table 3 does not constitute a validation of the long-run non-neutrality of money hypothesis. This requires further empirical evidence including identifying and quantifying the channels of transmission between money and economic activity.

[7] Various combinations of the variables of interest were tested but were found to have no cointegrating relationship.

[8] On a technical point, we have chosen to regard all variables as endogenous to the system. In practice, this approach has a tendency to favour the non-rejection of the null hypothesis of cointegration. The literature has recently recognised this problem and come up with a proper framework to deal with the presence of I(1) exogenous variables. However, we have not pursued the approach here, as our emphasis in not on the long-run multiplier estimates *per se*, but rather on establishing the existence of a stable relationship between the variables of interest.

**Table 3**
**Summary of Cointegration Tests[9]**

| Variables | | | | No. of CVs/$H_0$ | Model | No of Lags | L-max | Trace | 5% Crit Values $H_0$: r=1 |
|---|---|---|---|---|---|---|---|---|---|
| Income | Monetary Aggregate | Financial Aggregates | Control Variables | | | | | | |
| NGDP90 | FMB | NEER | | 1 | 1 | 5 | 2.70 | 2.76 | 19.99 |
| NGDP90 | FMB | NEER, | | 1 | 1 | 5 | 18.24 | 23.98 | 34.79 |
| | | AINTBK3 | | 1 | 1 | 4 | 14.55 | 20.91 | |
| NGDP90 | | NEER, | PGDP90 | 1 | 1 | 5 | 17.09 | 24.82 | " |
| | | AINTBK3 | | | | | | | |
| NGDP90 | FMB | NEER, | PGDP90 | 1 | 1 | 5 | 21.58 | 37.88 | 53.42 |
| | | AINTBK3 | | 1 | 1 | 4 | 16.11 | 34.96 | |
| NGDP90 | FMB | NEER, | PGDP90, | 1 | 1 | 5 | 29.20 | 59.73 | 75.74 |
| | | AINTBK3 | NCG90 | 1 | 1 | 4 | 19.26 | 57.68 | |
| NGDP90 | FMB | NEER, | PGDP90, | 2 | 1 | 5 | 21.68 | 35.63 | " |
| | | AINTBK3 | NIC | 1 | 1 | 4 | 29.74 | 59.59 | |
| NGDP90 | FMB | NEER, | PGDP90, | 1 | 1 | 5 | 36.85 | 61.44 | " |
| | | AINTBK3 | NODX | 1 | 1 | 4 | 23.77 | 56.03 | |
| NGDP90 | FMB | NEER, | PGDP90, | 2 | 1 | 5 | 20.57 | 28.98 | 53.42 |
| | | AINTBK3 | UR* | 3 | 1 | 4 | 9.69 | 12.74 | |

Notes:

- Calculated statistics in red (blue) mean the null hypothesis of cointegration is not rejected at the 10% (5%) level of confidence.
- When the L-max and trace statistics lead to different conclusions, the one given by the Trace statistic is adopted, in line with evidence from Monte Carlo simulations which generally come out in favour of the latter.
- * The unemployment rate was treated as an I(0) exogenous variable
- CVs – cointegrating vectors

## Hypothesis Testing on the ECM: Information Content of Money

2.8 From an econometric perspective, the finding of cointegrating vectors implies the use of an ECM for hypothesis testing on the information content of money and interest rates. In our first set of estimated test equations, we include the first difference terms at lags one to five and a single lag of the error correction term. This lag structure – for quarterly data – is around the average length that is commonly used in most of the applied work reviewed in Table 1 above. The null hypothesis is formulated as:

$$H_0: \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = \theta_1 = 0$$

[9] All cointegration tests are run in the CATS sub-routine of WinRATS 32.

The appropriate statistics follows an F distribution. A summary of the test results is provided in Table 5.

**Table 4**
**Information Content of Money and Interest Rates**
**Dependent Variable: Real GDP Growth; Sample, 1976:1 to 1998:1**

| Eq | Regressors | | | | | | | | | Adj-$R^2$ | F-Test for the Exclusion of ECM & Short-run Terms On: | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | NEER | FMB | AINTBK3 |
| 1 | NGDP90 | NEER | FMB | AINTBK3 | | | | | | 0.008 | 1.171 | 1.118 | 0.698 |
| | | | | | | | | | | | (0.333) | (0.362) | (0.652) |
| 2 | NGDP90 | NEER | | AINTBK3 | PGDP90 | | | | | 0.029 | 1.252 | | 0.488 |
| | | | | | | | | | | | (0.293) | | (0.815) |
| 3 | NGDP90 | NEER | FMB | AINTBK3 | PGDP90 | | | | | 0.031 | 1.715 | 0.988 | 0.758 |
| | | | | | | | | | | | (0.134) | (0.413) | (0.584) |
| 4 | NGDP90 | NEER | FMB | AINTBK3 | PGDP90 | NCG90 | | | | 0.081 | 1.292 | 1.468 | 1.247 |
| | | | | | | | | | | | (0.278) | (0.208) | (0.298) |
| 5 | NGDP90 | NEER | FMB | AINTBK3 | PGDP90 | | NIC | | | 0.263 | 4.100 | 3.139 | 3.433 |
| | | | | | | | | | | | (0.001) | (0.0109) | (0.004) |
| 6 | NGDP90 | NEER | FMB | AINTBK3 | PGDP90 | | | NODX | | 0.064 | 2.062 | 1.340 | 1.299 |
| | | | | | | | | | | | (0.074) | (0.257) | (0.275) |
| 7 | NGDP90 | NEER | FMB | AINTBK3 | PGDP90 | | | | UR | 0.239 | 1.715 | 1.478 | 1.634 |
| | | | | | | | | | | | (0.127) | (0.197) | (0.148) |

* All regressors are included at lags 1-5 and the error correction term is included at lag 1.

* Figures in red are significant at 10% level of confidence.

* P-values are given in parenthesis.

2.9 The hypothesis that money and/or interest rates have information content was rejected in all cases, except on one instance (equation 5). Moreover, the statistical significance of the policy instrument, NEER, was not established in most cases.

2.10 We next tried experimenting on the lag structure of the right-hand side variables.[10] The models presented in Table 5 are the best fitting regression of that category, as determined by criteria such as the adjusted-$R^2$, AIC and/or SIC. The hypothesis test results are vastly different from those obtained earlier when we allow

[10] Note that the window for each of the variables included in the regression can be different. For example, NEER can enter into the regression at lags eight to twelve, while FMB can enter the same regression at lags three to seven. The error correction term can enter the regression with one to five lags. In addition, if the error correction term enters the regression with five lags, its window is also allowed to vary. All windows, with the exception of the ones for NGDP90, are varied one lag at a time, with the starting lag beginning from one to eleven, and for only one variable at a time. While this does not exhaust all the possible combinations within the period of consideration, it does provide for a more systematic search, given the immense number of possible combinations of regressors.

a longer lag in the relationship between interest rates, money and economic activity. In general, the NEER terms entered the test regressions reported in Table 5, after a lag of about seven quarters (to 11 quarters), while the interest rate variable was included with a lag of three to seven. We have found in various econometric work, that the NEER can have a long lag effect on both prices and economic activity, the latter primarily working through the export competitiveness channel. The delay in the impact of the interbank interest rate on spending could also reflect the lag in adjustments in the prime lending rate. The M2 variable, however, appears from lag one to five for all regressions, except for equation No. 7 in Table 5, where we tried a longer lag structure. This did not materially affect the results.

2.11 By allowing for a more generalised and fairly long lag structure between financial variables and real GDP, our general result is now of acceptance of the hypothesis that money and interest rates have predictive content for future movements in real GDP beyond that contained in real GDP itself. This is robust to variation in the components of the Z variable vector. [11]

**Table 5**
**Information Content of Money and Interest Rates**
**Dependent Variable: Real GDP Growth; Sample, 1976:1 to 1998:1**

| Eq | Regressors | | | | | | | | | Adj-$R^2$ | F-Test for the Exclusion of ECM & Short-run Terms On: | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | NEER | FMB | AINTBK3 |
| 1 | NGDP90 | NEER | FMB | AINTBK3 | | | | | | 0.256 | 4.332 | 1.767 | 2.093 |
| | | | | | | | | | | | (0.001) | (0.124) | (0.069) |
| 2 | NGDP90 | NEER | | AINTBK3 | PGDP90 | | | | | 0.231 | 3.554 | | 1.427 |
| | | | | | | | | | | | (0.008) | | (0.230) |
| 3 | NGDP90 | NEER | FMB | AINTBK3 | PGDP90 | | | | | 0.483 | 3.844 | 2.862 | 3.466 |
| | | | | | | | | | | | (0.001) | (0.009) | (0.002) |
| 4 | NGDP90 | NEER | FMB | AINTBK3 | PGDP90 | NCG90 | | | | 0.433 | 3.611 | 1.622 | 2.344 |
| | | | | | | | | | | | (0.002) | (0.137) | (0.028) |
| 5 | NGDP90 | NEER | FMB | AINTBK3 | PGDP90 | | NIC | | | 0.446 | 5.774 | 3.419 | 3.684 |
| | | | | | | | | | | | (0.000) | (0.003) | (0.002) |
| 6 | NGDP90 | NEER | FMB | AINTBK3 | PGDP90 | | | NODX | | 0.354 | 3.822 | 2.509 | 2.862 |
| | | | | | | | | | | | (0.002) | (0.020) | (0.015) |
| 7 | NGDP90 | NEER | FMB | AINTBK3 | PGDP90 | | | | UR | 0.627 | 4.429 | 2.740 | 2.852 |
| | | | | | | | | | | | (0.000) | (0.010) | (0.008) |

* All regressors are included in differing windows of 5 lags and the error correction term is included in differing windows of up to 5 lags.
* Figures in red are significant at 10% level of confidence.
* Figures in blue are significant at 5% level of confidence.
* P-values are given in parenthesis.

[11] All the regressions were also ran with windows of four lags. There was no major deviation from the results presented here.

2.12 We also concluded a rolling-window F-test on equations (3), (6) and (7)[12]. The rolling-window F-test is done by conducting a F-test on a restricted sample of 50 or 60 observations. The window is then moved one observation forward and the F-statistic is recalculated. The F-statistic here is a slight modification from the previous one, in that the zero restrictions are confined only to short-run, or first-differenced terms, i.e., $H_0$: $\lambda_1 = \lambda_2 = \ldots = \lambda_n = 0$. The coefficient on the error-correcting term is left unconstrained, because we are testing a series of essentially short-run relationships over a limited observation set each time, whereas the error-correcting term can be expected to operate only over a longer **span** of observations. Nevertheless, including the $\theta=0$ restriction, does not substantially alter the result reported here.

2.13 Note, also that we have not chosen to do a recursive estimate, i.e., where the sample size is extended by one data point each time from a common starting observation, so that the sample size becomes progressively larger. There is a persuasive view in the literature that recursive regression should not be carried out as a principle, because we should always be using the maximum possible observations at hand for estimating and testing.

2.14 For the sake of brevity, only the results for the 50-observations window for equation (3) are presented in Charts 2 to 4. It can be seen that, except for a few initial windows, the F-statistic calculated are highly significant. This provides evidence that links between real GDP growth and the growth rates of the nominal exchange rate, M2 and the interest rate have been relatively stable[13]. However, because of the need to accommodate a fairly generous lag structure, the size of the window had to be of a minimum length, to ensure sufficient degrees of freedom for the hypothesis testing. Thus, we were unable to provide a definitive conclusion to the stability issue, especially for the later part of the sample.

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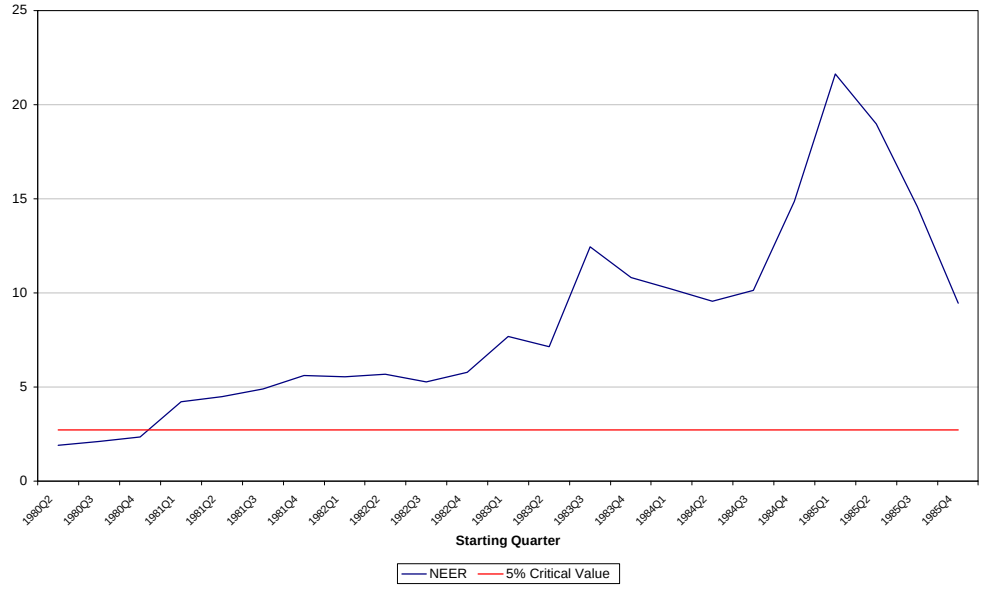
[12] Equation (3) was selected to serve as a benchmark. Equation (6) (with four lags instead of five) was selected as it has the best SIC, while equation (7) had the best adjusted-$R^2$ and AIC.

[13] The result for the 60-observations window for equation (3) is similar. The results for NEER for equation six and seven are also similar. However, for equations (6) and (7), both the 50- and 60-observations rolling-window F-tests for the exclusion of FMB and AINTBK3 are mostly insignificant. This could possibly be attributed to a degree of freedom problem, as the tests for equation (3) were significant.

## Chart 2
## Rolling-Window F-Test for the Exclusion of NEER for Equation Three (50-observations window)*




* the ticks on the horizontal scale correspond to the beginning of each rolling window. The last 'window' covers the period 1985Q4 to 1998Q1.

## Chart 3
## Rolling-Window F-Test for the Exclusion of FMB for Equation Three (50-observations window)

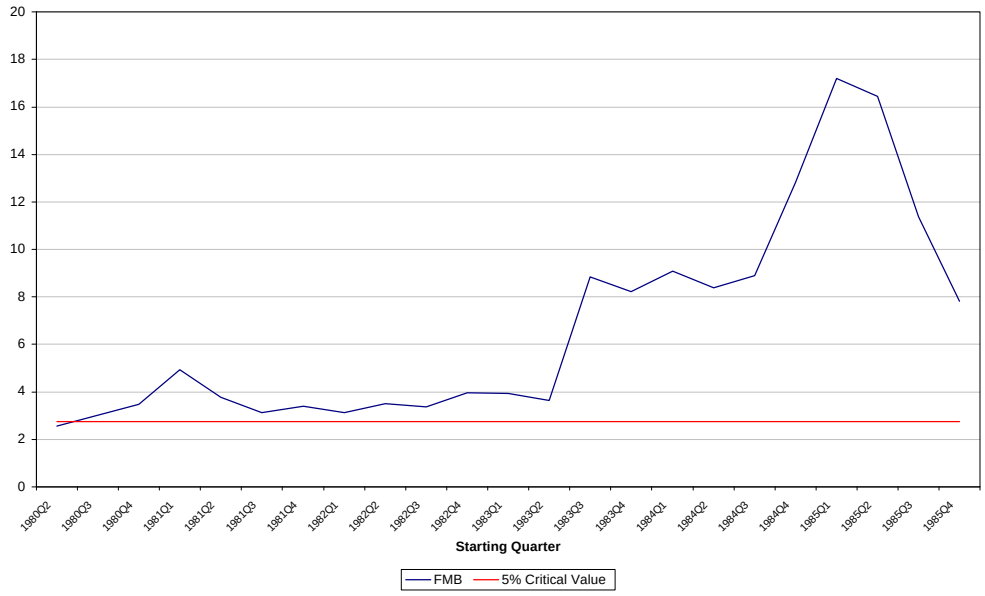
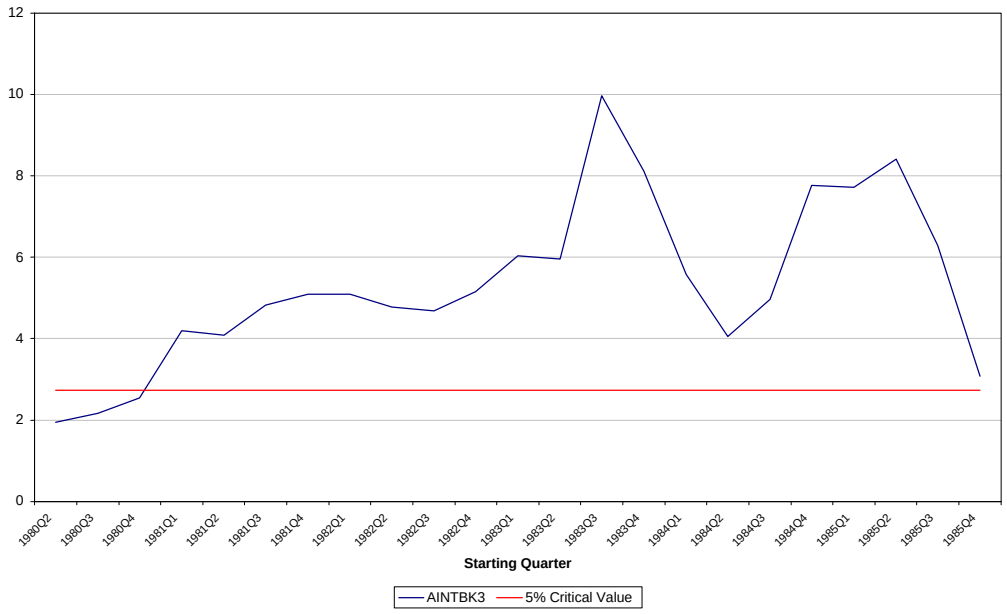


**Chart 4**
**Rolling-Window F-Test for the Exclusion of AINTBK3 for Equation Three (50-observations window)**



## 3 CONCLUSION

3.1 The results of this paper confirm that money (M2) and interest rates have information content for future movements in real GDP beyond that contained in past values of GDP itself. This relationship only establishes itself with a lag. The finding suggest the possibility of making use of the money-income relationship for forecasting purposes, although the relatively long lag structure involved for the interest rate and exchange rate variables, may limit its usefulness for very short-run predictions.

3.2 We had observed at the beginning of the paper that one of the assumptions of the theoretical framework behind our exchange rate centred monetary policy was that money adjusts passively to economic activity. However, the richness of macroeconomic relationships and linkages imply that the particular structure of the economy rests along a continuum between extreme theoretical conceptualisations. The econometric results pertaining to information content of financial variables, reflect this reality without necessarily questioning the relevance of the prevailing theoretical orthodoxy.

3.3 Our findings also provide a strong basis to proceed with a further study to identify and quantify the channels though which various monetary impulses - particularly interest rate and exchange rate changes - may impact on key sectors and expenditure categories in the economy.

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