Demand for Money in Papua New Guinea

Tanu Irau
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Abstract

Time series data for the period 1978:Q1 to 2010:Q4 was analyzed to estimate the demand for real broad money (M3) in Papua New Guinea (PNG) with the aim of establishing its determinants and the function's stability. As most time series data are non-stationary, which potentially may lead to the spurious regression problem, individual data series were tested for unit roots using the Augmented Dickey Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests. The tests showed that variables defined in levels are non-stationary but are stationary in first differences, i.e. integrated of order one.

The Engel-Granger method of co-integration and error correction was adopted to model the demand for money in PNG. It was found that there is a long-run co-integrating relationship between real broad money, income, price, financial innovation and the exchange rate. Demand for money is determined by income, financial innovation and the US$/kina exchange rate in the long-run. Interest rate was found to be insignificant in explaining real money demand in PNG in the long-run. Income and price (inflation) influence the demand for money in the short-run.

Table of Contents

1.0 Introduction

A stable money demand function is necessary for monetary policy and a useful instrument for macroeconomic policy. It is therefore essential that policy makers are mindful of the properties of the money demand function and its linkage to the rest of the economy when formulating policy. Given the important link of money demand to the rest of the economy, it has been studied extensively at both the theoretical and empirical levels in many countries.

The study of money demand seeks to establish whether the function is stable for the concerned economy. If the function is stable then its application in monetary policy can exert a predictable influence on the real economy because "the quantity of money is predictably related to a set of variables linking money to the real sector of the economy" (Judd & Scadding, 1982). A stable money demand function hence becomes necessary for monetary policy formulation and a useful instrument of macroeconomic policy.

Though economic theory does not provide a precise mathematical function for the demand for money, there is a general consensus that the log-linear version is the appropriate functional form (Zarembka, 1968). The general specification of the model and the selection of variables relate some monetary aggregate to a scale variable and an opportunity cost variable.

This analysis is motivated by the following observations. Firstly, the Bank of Papua New Guinea (BPNG) formulates and implements monetary policy in the absence of an empirically tested money demand function. Secondly, the demand for money is important in determining the effectiveness of fiscal policy in changing the level of income (Dornbusch & Fisher, 1981). Thirdly, apart from a piece in the International Monetary Fund (IMF) 1993 Article IV Consultation report, Kanari's (1998) in-house discussion paper and Kannapiran (2001), there is no other published work on money demand in PNG.

The objective of the paper is to examine the determinants and stability of the money demand function for PNG.

The paper proceeds as follows. Theories of money demand are briefly covered in section 2. Section 3 provides a review of money demand analysis done for PNG. In section 4, data, methodology and empirics are presented, while results are discussed in section 5. Section 6 concludes the paper and highlights areas for further research.

2.0 Theories of Money Demand

The Classical Theorists' "*equation of exchange*" relates the amount of money in circulation in an economy to the number of transactions and the average price level in a given period. This is done through a proportionality factor called the transactions velocity of circulation; $\mathrm{MV} = \mathrm{PT}$, where M is total quantity of money, V is velocity[1], P is the price level and T being the number of transactions. A feature of the quantity theory of money is that interest rates do not influence the demand for money (Mishkin, 2007). The equation of exchange is an identity where it does not say anything about the direction of change in income when there is a change in the supply of money.

According to Fisher (1911), velocity is determined by the institutions and technological features in an economy that affect the way individuals conduct transactions and it is assumed to be constant in the short-run. This is because it takes time for institutions and technology to change. It is also assumed that income is at the full employment level and is also constant. The quantity theory of money implies that the demand for money is determined by the number of transactions generated by the level of nominal income (price x income) and the institutions and technology in the economy. Classical economists believed in price flexibility whereby if income is relatively fixed in the short-run then money and price are proportional. This means that an increase in the money supply only leads to an increase in the price level and interest rate does not influence money demand.

The Keynesian approach that underpins the traditional IS-LM[2] framework, postulates that the demand for money is a special case where individuals hold money for transaction, precautionary and speculative reasons. The transaction motive stems from the emphasis that money is a medium of exchange and has a stable relationship to the level of income. This is because payments and receipts do not necessarily occur simultaneously. The precautionary reason creates demand for money when individuals are unsure of the payments they might want, or have to make; thus creating a fallback plan for unscheduled expenditure for unforeseen situations. According to Keynes, the speculative motive is really the "*liquidity preference theory of money*", where

[1] Velocity is defined as the average number of times per year (turnover) that a kina is spent buying the total amount of goods and services produced in the economy. In other words, it is total spending (Price x Income) divided by the quantity of money, M, i.e: $= \frac{PY}{M}$.

[2] A model often used as an extremely simple example of general equilibrium in macroeconomics. The IS curve shows the combinations of income (y) and interest rate (r) at which savings and investment are equal. The LM curve shows the combinations of y and r at which the supply of and demand to hold money are in equilibrium. Where the IS and LM curves intersect, both the market for goods and the market for money balances are simultaneously in equilibrium.

uncertainty about the future influences the demand for money. The focus was to identify a link between money and interest rates as interest rate matters in the demand for money – the opportunity cost of holding money. The basic Keynesian money demand function is normally stated as:

$$\left(\frac{M}{P}\right) = f(Y, i) \tag{1}$$

where real money demand $\left(\frac{M}{P}\right)$ is a function of income (Y) and interest rate (i). According to the Keynesians, velocity depends on the interest rate and when it fluctuates a lot so does velocity. For instance, an increase in the interest rate would lead to a decline in money holdings because it would be less profitable to hold money.

Applying the theory of asset demand, Friedman's (1956) modern quantity theory postulates that the demand for money is influenced by the same factors that influence the demand for any other asset. This is expressed as:

$$\left(\frac{M^d}{P}\right) = f\left(Y_p, r_b - r_m, r_e - r_m, \pi^e - r_m\right) \tag{2}$$

where

Y_p is permanent income
r_b is expected return on bonds
r_m expected return on money
r_e is expected return on equity
π^e is expected inflation rate

The modern quantity theory of money basically indicates that the demand for money should be a function of resources (wealth) and expected returns on other assets relative to expected return on money. All the coefficients of the determinants of real money demand are expected to be negative except for income, Y_p.

3.0 Money Demand Studies in Papua New Guinea

A money demand function for PNG was first estimated by the IMF; using quarterly data for the period 1980 to 1990. Based on the conventional partial adjustment model[3], money demand was specified as a log-linear function of real GDP, the inflation rate (π_t), financial innovation[4] and real money lagged one period. The scale variable for the analysis was the real *GDP*, a proxy for transactions relating to economic activity. The inflation rate was used as a proxy for the opportunity cost of holding money. Inaccessibility to financial services in an underdeveloped financial market is seen to be a reason why individuals hold money, so financial innovation was used to capture this effect[5] (BPNG, 2007).

The IMF study established that 98.5% of the variation in the demand for real money balances in PNG is explained by model. The signs on the coefficients were as expected with real money demand positively related to real GDP and money demand in the previous period, and inversely related to inflation and financial innovation. An increase in income results in an increase in the demand for money, all else held constant. Likewise, an increase in money demand in the previous period will lead to an increase in the demand for money in the current period, ceteris paribus. The increase in economic activity requires higher levels of money holdings to facilitate these transactions, hence an increase in the demand for money in the current period. With inflation, money loses its purchasing power and increases the cost of holding it thereby leading to a contraction in money demand. Financial innovation is expected to cause a decline in demand for money, everything else held constant.

An in-house discussion paper by Kanari (1998) followed the IMF's partial adjustment model with an increased number of observations; 1978Q1 – 1997Q4 as the sample period. The results were similar to the IMF's.

Kannapiran (2001) provided a brief review of earlier research on money demand which gave the basis for the estimated money demand function for PNG. He cited a number of money demand studies done for developed and developing countries. Quarterly data for the period 1975 to 1995 were used and the error correction framework was applied as it has proven to be a successful tool in applied money demand research (Sriram, 1999). The study aimed to establish the empirical basis for the conduct of monetary policy by the BPNG. It was found that the demand for money was influenced by real GDP, inflation and money demand in the previous period, while interest rate was found to be insignificant.

[3] See Appendix for a brief discussion on the partial adjustment model.
[4] Financial innovation is defined as the ratio of currency in circulation (cic) to total deposits at the commercial banks. Tseng and Corker's (1991) study on SEACEN[4] member countries confirmed that financial innovation does influence money demand.
[5] Hye (2009) found that financial innovation (defined as the ratio of narrow money and broad money) had significant effect both in the short and long run in the demand for money in Pakistan.

Kannapiran (2001) established that 82% of the variation in the demand for money in PNG was explained by the model. The signs of all the coefficients were as expected and were significant at the 1 percent level of significance with the exception of the interest rate variable. The level of income was found to be the main determinant of the demand for money with an income elasticity of 0.21. According to the Kannapiran study, money demand was stable during the period 1975-1995. However, the study was done before the financial sector reforms in 2000 and since then changes have taken place which warrants a re-assessment of the money demand function.

4.0 Empirics

4.1 Data

This analysis is based on quarterly data for the period 1978-2010, sourced from various issues of BPNG's Quarterly Economic Bulletin (QEB), the Department of Treasury and the National Statistical Office (NSO). The dependent variable is real broad money (M3*)[6]. The scale variable is real GDP while the Consumer Price Index (CPI) and 182-day weighted average Treasury bill rate are proxies for the opportunity cost variable. Mundell (1963) argued that in addition to interest rate and income, the demand for money is likely to depend on the exchange rate, hence the inclusion of the US/kina exchange rate to see if this is the case in PNG. The coefficient for the exchange rate is expected to be either positive or negative. Arango and Nadiri (1981) argue that a depreciation of the domestic currency (an appreciation of foreign currency) increases the domestic currency value of foreign securities held by domestic residents. If this increase is perceived as an increase in wealth, the demand for domestic currency by domestic residents could increase, hence a positive coefficient. In contrast, Bahmani-Oskooee and Poorheydarian (1990) argued that when the domestic currency depreciates, there could be expectation of further depreciation. This could induce the public to increase holdings of foreign currency by drawing down their holdings of domestic money.

Following the IMF model, the ratio of currency in circulation to total deposits (placed at commercial banks) is included as a proxy for financial innovation. An alternative proxy for financial innovation is to include a trend variable in the model but this is not considered in this analysis. It should be noted that PNG's NSO only

[6] Broad money supply (M3*) in PNG comprises narrow money (M1*) plus quasi-money.

compiles annual GDP and so the quarterly series was derived from the annual series by employing a simple interpolation method (frequency conversion from low to high[7] in Eviews. Tables A1 and A2 in the Appendix present the descriptive statistics and the results of correlation analysis. The correlation analysis shows that real broad money is related to the selected explanatory variables. With the exception of the interest rate variable, the correlations are statistically significant at the 1% level of significance.

4.2 Unit Root Test[8]

Before testing for no co-integration, unit root test is undertaken to make certain that the variables are integrated of the same order, in this case integrated of order one, I(1). Unit root tests such as the ADF, Phillips-Perron and KPSS[9] are now a standard procedure for testing for the order of integration of the variables. Figures A1 and A2 (see Appendix) plot the variables defined in levels and first differences, respectively, as an informal test for stationarity (Takaendesa, 2006).

The ADF tests are based on the following autoregressive (AR) models:

$$\Delta x_t = \mu + \rho x_{t-1} + \sum_{i=1}^{k} \theta_i \Delta x_{t-i} + \varepsilon_t \qquad (3)$$

$$\Delta x_t = \mu + \delta t + \rho x_{t-1} + \sum_{i=1}^{k} \theta_i \Delta x_{t-i} + \varepsilon_t \qquad (4)$$

$$\Delta x_t = \rho x_{t-1} + \sum_{i=1}^{k} \theta_i \Delta x_{t-i} + \varepsilon_t \qquad (5)$$

where k = the number of lags selected and t = time period

The null hypothesis of a unit root is rejected in favor of the alternative of level stationary if rho (ρ) in equations 3, 4 and 5 are significantly different from zero. For this study, the ADF tests in levels use equation (4) because trends are apparent except for the interest rate series while equation (3) is used for the first differences. ADF unit root

[7] This method fits a quadratic polynomial for each observation of the low frequency series, and then uses this polynomial to fill in all observations of the high frequency series associated with the period. The quadratic polynomial is formed by taking sets of three adjacent points from the source series and fitting a quadratic so that the average of the high frequency points matches the low frequency data actually observed. For most points, one point before and one point after the period currently being interpolated are used to provide the three points. For end points, the two periods are both taken from the one side where data is available (see EViews User's Guide I, pp. 119).

[8] See Appendix for a simplified ADF procedure.

[9] The ADF test often suffers from low power. That is, probability that they lead to rejecting the null hypothesis of unit root is low hence leading to the conclusion that there are unit roots where there are not. The KPSS test is a way to circumvent this problem is to test the null hypothesis that there is no unit root against the alternative that there is a unit root.

test for data defined in first differences excludes the time trend as no trend is apparent. The computed ADF test statistics for the levels and first differences are presented in Table 1. The results indicate that the variables defined in levels[10], where the null hypothesis of unit root (non-stationary) cannot be rejected at the 5% level of significance, but the null that their first differences have unit roots is clearly rejected. Therefore, it is concluded that the variables defined in levels are integrated of order one, I(1) and can be modeled with the vector auto-regression (VAR) if the co-integration test does not reject the null hypothesis of no co-integration. An error correction (or VEC approach) would be appropriate if the variables are found to be non-stationary and co-integrated. The results from the KPPS unit root test confirm that variables in levels are non-stationary but stationary in first difference, at the 1% level of significance.

Table 1: Unit Root Test

Variable	Augmented Dickey-Fuller test		Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test statistic	
	Level	1st Difference	Level	1st Difference
lrm3	-1.28	-7.06***	0.140	0.141
lry	-2.20	-8.13***	0.088	0.057
l*p*	-1.50	-9.24***	0.214	0.128
fin	-2.55	-6.19***	0.176	0.076
int	-3.25*	-8.09***	0.184	0.111
xr	-1.16	-11.10***	0.118	0.141
	Critical Values[11]			
1%	**-3.48**	**-4.03**	**0.216**	**0.739**
5%	**-2.88**	**-3.44**	**0.146**	**0.463**
10%	**-2.58**	**-3.15**	**0.119**	**0.347**

Note:
*** 1% level of significance
** 5% level of significance
* 10% level of significance

[10] Data transformed into logarithms only smooth the series but does not solve for stationarity.

[11] The critical values for the ADF test are taken from R. Davidson and J.G MacKinnon (1993), Estimation and Inference in Econometrics, New York, Oxford University Press, p. 708. Critical values for the KPPS test are from *Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1).

The variables in Table 1 are defined as:

l*rm3:* natural log of real broad money
l*ry:* natural log of real gross domestic product
l*p:* natural log of consumer price index
fin: financial innovation (cic[12]/deposits)
int: weighted average interest rate on 182-day Treasury bills (%)
xr: kina exchange rate against the US dollar (USD/PGK)

4.3 Co-integration and Error Correction

Developments in both the theoretical and technological levels have led to the concept of co-integration and error-correction models (ECM) becoming increasingly popular as they appear to provide better results. Co-integration deals with the relationships amongst a set of non-stationary time series data. If a set of variables are co-integrated, the effects of a shock to one variable spreads to the others, possibly with time lags, so as to preserve a long-run relationship between the variables. The ECMs have proven to be one of the most successful econometric tools in applied money demand research. This type of formulation is a dynamic error-correction representation in which the long-run equilibrium relationship between money and its determinants is entrenched in an equation that captures short-run variation and dynamics (Kole and Meade, 1995). The ECM is shown to contain information on both the short and long-run properties of the model with disequilibria as a process of adjustment to the long-run model.

To determine whether real money balance in PNG has a long-run equilibrium relationship with the explanatory variables, the Engel and Granger (1987), often referred to as the EG approach is adopted. As a starting point and following Kannapiran (2001)[13], the EG approach is used to estimate the basic Keynesian money demand function (equation 1). The results are presented below:

$$\mathrm{l}rm3_t = -8.70 + 1.69\mathrm{l}ry_t + 0.20int_t \qquad (6)$$

(t-stat) (-14.12)*** (21.41)*** (0.67)

R^2 = 0.78 Adjusted R^2 = 0.77 SER = 0.17 DW = 0.13

F = 232.20 (p-val = 0.000)

[12] As defined on page 7, footnote 4.

[13] Slightly varied with the inclusion of additional explanatory variables and the selected number of lags.

Note:

*** represents 1% level of significance

** represents 5% level of significance

* represents 10% significance level

The unit root test on the residual from equation (6) showed the following:

$$\Delta\varepsilon_t = -0.06\varepsilon_{t-1} + 0.06\Delta\varepsilon_{t-1} \qquad (7)$$

(-2.09) (0.84)

The t-statistic for rho (ρ) is equal to -2.09 in equation (7) is greater than the 1%, 5% and 10% critical values of -3.39, -2.76 and -2.45 respectively and therefore we fail to reject the null hypothesis of no co-integration and conclude that equation (1) is a non-co-integrating relationship. As such, the ECM cannot be applied. Since the null hypothesis of no co-integration cannot be rejected, an alternate econometric model is estimated where the long-run demand for real broad money is specified as:

$$\mathrm{l}rm3_t = a_0 + \alpha_1 \mathrm{l}ry_t + \alpha_2 int_t + \alpha_3 fin_t + \alpha_4 xr_t + a_5 \mathrm{l}p_t + \varepsilon_t \qquad (8)$$

The specified econometric model in equation (8) is a potential long-run co-integrating relationship. If the residuals from the ordinary least squares (OLS) regression (equation (8)) are found to be stationary, that is, $\varepsilon_t \backsim I(0)$, (but only if each of the underlying series is integrated of order 1, I(1) then it can be concluded that equation (8) is a co-integrating relationship. This is estimated with the two-step Engel-Granger method, where the residuals from the static regression, equation (8), is included as an explanatory variable in equation (9), to determine the speed of adjustment (θ) to its long-run equilibrium. The general error correction representation of equation (8) is:

$$\Delta \mathrm{l}rm3_t = \mu + \delta_1 \mathrm{l}ry_t + \delta_2 int_t + \delta_3 fin_t + \delta_4 xr_t + \delta_5 \mathrm{l}p_t + \sum_{i=1}^{k} \varphi_i \, \Delta \mathrm{l}rm3_{t-i} + \sum_{i=0}^{k} \gamma_i \, \Delta \mathrm{l}ry_{t-i} + \sum_{i=0}^{k} \vartheta_i \, \Delta int_{t-i} + \sum_{i=0}^{k} \omega_i \, \Delta fin_{t-i} + \sum_{i=0}^{k} \sigma_i \, \Delta xr_{t-i} + \sum_{i=0}^{k} \tau_i \, \Delta \mathrm{l}p_{t-i} - \theta EC_{t-1} + u_t \qquad (9)$$

where k = 1 – 4 lags

Table 1 shows the results of the long-run money demand relationships.

Table 1: Regression Results (long-run models)

Variable	Model 1	Model 2	Model 3
a_0	-4.291 (-3.729)***	-3.870 (-3.713)***	-2.876 (-2.980)***
$\mathrm{l}ry_t$	0.923 (6.267)***	0.950 (6.617)***	0.890 (5.986)***
int_t	0.597 (2.185)**	0.490 (2.042)**	…..
fin_t	-8.108 (-8.995)***	-8.208 (-9.191)***	-8.444 (-8.906)***
xr_t	0.412 (3.444)***	0.319 (6.110)***	0.271 (2.652)***
$\mathrm{l}p_t$	0.066 (0.857)	…..	-0.009 (-0.135)
R^2	0.873	0.872	0.868
Adjusted R^2	0.868	-0.868	0.864
SER	0.132	0.132	0.134
F-statistic	173.530	217.148	209.500
AIC	-1.161	-1.70	-1.139
SC	-1.03	-1.126	-1.030
Residual-based Co-integration test: rho (ρ)	-3.52	-3.50	-3.40

The results of the long-run models 1 and 2 have the expected signs on the income, financial innovation and exchange rate but the opportunity cost variables have the incorrect signs. As such these are discarded and model 3 is chosen as the appropriate long-run model. The residual-based ADF unit root test for no co-integration (model 3) showed the following results:

$$\Delta\varepsilon_t = -0.25\varepsilon_{t-1} - 0.33\Delta\varepsilon_{t-1} \qquad (10)$$

(t-stat) (-3.40)*** (-4.05)***

For the selected long-run model (3), the value of rho in equation (10) is -3.40, which is less than the critical value at the 1% level of significance (-3.39) and therefore we reject the null hypothesis of no co-integration and conclude that equation (8) is indeed a long-run co-integrating relationship. The results of the over-parameterized general ECM representation (equation 9) are shown in the appendix (Table A3). A parsimonious model is estimated after sequentially omitting the insignificant variables and the results are shown in Table 2.

Table 2: Regression Results (parsimonious model)

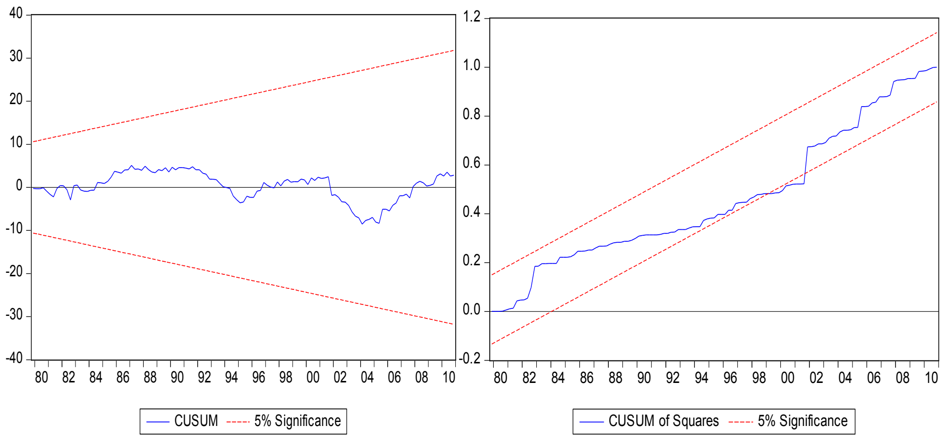
Variable	Coefficient	Std. Error	t-Statistic	Probability
$\mathrm{l}ry_t$	0.01	0.00	6.99	0.000
Δlp_t	-1.24	0.20	-6.14	0.000
Δlp_{t-2}	-0.68	0.20	-3.40	0.001
EC_{t-1}	-0.09	0.03	-2.83	0.005
R^2	0.327			
Adjusted R^2	0.311			
SER	0.044			
Diagnostic Tests				
Serial Correlation	*H_0: no autocorrelation; H_1: autocorrelation*			
Breusch-Godfrey LM Test				
AR(1)	F-stat = 0.859 Prob. F(1, 124) = 0.356 [fail to reject H_0]			
AR(12)	F-stat = 1.41 Prob. F(12, 113) = 0.335 [fail to reject H_0]			
Durbin-Watson	2.160 [no autocorrelation]			
Heteroskedasticity	*H_0: homoskedatsic; H_1: heteroskedastic*			
Breusch-Pagan-Godfrey (e^2 = c dp dlry(-2) e(-1))	F-stat = 0.373 Prob. F(3, 125) = 0.828 [fail to reject H_0]			
White (e^2 = c dp^2 $dlry(-2)^2$ $e(-1)^2$)	F-stat = 0.403 Prob. F(3, 125) = 0.806 [fail to reject H_0]			

Stability Ramsey RESET dlm3 c dp lry(-2) e(-1) $dlm3^2$	*H_0: no specification error; H_1: specification error* F-stat = 0.006 Prob. (0.939) [fail to reject H_0]

Stability Test

As highlighted by Laidler (1993) and noted by Bahmani-Oskooee (2001), some of the problems of instability are due to inadequate modeling of the short-run dynamics indicating departures from the long-run relationship. Hence, it is useful to incorporate the short-run dynamics for constancy of long-run parameters. In view of this, the CUSUM and CUSUMSQ tests proposed by Brown et al (1975) are applied. The CUSUM test is based on the cumulative sum of recursive residuals based on the first set of *n* observations. It is updated recursively and plotted against the break points. If the plot of CUSUM statistic is within the 5% significance level, then estimated coefficients are said to be stable. Similar procedure is used to carry out the CUSUMSQ test that is based on the squared recursive residuals. Graphical presentation of these two tests is provided in Figures 1 for the parsimonious model. The tests show that there is no significant evidence of coefficient instability.

Figure 1: Cumulative sum of residuals



5.0 Results and Interpretation

The results of the basic Keynesian long-run money demand function showed that only income was significant in explaining the demand for money but not the selected opportunity cost variable, the 182-day Treasury bill interest rate. These results are consistent with the findings by the IMF (1993) and Kannapiran (2001). The signs of the coefficients are as expected with income having a positive relationship with money demand and the interest rate having an inverse relationship (negative coefficient). However, when the residual series of the basic model was tested for co-integration, the null hypothesis of no cointegeration was not rejected and therefore an ECM could not be specified. An alternate long-run model was estimated which included additional explanatory variables (equation 8) and the ECM specification in equation 9.

5.1 Long-Run Elasticity

The results of the estimated long-run model show that the income elasticity is around 0.9, higher than the estimates by IMF and Kannapiran but very much in line with most money demand studies for developing countries. The income elasticity suggests that the demand for money in PNG has been growing less than proportional of the growth in real income. This implies that a 1 percent increase in income will lead to an increase in demand for money by 0.9 percent, (or a 10 percent increase in income results in money demand increasing by 9 percent) everything else held constant. The *t*-statistic of 5.99 is statistically significant at the 1% level. Financial innovation and the US$/kina exchange rate were also found to be significant at the 1% significance level while the general price level was insignificant in explaining the demand for money in PNG in the long-run.

A unit increase in the price level leads to a contraction in the demand for money by 0.01 percent, all else held constant. This finding differs significantly from the IMF's and Kannapiran's results of 0.97 and 11.39, respectively. As postulated by money demand theory, rising prices erode the purchasing power of money and therefore consumers tend to substitute money holdings for alternative assets. However, the lower price coefficient is explained by the fact that a large proportion of the population in PNG has limited access to investment opportunities, particularly government securities and real assets and therefore would not necessarily reduce their money holdings by a significant proportion when there is a price increase.

Financial innovation was found to be statistically significant with a unit change resulting in around 8 percent decline in demand for money, ceteris paribus. Lieberman (1977) argued that increased use of credit, better management of income and expenditures, more intensive use of money substitutes, and more efficient payment systems will tend to reduce the demand for money over time. Ochs and Rush (1983) suggested that once innovations that economize on the use of currency have occurred, the impact on the demand for currency is likely to be permanent since these innovations require capital investments with very substantial sunk costs but low operating costs.

A 1% appreciation in the US$/kina exchange rate results in the demand for money increasing by 0.27 percent. This is in line with the argument by Arango and Nadiri (1981) that a depreciation of the domestic currency (an appreciation of foreign currency) increases the domestic currency value of foreign securities held by domestic residents. When this increase is seen as an increase in wealth, the demand for domestic currency by domestic residents could increase, therefore a positive coefficient.

5.2 Short-run Dynamics

Equation 9 is an over-parameterized general error correction model with lags in differences. It is clear that most of the lagged variables are insignificant. Taking a general-to-specific approach, the insignificant variables are omitted sequentially in order to select a parsimonious short-run model. The parsimonious model shows that the demand for real broad money in the short-run is determined by income level in the current period and change in the price level and lagged two quarters. The signs on the coefficients are as expected with income having a positive relationship and the price level having a negative relationship. Income and the opportunity cost variable (price) are statistically significant at the 1 percent level of significance. In the short-run, a one percent increase in income causes demand for money to increase by 0.01 percent, everything else held constant. A unit increase in the change in general price level results in a decline in the demand for money by 1.2 percent while a change in the price level lagged two quarters cause money demand to fall by 0.68 percent, ceteris paribus.

The error correction term has a coefficient of 0.09 with the appropriate negative sign, as is required for dynamic stability and is statistically significant at the 5% level of significance. The error correction term provides evidence that money demand adjustments occur to maintain equilibrium, and these adjustments account for a share of the explained variation in the estimated money demand equation. The estimated coefficient indicates that 9 percent of the disequilibrium in the previous quarter is corrected in the current quarter and the long-run equilibrium is restored in eleven quarters.

6.0 Conclusion

The analysis based on the variant of the basic Keynesian money demand function shows that there is a long-run co-integrating relationship between real broad money and the selected explanatory variables (real income, price, exchange rate and financial innovation). Real income, financial innovation and the US$/kina exchange rate are significant at the 1% level in the long-run. Interest rate is found to be insignificant in the long-run. It is found that the main determinants of money demand in PNG are income, prices (inflation in particular) and financial innovation, which is consistent with the earlier studies. In the short-run, inflation and income are significant at the 1% level. The significance of income and financial innovation in the long-run imply that income and financial innovation do not necessarily change overnight but take time and therefore in the short-run would not have a significant influence on the demand for money but are the main determinants in the long-run.

The CUSUM and CUMSQ tests confirm that demand for money in PNG has been stable during the period 1978Q1 to 2010Q4. The function being stable implies that its application in monetary policy can exert a predictable influence on the real economy. A stable money demand function hence becomes necessary for monetary policy formulation and a useful instrument of macroeconomic policy.

Lack of appropriate and reliable time series data is a problem and hence a short coming for this analysis. The interpolated quarterly GDP data may not be a true reflection of the actual outcomes and therefore the results may be misleading. An option would be to use quarterly GDP derived by Lahari et al (2009) or construct such a series using the same techniques. In addition, the proxy for financial innovation may not be appropriate and so alternative proxies have to be established and data on such a proxy collected/constructed. Similarly, an appropriate market determined interest rate should be included in the model.

7.0 Appendix

Table A1
Descriptive Statistics

	Real M3	Real GD...	CPI	182-day TBill Rate	Financial Innovation	USD/PGK
Mean	1.756	6.051	5.782	1.104	0.113	0.809
Median	1.813	6.078	5.571	1.098	0.107	0.948
Maximum	2.517	6.442	6.970	1.253	0.186	1.553
Minimum	1.075	5.695	4.641	1.011	0.054	0.249
Std. Dev.	0.365	0.191	0.714	0.051	0.034	0.419
Skewness	0.049	0.066	0.172	0.899	0.367	0.065
Kurtosis	2.450	1.998	1.652	3.407	2.348	1.556
Jarque-Bera	1.717	5.613	10.638	18.683	5.307	11.562
Probability	0.424	0.060	0.005	0.000	0.070	0.003
Sum	231.768	798.727	763.250	145.746	14.868	106.743
Sum Sq. Dev.	17.431	4.800	66.722	0.346	0.147	23.008
Observations	132	132	132	132	132	132

Table A2
Correlation Analysis

Correlation t-Statistic Probability	Real M3	Real GDP	CPI	182-day TBil...	Financial in...	USD/PGK
Real M3	1.000 ----- -----					
Real GDP	0.884 21.586 0.000	1.000 ----- -----				
CPI	0.717 11.736 0.000	0.833 17.187 0.000	1.000 ----- -----			
182-day TBill rate	-0.101 -1.163 0.247	-0.145 -1.676 0.096	-0.046 -0.528 0.598	1.000 ----- -----		
Financial innova...	-0.896 -23.037 0.000	-0.900 -23.546 0.000	-0.863 -19.435 0.000	0.076 0.867 0.387	1.000 ----- -----	
USD/PGK	-0.648 -9.710 0.000	-0.773 -13.914 0.000	-0.960 -39.099 0.000	-0.112 -1.280 0.203	0.823 16.549 0.000	1.000 ----- -----

Table A3
Over-parameterised ECM

Dependent Variable: D(LRM3)
Method: Least Squares
Date: 11/27/14 Time: 10:41
Sample (adjusted): 1979Q2 2010Q4
Included observations: 127 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.047886	0.580269	-1.805861	0.0740
LRY	0.187849	0.092634	2.027869	0.0453
FIN	0.899742	0.614396	1.464434	0.1463
LCPI	-0.018340	0.030752	-0.596384	0.5523
XR	-0.029782	0.045449	-0.655280	0.5138
D(LRM3(-1))	-0.251465	0.107829	-2.332064	0.0218
D(LRM3(-2))	-0.078143	0.108370	-0.721072	0.4726
D(LRM3(-3))	-0.070737	0.101584	-0.696343	0.4879
D(LRM3(-4))	-0.084225	0.082093	-1.025972	0.3075
D(LRY)	0.171828	0.330791	0.519445	0.6046
D(LRY(-1))	-0.306179	0.339106	-0.902903	0.3688
D(LRY(-2))	0.326582	0.348707	0.936553	0.3513
D(LRY(-3))	-0.215109	0.340694	-0.631386	0.5293
D(LRY(-4))	-0.194443	0.332134	-0.585435	0.5596
D(FIN)	-2.082185	0.688885	-3.022543	0.0032
D(FIN(-1))	-2.226443	0.832894	-2.673140	0.0088
D(FIN(-2))	-1.974946	0.712362	-2.772391	0.0067
D(FIN(-3))	-1.293464	0.633136	-2.042949	0.0438
D(FIN(-4))	-0.312843	0.528278	-0.592194	0.5551
D(LCPI)	-1.005578	0.428063	-2.349137	0.0208
D(LCPI(-1))	-0.779925	0.453137	-1.721170	0.0884
D(LCPI(-2))	-0.564445	0.443082	-1.273906	0.2057
D(LCPI(-3))	-0.104029	0.430856	-0.241448	0.8097
D(LCPI(-4))	-0.263828	0.435898	-0.605252	0.5464
D(XR)	0.215499	0.126951	1.697494	0.0928
D(XR(-1))	0.183124	0.125694	1.456904	0.1484
D(XR(-2))	0.013327	0.123465	0.107939	0.9143
D(XR(-3))	-0.239620	0.123619	-1.938383	0.0555
D(XR(-4))	0.001814	0.123161	0.014731	0.9883
E7(-1)	-0.023620	0.047400	-0.498307	0.6194

R-squared	0.474227	Mean dependent var	0.010309
Adjusted R-squared	0.317037	S.D. dependent var	0.053270
S.E. of regression	0.044023	Akaike info criterion	-3.205242
Sum squared resid	0.187989	Schwarz criterion	-2.533387
Log likelihood	233.5329	Hannan-Quinn criter.	-2.932276
F-statistic	3.016903	Durbin-Watson stat	1.980209
Prob(F-statistic)	0.000027		

Partial Adjustment Model

The partial adjustment model comprises of a static part which describes how the desired amount is determined and the dynamic partial adjustment process:

$$y_t^* = a_0 + a_1 x_t + u_t \qquad \text{(A1)}$$

$$y_t - y_{t-1} = \mu(y_t^* - y_{t-1}) \qquad \text{(A2)}$$

where y^* is the desired level of *y*.

By substituting the expression for y^* (A1) into (A2) we obtain equation A3:

$$y_t - y_{t-1} = \mu(a_0 + a_1 x_t + u_t - y_{t-1})$$

$$y_t = \mu a_0 + \mu a_1 x_t + \mu u_t - \mu y_{t-1} + y_{t-1}$$

$$y_t = \mu a_0 + \mu a_1 x_t + \mu u_t - \mu y_{t-1} + y_{t-1}$$

$$y_t = a_0 \mu + (1-\mu) y_{t-1} + \mu a_1 x_t + \mu u_t \qquad \text{(A3)}$$

We can estimate equation A3 as a general autoregressive distributed lag (ARDL) model as follows:

$$y_t = \beta_0 + \beta_1 y_{t-1} + \beta_2 x_t + \beta_3 x_{t-1} + v_t \qquad \text{(A4)}$$

In this case, the following restriction would be imposed if partial adjustment occurred:

$$\beta_3 = 0$$

In addition we could get estimates of the parameters in the original equation containing the desired level of *y*, as well as the adjustment parameter μ. In the above case:

$$\beta_1 = (1-\mu) \Rightarrow \mu = (1-\beta_1)$$

$$\beta_2 = a_1 \mu$$

$$\beta_0 = a_0 \mu$$

The parameter μ measures the speed of adjustment and lies between 0 and 1. The closer it is to 1 the faster the speed of adjustment.

Figure A1: Variables in Levels

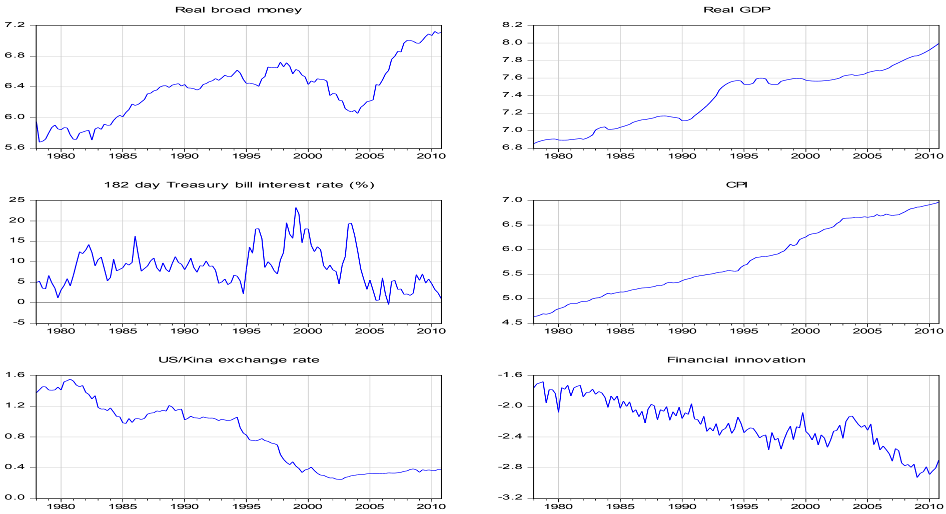
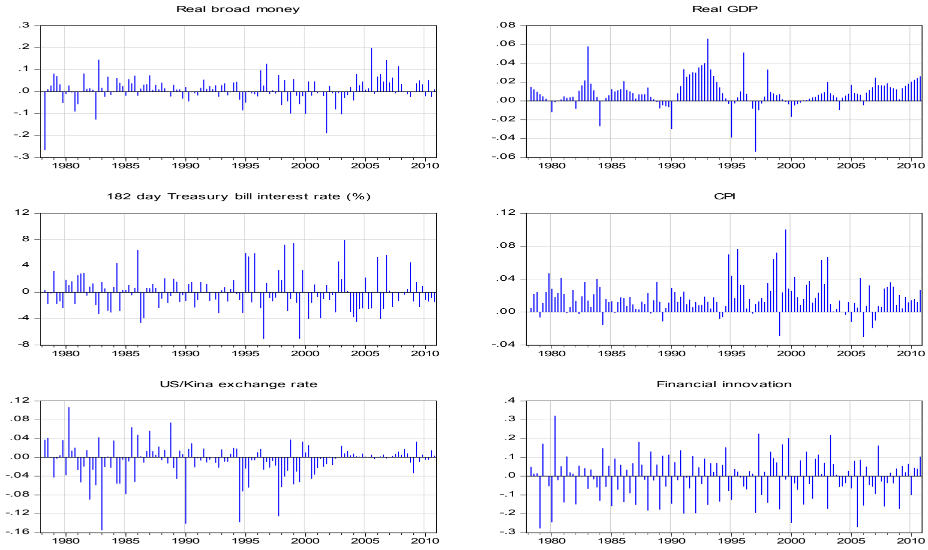


Figure A2: Variables in First Difference



The ADF test procedure is as follows:

Hypothesis:

Null hypothesis: $H_0: \rho = 0 \rightarrow$ unit root (non-stationary)

Alternative hypothesis: $H_1: \rho \neq 0 \rightarrow$ no unit root (stationary)

Decision:

Do not reject H_0 if the calculated ADF test statistic $>$ the critical value for the desired level of significance (normally at 1% or 5%).

Conclusion: Variable is non-stationary.

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