THE DEMAND FOR MONEY IN PAPUA NEW GUINEA: EVIDENCE FROM COINTEGRATION TESTS*

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1. Introduction

The specification and stability of the money demand function has been extensively researched over the past decade for a number of countries including less developed countries (LDCs). In this process there have been a few noticeable developments in this area: the analysis of the role of money as a buffer stock asset which absorbs unforeseen monetary shocks disturbing the balance between receipts and payments (Cuthberston and Taylor: 1986 and 1989, Goodhart: 1984 and Laidler: 1984); the analysis of shift or stability in the money demand in the 1980s as a result of financial innovations (Hetzel and Mehra: 1989 and Taylor: 1987); and extensive use of techniques of cointegration and error correction in derivation of the money demand equations (Hendry: 1979 and 1986, Gorden: 1984, Miller: 1991, Muscatelli and Hurn: 1992, and Rose: 1985). The objective of this paper is to determine whether there exists a stable and predictable relationship between money balances and economic aggregates, namely, price level, economic activity, interest rates, and nominal effective exchange rate for a small developing economy of Papua New Guinea (PNG) utilising the developments in currency substitution and cointegration. According to my knowledge, there are no other studies on money demand for PNG using this approach. The rest of the paper is organised as follows: in Section 2, a summary discussion on the model and the testing procedure is presented; the empirical evidence of testing for equilibrium relationship between monetary aggregates and economic aggregates, namely, price level, economic activity, interest rates, and nominal effective exchange rate is discussed in Section 3; and finally conclusions are presented in Section 4.

2. Model Specification

It is hypothesised that the following relationship between demand for money and its determinants:

$$M_t = f(P_t, Y_t, R_t, R_t^a) \qquad (1)$$

where M is money in nominal terms, Y is the real income variable, R is the rate of return on money, R^a is the interest rate on alternative assets and P is the price level. With log

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linear specification Equation 1 can be expressed as

$$\log M_t = \alpha_0 + \alpha_1 \log Y_t + \alpha_2 \log P_t + \alpha_3 \log R_t + \alpha_4 \log R_t^a + u_t \qquad (2)$$

where u is the error term, and $\alpha_1, \alpha_2, \alpha \geq 0$ and $\alpha_4 \leq 0$

Equation 2 assumes that the long run demand for nominal money balances positively depends on the price, rate of return on money, and income levels and negatively on the rate of return on alternative assets.

Equation 2 can be respecified to capture the impact of change in the exchange rate by adding the nominal effective exchange rate as an explanatory variable[1].

$$\log M_t = \beta_0 + \beta_1 \log Y_t + \beta_2 \log P_t + \beta_3 \log R_t + \beta_4 \log R_t^a + \beta_5 \log NE_t + w_t \qquad (3)$$

The sign of the coefficient for the nominal effective exchange rate could be either positive or negative. According to the currency substitution literature, the depreciation of domestic currency leads to increase in quantity of money demand implying a negative relationship[2]. The effects of depreciation on money demand could be positive through the expectations of future depreciation thus lessening demand for domestic money[3].

The money demand functions in Equations 2 and 3 are specified in nominal terms, since price homogeneity is to be tested as a long run restriction. In other words, it is to be tested whether $\alpha_2 = 1$ and $\beta_2 = 1$ in Equations 2 and 3 respectively. If the hypothesis of homogeneity is accepted, Equation 2 or 3 can be expressed in real terms.

The choice of variables for money demand equations is always debatable. Questions arise about appropriate monetary aggregates, interest rates and income variables. In this study the money demand equation is estimated for both narrow (M1) and broad money (M3). For the narrow definition of money, the own rate of return of money would be zero and the return on alternative assets can be approximated by the deposit rate[4].

1. For a discussion on exchange rate sensitivity of the demand of money in LDCs, see Bahmani-Oskoose and Malixi (1991).

2. See, Avango and Nadiri (1981), Cuddington (1983) and McKinnon (1982).

3. See, Bahmani-Oskoose and Malixi (1991).

4. In most of earlier studies of LDCs, expected inflation was used as rate of return on alternative assets, due to controls on interest rates. See Aghevli et.al. (1979)

For the Broad definition of money, the deposit rate (DEPR) was used as a proxy for the return of money and the Treasury Bill rate (TBR) is used as the return on alternative assets. Real Gross Domestic Product is used as the income variable (RGDP). The price level and exchange rate are measured by the Consumers Price Index (CPI) and Nominal Effective Exchange Rate (NEER).

Before proceeding with the estimation, the time series properties of the data need to be investigated. The basic question to be answered is whether the variables are stationary[5] or nonstationary. The stationarity of the data is important since if time series are characterised by nonstationarities, then the classic t-test and F-test are inappropriate because the limiting distribution of the asymptotic variance of the parameter estimates is infinite (Fuller, 1985). If a nonstationary time series can be converted to a stationary time series after differencing d times, the series is called integrated of order d (denoted by I (d)). Appropriate tests have been developed by Fuller (1976) and Dickey and Fuller (1979) to test the order integration of a time series. Consider the time series X. In order to test if this series is stationary and if not, to what order it is integrated, first estimate the equation 3.

$$\Delta x_t = b_0 + b_1 x_{t-1} + \sum_{i=1}^{k} b_{1+i} \Delta x_{t-1} + e_t \quad (3)$$

where k is chosen so that the residual e_t is approximately white noise. The hypothesis H_0: $b_1 = 0$ is tested by comparing the calculated t ratio with critical values in accordance to Fuller (1976). If $k = 0$, the test is known as the Dickey-Fuller (DF) test and if $k = 1$ it is known as the Augmented Dickey-Fuller (ADF). If the null hypothesis is rejected, the series X is stationary. If we cannot reject the null hypothesis, the next step is to test whether the first difference is stationary implying $X \sim I(1)$. The same testing procedure can be used after reestimating equation 3 by substituting ΔX for X.

Engle and Granger (1987) have discussed the concept of a long run equilibrium economic relationship using the statistical notion of Cointegration. The vector X of n dimensional time series, each integrated of the same order, say b, is said to be cointegrated of order d if there exists a vector such that $W = \alpha' X$ is I (b- d) $d > 0$. If cointegration occurs, then it must be unique in the bivariate case. Engle and Granger (1987) have suggested a two step estimation procedure for cointegration in the bivariate case. For a multivariate

5. A series X is stationary if its mean, variance and autocovariances are independent of time.

case, if cointegration exists, it will not be unique as there are several equilibrium relationships linking n (> 2) variables. Johansen (1988) and Johansen and Juselius (1990) developed a procedure to examine the question of cointegration for a multivariate setting. The Johansen testing procedure allows us not only to test for the number of cointegrated vectors but also to estimate the cointegration vectors. Furthermore, tests of certain restriction suggested by economic theory, such as sign and size of the estimated elasticities, also may be conducted[6].

3. **Empirical Analysis**

Table 1 reports DF and ADF tests for the stationarity of the logarithms of M1, M3, RGDP, CPI, NEER, TBR and DEPR over the estimated period. For the levels of the series, none rejects the null hypothesis of nonstationarity at the 5 per cent level. After first differencing, each series rejects the null hypothesis of nonstationarity at the 5 per cent level.

Table 1

TESTS FOR STATIONARITY

Variable	Level		Difference	
	DF	ADF	DF	ADF
LM1	− 0.74	− 0.52	− 10.10	− 5.35
LM3	− 1.25	− 1.04	− 5.62	− 3.13
LCPI	− 1.01	− 0.87	− 4.91	− 4.31
LRGDP	− 0.22	− 0.96	− 7.13	− 3.46
LNEER	− 2.10	− 1.18	− 6.08	− 3.29
LDEPR	− 2.12	− 2.39	− 5.33	− 3.93
LTBR	− 2.92	− 2.10	− 6.37	− 4.09

6. For derivation of the Johansen Maximum Likelihood estimator and its method of implementation, see Johansen (1988), Johansen and Juselius (1990), Hall (1989), Muscatelli and Hurn (1992), and Hall and Henry (1988).

Table 2

COINTEGRATION TESTS FOR DEMAND FOR NARROW MONEY

Section A: Variables in the cointegrated system LM1, LCPI, LRGDP, LDEPR

Null Hypothesis	Maximal* Eigen value	Trace*
$r = 0$	18.01 (27.07)	43.60 (47.21)
$r \leq 1$	12.12 (20.96)	25.58 (29.68)
$r \leq 2$	10.86 (14.06)	12.46 (15.41)

Section B: Variables in the cointegrated system LM1, LCPI, LRGDP, LDEPR, LNEER

Null Hypothesis	Maximal* Eigen value	Trace*
$r = 0$	45.99 (33.46)	102.56 (68.52)
$r \leq 1$	30.64 (27.07)	57.08 (47.21)
$r \leq 2$	12.55 (20.96)	26.44 (29.68)
$r \leq 3$	11.36 (14.06)	13.89 (15.41)

Section C: Hypothesis testing of the cointegrating vector in section B $(1.0, \alpha_1, \alpha_2, \alpha_3, \alpha_4)$

Null Hypothesis	LR Test Statistics χ^2 2 d.f.
H_0: $\alpha_1 = 0$	26.19
H_0: $\alpha_2 = 0$	10.30
H_0: $\alpha_3 = 0$	14.29
H_0: $\alpha_4 = 0$	6.76
H_0: $\alpha_1 = 1$	14.51
H_0: $\alpha_2 = 1$	18.66

χ^2 value 0.05 level 2 d.f = 5.99

Section D: Normalised Co-integration Vector (Section B)

(– 1.00, 0.547, 0.658, – 0.297, – 0.464)

* 95% critical values are in brackets.

Table 2 reports the results of the cointegration test on the specification that uses the logarithms of the narrow definition of money, price level, real income, and deposit rate. The two test statistics, LR test based on maximal eigen values and LR test based on the trace of the stochastic matrix, are reported to determine the number of cointegration vectors[7].

The findings reported in section A of Table 2 indicate that the test statistics are unable to reject null hypothesis $r = 0$ with respect to LM1, LCPI, LRGDP and LDEPR. In other words, these results indicate absence of long run relationship among the variables mentioned above. Tseng and Corker (1991) found the same results for Korea, PNG and Thailand.

7. The null hypothesis under the LR maximal eigen value test is H_0: $r \leq r_0$ against H_1: $r = r_0$ while the LR trace test is H_0: $r \leq r_0$ against H_1: $r \geq r_0$. As far as the power of these tests are concerned, the power of LR trace test is lower (Johansen and Juselius: 1990). In all of these test lag structure is chosen ad 4, after the model was tested for residual mis-specification.

Adding the nominal effective exchange rate, changes the results for narrow money. The LR test statistics reject the null hypothesis that there are zero cointegrating vectors against the 5 per cent critical value. Moreover, the test statistics suggest that there are at most two cointegrating vectors for narrow definition of money. However, only the signs of the second vector appeared to make economic meaning.

A number of hypothesis were tested to explore the proportions of the long-run money demand and the results are reported in section C of Table 2. The first set of hypothesis $\alpha_i = 0$, i = 1, 2, 3, 4, 5 are tests of zero restrictions on the coefficients of the cointegration vector. None of the coefficient could be set equal to zero at the 5 per cent level. In other words, all the estimated elasticities in the broad money demand equation are significant at the 5 per cent level. These results are particularly important in the case of the coefficients for interest rates and nominal effective exchange rates, as these results indicate money demand function is sensitive to interest rates and exchange rate changes. This result of exchange rate sensitivity of money demand is consistent with other studies for some LDCs and developed countries[8]. Next two hypothesis are tests of unit price and income elasticities of demand. It is clear from Table 3 that these restrictions could not be imposed in demand for money.

Section D of the Table 2 reports estimated normalised cointegration vector for the narrow money. The result of the normalized cointegration vector is quite interesting since it represents the estimates of the long run elasticities. Our estimated long run income elasticity with respect to M1 is 0.66 and the long run interest and exchange rate elasticities are -0.29 and -0.46 respectively[9].

The results for broad definition of money reported in Table 3, are different than those for narrow money. The test statistics indicate that the hypothesis that there are at most two cointegrating vectors is accepted for broad money. This result is in contrast to the findings for narrow definition of money. The signs of the first vector appeared to be consistent with the expected signs. The results of the reestimated model including nominal effective exchange rate are reported in Section B of Table 3. The results indicate that there are at most 3 cointegrating vectors present in the broad money de-

8. See, Arize (1992) for similar results for Thailand, Bahmani-Oskoose and Malixi (1991) for group of LDCs, Ghosh (1989) for Canada and Ramirez-Rajas (1985) for Argentina, Mexico and Uruguay.

9. It is not possible to compare our results with other LDCs, since the elasticities were calculated for real money in all other studies.

Table 3

COINTEGRATION TESTS FOR DEMAND FOR BROAD MONEY

Section A: Variables in the cointegrated system LM1, LCPI, LRGDP, LTBR, LDEPR

Null Hypothesis	Maximal* Eigen value	Trace*
$r = 0$	50.62 (33.46)	89.48 (68.52)
$r \leq 1$	22.32 (27.06)	38.86 (47.12)
$r \leq 2$	11.45 (20.96)	16.54 (29.68)
$r \leq 3$	5.06 (14.06)	5.04 (15.41)

Section B: Variables in the cointegrated system LM1, LCPI, LRGDP, LTBR, LDEPR, LNEER

$r = 0$	76.33 (39.37)	200.70 (94.15)
$r \leq 1$	62.78 (33.45)	124.36 (68.52)
$r \leq 2$	33.74 (27.06)	61.59 (47.21)
$r \leq 3$	21.41 (20.96)	27.85 (29.68)
$r \leq 4$	6.38 (14.06)	6.43 (15.41)

Section C: Hypothesis testing of the cointegrating vector in section B (1.0, β_1, β_2, β_3, β_4, β_5)

Null Hypothesis	LR Test Statistics χ^2 3 d.f.
H_0: $\beta_1 = 0$	47.69
H_0: $\beta_2 = 0$	39.12
H_0: $\beta_3 = 0$	31.20
H_0: $\beta_4 = 0$	38.43
H_0: $\beta_5 = 0$	31.50
H_0: $\beta_1 = 1$	25.79
H_0: $\beta_2 = 1$	38.69
H_0: $\beta_3 = \beta_4$	38.31

χ^2 value 0.05 level 3 d.f = 7.99

Section D: Normalised cointegration vector in Section B

(– 1.00, 1.09, 0.560, – 0.505, 0.245, – 1.06)

* 95% critical values are in brackets.

mand. However, close examination of the vectors reveals only signs of the first vector appeared to make economic sense.

A number of hypothesis were tested to explore the proportions of the long-run money demand and the results are reported in section B of Table 3. The first set of hypothesis $\beta_i = 0$, i = 1, 2, 3, 4, 5 are tests of zero restrictions on the coefficients of the cointegration vector. None of the coefficient could be set equal to zero at the 5 per cent level. In other words, all the estimated elasticities in the broad money demand equation are significant at the 5 per cent level. These results are particularly important in the case of the coefficients for interest rates and nominal effective exchange rates, as these results indicate money demand function is sensitive to interest rates and exchange rate changes. Next two hypothesis are tests of unit price and income elasticities of demand. It is clear from Table 3 that these restrictions could not be imposed in demand for money.

Section D of the Table 3 reports the normalised cointegrating vector for broad money. This will provide the income, interest rates and exchange rates elasticities for money demand. The reported long run income elasticity for broad money is 0.56, which is marginally lower than the income elasticity for narrow money. Long run own interest rate elasticity and interest rate elasticity for alternative assets are 0.24 and – 0.50 respectively. The long run elasticity of nominal effective exchange rate is – 1.06.

The results reported in this paper have significant implications for estimating money demand equations in PNG. First, the rejection of acceptance of unit price elasticity, suggests that the tradition of modelling money demand as real money demand in PNG is a correct procedure. Second, the rejection of interest rates elasticities are equal in absolute terms indicate that it would not be appropriate to model money demand in terms interest rates differentials. However, inclusion of interest rate levels could create a multicollinearity problem.

There are several policy implications arising from results of this paper. One such policy issue is concern over the selection of a appropriate monetary aggregate, if money were selected as immediate target variable of the monetary policy. Narrow money can not be selected as a target variable as a result of the lack of long run relationship between narrow money and price, income, interest rate and effective exchange rate. On the other hand, the existence of a long run relationship between broad money and price, income, interest rates and exchange rates indicates that a broad money may be more appropriate target. The exchange rate sensitivity of money demand calls for coordinating of monetary and exchange rate policy.

The empirical findings reported in this paper, concerning the own and alternative interest rate effect have policy implications for the effectiveness of monetary aggregates as immediate targets. One policy issue related to the own and alternative interest rate effect is stability of the monetary target strategy.[10] The dynamic stability problem was first recognised by Cagan (1956). Monetary policy influences the nominal interest rates relative to inflation. The level of real interest rates, in turn, impacts on economic activity, inflation, and inflationary expectations. Consider the target strategy of the contracting nominal money supply. If the interest sensitivity is high, it is possible that demand for money may decline to an even greater extent than the real money supply. In these

10. For a discussion on this issue in the Australian context, see Blundell-Wignal and Thorp (1987).

circumstances, constraining the growth of the nominal money supply could be associated with downward pressure on real interest rates adding to inflationary pressure.

These risks greatly reduced if the interest sensitivity of money demand is small or there is an own rate of interest effect. An own interest rate effect is equivalent to reducing the interest sensitivity of money demand since downward pressure on money demand caused by an increased competing interest rate would be, to a large extent, offset by rising money demand associated with the own rate. Where own rate effects are present, containing the growth of monetary aggregate are more likely to be associated with rising real interest rates. The results reported in this paper indicate that the null hypothesis that two interest rate elasticities are equal in absolute terms can be rejected. This indicates that Broad money targeting is likely to be associated with dynamic instability.

The interest rate sensitivity of monetary aggregates relates to the second policy issue: interest rate overkill.[12] The more sensitive the demand for money, more likely the probability of unnecessarily high interest rates. The presence of an own rate effect reduces the extent of real interest rate overkill associated with monetary aggregates as intermediate objectives. Moreover, the rejection of the null hypothesis that two interest rate elasticities are equal in absolute terms indicates that there are risks of interest rate overkill which could destabilise other aspects of economic activities.

The above two results, dynamic instability and interest rate overkill of M3, raises the question of appropriateness of monetary targeting. Should we use other monetary variables as target variables? At present, the Reserve Bank of PNG aims monetary base and non-mining sector credits as immediate target variables of the monetary policy, through the minimum liquid assets ratio, the discount facility, the exchange settlement account and transaction in government securities. Therefore, findings of this paper open the path for future research on the appropriateness of monetary base and non-mining sector credits targeting.

4. Conclusions

In this study an attempt was made to analyse the long run money demand function of a small, open less developed economy, this economy being the PNG economy.

11. For a discussion on this issue in the Australia context, see Blundell-Wignall and Thorp (1987).

Econometric techniques designed to accommodate nonstationary data are used to derive the different elasticities in the money demand. In this context, Johansen's cointegration methodology was used to identify cointegrating vectors for the money demand data. The evidence suggests that variables entering into the demand for narrow money equation may not form a cointegrated system even after the inclusion of the nominal effective exchange rate. In contrast, the results indicate the presence of a long run demand function for broad money when real gross domestic product, interest rates, price level and nominal effective exchange rate are included in the system. All the estimated elasticities proved significant and were correctly signed. In particular, the long-run effect of change in exchange rate on money demand is positive. The results suggest that the modelling money demand as real money demand in PNG is not a correct procedure. Further, interest rate variables play an important role in determining the demand for money in PNG. The evidence from this paper suggests only M3 can be considered as a better candidate for a monetary aggregate indicator. Nevertheless, M3 targeting is likely to be associated with dynamic instability and interest rate overkill.

Appendix

Data Source: All data are quarterly and taken from the following sources:
(a) International Financial Statistics of IMF (various issues).
(b) Quarterly Bulletin of Reserve Bank of Papua New Guinea (various issues).
Quarterly data for Real Gross Domestic Product are not available for Papua New Guinea. In view of this, Gandolfo (1981) method is used to calculate the quarterly RGDP data.

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Abstract

In this study an attempt is made to analyse the long run money demand function of a small, open and less developed economy, this economy being the PNG economy, using Johansen's cointegration methodology. The evidence suggests that the variables entering into the demand for narrow money equation may not form a cointegrated system unless the nominal effective exchange rate is included. In contrast, the results indicate that the presence of a long run demand function for broad money when real gross domestic product, interest rates, price level and nominal effective exchange rate are included in the system. All the estimated elasticities proved significant and were correctly signed. In particular, the long-run effect of change in exchange rate on money demand is positive. The results suggest that the modelling money demand as real money demand in PNG is not a correct procedure. Further, interest rate variables play an important role in determining the demand for money in Papua New Guinea. The evidence from this paper suggests that only M3 can be considered as a better candidate for a monetary aggregate indicator and M3 targeting is likely to be associated with dynamic instability and interest rate overkill.

LA DEMANDE DE MONNAIE EN PNG: DES RESULTATS TIRES D'UN TEST DE COINTÉGRATION

RESUME

Dans cette étude nous essayons, en nous servant de la méthodologie de cointégration de Johansen, d'analyser la fonction de la demande de monnaie à long terme d'une petite économie, ouverte et moins développée, c'est-à-dire celle de PNG. Tout nous porte à croire que les variables qui sont impliquées dans l'équation de la demande de "monnaie au sens étroit" ne formeront pas nécessairement un système cointégré à moins que le taux d'échange nominal effectif y soit compris. Au contraire, les résultats indiquent la présence d'une fonction de la demande de "monnaie au sens large" à long terme quand le produit national brut effectif, le taux d'intérêt et le taux de change nominal effectif sont compris dans le système. Toutes les élasticités estimées se sont révélées signifiantes et marquées correctement. En particulier, l'effet à long terme de changements dans le taux de change sur la demande de monnaie est positif. Les résultats indiquent que l'élaboration de la demande de monnaie en tant que demande de monnaie effective en PNG n'est pas une bonne méthode. Du reste, le taux d'intérêt contribue à déterminer la demande de monnaie en PNG. Nous concluons que M3 peut être considéré comme un bon indicateur monétaire global et que si l'on vise M3 cela mènera sans doute à de l'instabilité et au phénomène de "overkill" dans les taux d'intérêt.