Studies on the Economy of Papua New Guinea

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Preface

It is with great pleasure we present this publication, a collection of papers written by select graduate staff at the Bank of Papua New Guinea (BPNG). Each paper began its life as part of an econometrics course held at BPNG between June and August 2012. As part of this course, participants were required to produce a small, independent research project, which brought together the various techniques and concepts covered in the course, as well as given participants an opportunity to improve their analytic, written and presentational skills. Participants were advised to choose topics that closely mirrored their areas of work. Eli and Mark work on monetary policy, and hence chose interest rate pass-through and the money multiplier respectively. Ludwig works on real sector analysis, and hence chose a project focusing on sales in various industries, whilst Ishmel, as a recent graduate, chose balance of payments to complement the other projects.

Many of the results from the projects undertaken through this course were subsequently incorporated into two newly constructed macroeconomic tools at BPNG; firstly, the Financial Programming and Policies (FPP) framework, and secondly, the Forecasting and Policy Analysis System (FPAS). Both were developed by BPNG and Mr Jan Gottschalk, macroeconomic advisor based at the Pacific Financial Technical Assistance Centre (PFTAC), a regional branch of the International Monetary Fund (IMF). For instance, Eli's work on interest rate pass-through was used to build the interest rate block in the FPAS, whilst Ishmel's work helped create agricultural export forecasts, linked to prices, within the FPP.

Following on from the course, it was suggested that a few of these projects should be expanded on and collected together into a working paper, to be published through the BPNG Working Papers series. In choosing which papers to include in the current publication, the editors considered not only the quality of the initial research project, but also their coherence as a collective article. As such, the four papers chosen cover the monetary, real and external sectors.

It should be noted that, whilst these papers attempt to adhere to the highest levels of qualitative and quantitative accuracy, they do not aspire to being ground-breaking or original in scope. They are simply attempts by graduate staff, for whom the econometric and theoretical concepts involved were entirely foreign prior to undertaking this research, to practice and hone their skills as applied economists by addressing simple yet relevant issues. Publishing the papers hopefully gives the reader an insight into the type of issues considered within BPNG.

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BANK OF PAPUA NEW GUINEA

Part 1

Linking Sales in Manufacturing and Wholesale

Linking sales in the manufacturing and wholesale sectors: an error-correction approach

Ludwig Aur Aba*

May 2013

1 Introduction

The manufacturing sector has benefited from the developments and growth in other sectors of the economy, and establishing the relationships empirically between the different sectors of the economy has been on the drawing board for some time. A number of non-technical exercises undertaken generated limited results. One obvious contributor to the growth in the manufacturing sector is the wholesale sector, a distributive network, which to some extent captures the level of demand in the economy, and in turn influences the sales in the manufacturing sector. Therefore, the activity in the wholesale sector affects the level of activity in the manufacturing sector, to a certain degree. This project aims to identify, test and establish empirically the short and long-run relationship between the manufacturing and wholesale sectors, and if successful will apply the same method to the other sectors of the economy. From observations and the eyeballing results, there is a positive relationship between the variables and both variables are trending upwards. This project will follow similar papers such as [Nkang et al, 2006] and [Aba et al, 2012] on the process of estimating an error correction model (ECM).

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2 Data

The data source for this project is the nominal value of sales from the Bank of Papua New Guinea's (BPNG) quarterly Business Liaison Surveys (BLS) from 2001 to 2012. Sales revenue from the BLS are used as proxies for the activity in both the manufacturing and wholesale sectors.

3 Methodology

3.1 Outline of approach

$$lman\_nom = \beta_1 + \beta_2 lwho\_nom + u_t, \quad (1)$$

where $lman_nom$ is the nominal value of sales in the manufacturing sector in logs, $lwho_nom$ is nominal value of sales in the wholesale sector in logs, β_1 and β_2 are coefficients, and u_t is an error term. A priori, we expect $\beta_2 > 0$, as we expect a positive relationship between sales in the two sectors.

3.2 Eyeballing

Graphing the two variables indicate some degree of relationship between them and are trending together in the long run. The eyeballing results indicate the presence of a trend for both variables, with a positive relationship and probably with lags between the manufacturing and wholesale sectors.

3.2.1 Real versus nominal

Figures 2 and 3 show that real sales after adjusting for inflation, for both the manufacturing and wholesale sectors follow similar trend as the nominal sales and does not deviate significantly. Therefore, the nominal value of sales for the manufacturing and wholesale sectors were used.
For full details of unit root test results, see Appendix A. To summarize the results, both the Augmented Dickey-Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests showed that wholesale is integrated of order 1, or I(1). The results for wholesale, however, were less consensual. At the 5% level, the ADF and Phillips Perron tests find the variable to be stationary, whereas the KPSS and the Elliott-Rothenberg-Stock tests find the variable to be non-

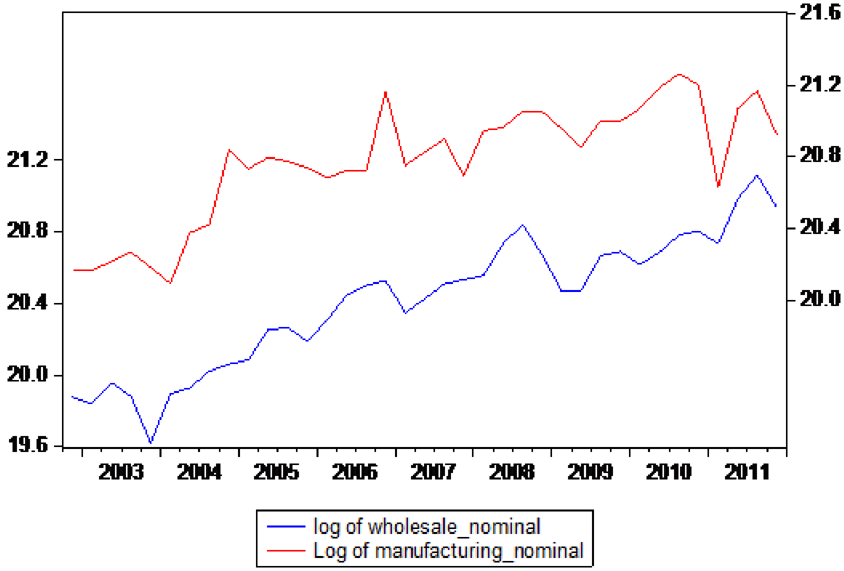

Figure 1: Graphing the variables

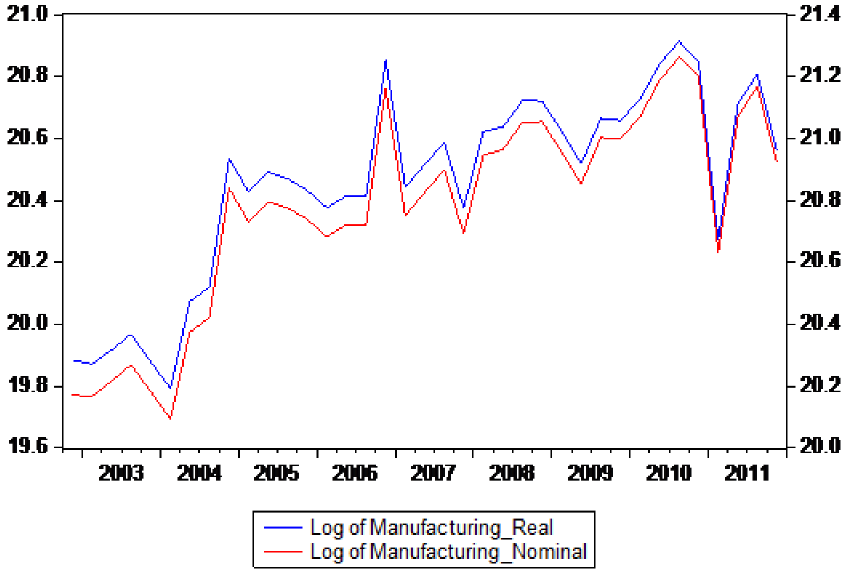

Figure 2: Real, nominal manufacturing sales

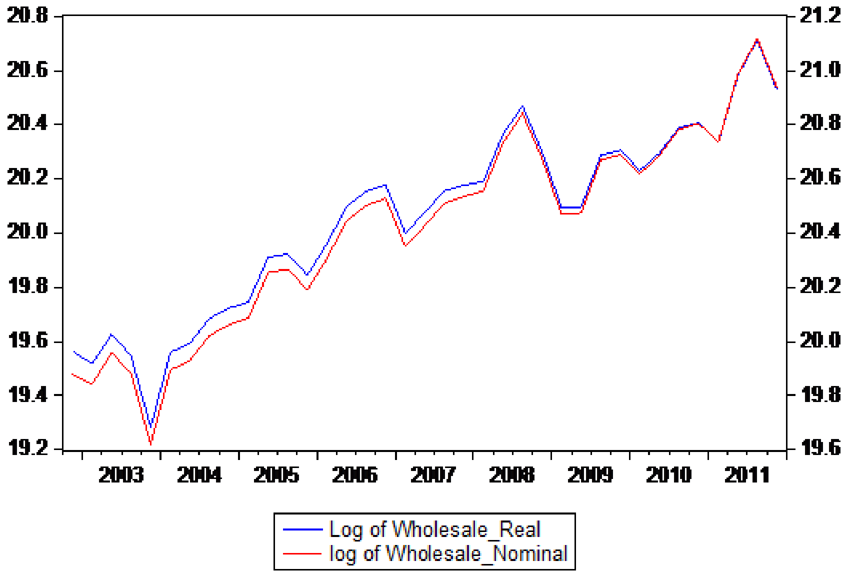

Figure 3: Real, nominal wholesale sales

stationary. As such, we will proceed under the assumption that both variables are I(1), but with caution regarding the stationarity of wholesale.

3.3 Cointegration

Both variables are stationary at first difference, and integrated of the same order (I(1)), therefore, we proceed to establish a cointegration equation using Fully Modified Least Squares (FMOLS) regression technique. The long run equation is tabulated in Figure 4.

The cointegration equation can be written as follows:

$$lman\_nom_t = 5.187 + 0.7634 lwho\_nom_t + \epsilon_t \tag{2}$$

The signs of the cointegration parameters are positive and significant. This confirms the initial thought that the wholesale and manufacturing sectors have a positive relationship. Using the Engle-Granger 2 step method, the above equation (i) was tested to confirm that the variables are in fact cointegrated. The results in Figure 5 confirm that the two variables are cointegrated.

The null hypothesis is that the manufacturing and wholesale sectors are not

Dependent Variable: LMAN_NOM
Method: Fully Modified Least Squares (FMOLS)
Sample (adjusted): 2003Q1 2011Q4

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LWHO_NOM	0.763404	0.099272	7.690042	0.0000
C	5.187600	2.028160	2.557786	0.0152

R-squared	0.725952	Mean dependent var	20.78889
Adjusted R-squared	0.717891	S.D. dependent var	0.318626
S.E. of regression	0.169235	Sum squared resid	0.973772
Durbin-Watson stat	1.187909	Long-run variance	0.045484

Figure 4: Long run regression results

Cointegration Test - Engle-Granger
Equation: COINT_MAN_WHO
Specification: LMAN_NOM LWHO_NOM C
Cointegrating equation deterministics: C
Null hypothesis: Series are not cointegrated

	Value	Prob.*
Engle-Granger tau-statistic	-3.893349	0.0215
Engle-Granger z-statistic	-22.36193	0.0118

*MacKinnon (1996) p-values.

Figure 5: Cointegration test results

Dependent Variable: DLMAN_NOM
Method: Least Squares
Date: 05/06/13 Time: 08:48
Sample (adjusted): 2003Q3 2011Q4
Included observations: 34 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLMAN_NOM(-1)	**-0.073278**	**0.243704**	**-0.300685**	**0.7659**
DLMAN_NOM(-2)	**0.079657**	**0.197466**	**0.403399**	**0.6897**
DLWHO_NOM	0.669733	0.246508	2.716886	0.0112
DLWHO_NOM(-1)	**0.193644**	**0.282172**	**0.686262**	**0.4982**
DLWHO_NOM(-2)	**-0.022387**	**0.286059**	**-0.078260**	**0.9382**
RESID_MAN_WHO(-1)	-0.617471	0.249656	-2.473291	0.0197

R-squared	0.479551	Mean dependent var	0.020734
Adjusted R-squared	0.386613	S.D. dependent var	0.208629
S.E. of regression	0.163396	Akaike info criterion	-0.626489
Sum squared resid	0.747556	Schwarz criterion	-0.357131
Log likelihood	16.65031	Hannan-Quinn criter.	-0.534630
Durbin-Watson stat	1.964558		

Figure 6: Over-parameterized ECM regression

cointegrated. Since the t statistic is 3.8933 and the p value is 0.0215, we reject the null and say the series are cointegrated; therefore, the variables have a long run relationship. As such, an ECM is estimated, using the general-to-specific approach.

A residual series $e_t = \hat{\epsilon}_t$ is created from equation (2), to be included in the ECM. That is:

$$e_t = lman\_nom_t - 5.187 - 0.7634 lwho\_nom_t \tag{3}$$

3.4 Establishing an error correction model

Both variables are integrated of the same order (I(1)) and the residuals from the long run regression linking the two are stationary. These conditions allow us to establish an Error Correction Mechanism (ECM). By using the general-to-specific approach in estimating the ECM, both variables, including their lags, are used, and insignificant terms are dropped until a group of significant variables and lagged variables are chosen.

In Figure 6, the lagged variables of both the dependent and independent variables, highlighted in bold, are considered insignificant and have been excluded

Dependent Variable: DLMAN_NOM
Method: Least Squares
Date: 05/06/13 Time: 08:32
Sample (adjusted): 2003Q2 2011Q4
Included observations: 35 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLWHO_NOM	0.653029	0.203238	3.213123	0.0029
RESID_MAN_WHO(-1)	-0.648637	0.165815	-3.911816	0.0004

R-squared	0.450754	Mean dependent var	0.021561
Adjusted R-squared	0.434110	S.D. dependent var	0.205597
S.E. of regression	0.154661	Akaike info criterion	-0.839711
Sum squared resid	0.789366	Schwarz criterion	-0.750834
Log likelihood	16.69494	Hannan-Quinn criter.	-0.809031
Durbin-Watson stat	2.031318		

Figure 7: Parsimonious ECM regression

from the final model, shown in Figure 7.

4 Discussion of results

The final model is as follows:

$$\Delta lman\_nom_t = \alpha \Delta lwho\_nom_t - e_{t-1} + u_t \tag{4}$$

$$\Delta lman\_nom_t = 0.564154 \Delta lwho\_nom_t - 0.633210 e_{t-1} + u_t \tag{5}$$

For details of residual diagnostic tests for the final ECM, see Appendix B. The adjusted R^2 is 0.43, indicating the strong explanatory power of the independent variable. The short-run coefficient of the wholesale sector carries a positive sign at the 1% level of significance, which meets prior expectations. The absence of lagged dependent variable terms indicates that the sales revenue in the manufacturing sector in previous periods will have very minimal impact on the current sales revenue. This model assumes that, in the long-run, manufacturing companies will attempt to adjust sales in response to the growth or contraction of sales revenue in the wholesale sector in the current period, and as expected the sign of the coefficient is positive but less than one. The speed of adjustment to correct disequilibrium is 64.5 percent, and the estimated coefficient (-0.648637) is significant at the 1% level and negative, as expected. The significance of the error correction term supports cointegration and suggests the existence of long-run equilibrium between the manufacturing and wholesale sectors. The coefficient of -0.645 indicates a reasonably strong speed of adjustment. Given any shock to the manufacturing sector in the current period, roughly 65 percent of that shock will pass through into wholesale sales the next period. To fully analyse the dynamics of the model, it would be desirable to plot impulse response functions. However, this is beyond the scope of the current project.

5 Conclusion

We can conclude that the manufacturing and wholesale sectors have a long run relationship. An error correction model was estimated, with a significant error correction term confirming the existence of a cointegrating relationship between the two variables. However, our intuition is that there are other significant variables, such as building and construction, transportation, etc. that are connected to manufacturing, which might be omitted. Further work is also required, as wholesale is not the only sector that affects manufacturing. An avenue for further research would be to conduct similar exercises for a variety of industries, as well as estimating a vector autoregressive (VAR) model that simultaneously links all sectors together.

References

[Aba et al, 2012] Aba, L.A., Aipi, B., Irau, T., 2012, "Supply Response of Coffee in Papua New Guinea", BPNG Working Papers, BPNGWP 2012/1.

[Nkang et al, 2006] Nkang, N.M., Abang, S.O., Akpan, O.E., Offem, K.J., 2005, "Cointegration and Error-correction Modeling of Agricultural Export Trade in Nigeria: The Case of Cocoa", Journal of Agriculture and Social Sciences, 2(4), pp 249-255.

A Unit root tests

Null Hypothesis: MAN_NOM has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.520024	0.0049
Test critical values:	1% level	-4.234972	
	5% level	-3.540328	
	10% level	-3.202445	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: MAN_NOM is stationary
Exogenous: Constant, Linear Trend

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.137538
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: MAN_NOM has a unit root
Exogenous: Constant, Linear Trend
Lag length: 0 (Spectral OLS AR based on SIC, maxlag=9)
Sample: 2002Q4 2011Q4
Included observations: 37

		P-Statistic
Elliott-Rothenberg-Stock test statistic		5.792224
Test critical values:	1% level	4.220000
	5% level	5.720000
	10% level	6.770000

Null Hypothesis: MAN_NOM has a unit root
Exogenous: Constant, Linear Trend

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-4.519882	0.0049
Test critical values:	1% level	-4.234972	
	5% level	-3.540328	
	10% level	-3.202445	

*MacKinnon (1996) one-sided p-values.

Figure 8: Unit root tests, manufacturing

Null Hypothesis: WHO_NOM has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 2 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.530901	0.3123
Test critical values:	1% level	-4.252879	
	5% level	-3.548490	
	10% level	-3.207094	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(WHO_NOM) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.694798	0.0000
Test critical values:	1% level	-3.639407	
	5% level	-2.951125	
	10% level	-2.614300	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: WHO_NOM is stationary
Exogenous: Constant, Linear Trend
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.065479
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: D(WHO_NOM) is stationary
Exogenous: Constant

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.432677
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Figure 9: Unit root tests, wholesale

B Residual diagnostics from ECM regression

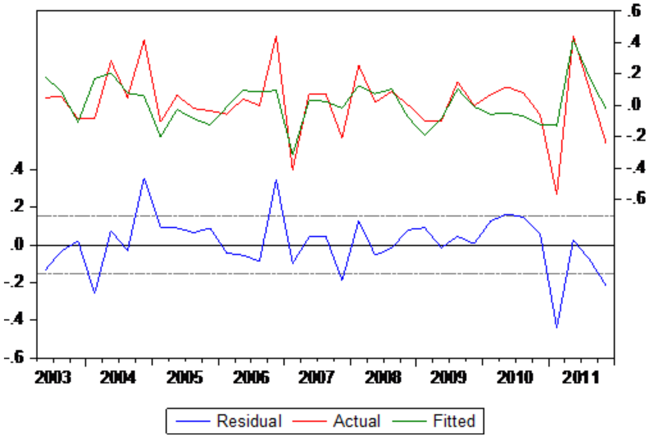

Figure 10: Residual diagnostics, ECM regression

The errors look stationary, i.e. do not deviate much from the mean. For the autocorrelation test, the null hypothesis is that there is no autocorrelation. Since the Breusch-Godfrey LM test indicates a p value of 0.7100, which is greater than 0.01, we do not reject the null. That is, there is no autocorrelation in the residuals. The Breusch-Pagan-Godfrey Heteroskedasticity Test was done to determine the existence of heteroskedasticity. Both ARCH and White tests for heteroskedasticity indicated absence of heteroskedasticity. However, our intuition is that there are other significant variables, such as building and construction, transportation, etc. that are connected to manufacturing, which might be omitted.

Part 2

Interest rate pass-through

Interest rate pass-through in Papua New Guinea

Eli Direye*

May 2013

1 Introduction

Interest rates are an important tool used by central banks throughout the world for the conduct of the country's monetary policy. Through interest rates, central banks attempt to exert influence on short-term money market rates and thereby the commercial bank retail deposit and lending rates, in order to control inflationary pressures. [Bogoev et al, 2011] explicitly explained how the adjustment in a central bank's policy and/or market rate is expected to affect a wider spectrum of financial instruments as well as commercial banks retail interest rates, so that changes in those interest rates will influence the investment and expenditure behavior of economic agents, which eventually impact overall economic activity. This practice is underpinned by the theoretical concept of interest cost refinancing, whereby commercial banks match the interest cost of their liabilities (deposits) with the corresponding term structured interest earning assets (money market securities). The Bank of Papua New Guinea (BPNG) has undergone thorough reform in its conduct of monetary policy over the last few decades by gradually moving towards a market oriented monetary policy framework. This has been an evolutionary process where BPNG introduced the Kina Facility Rate (KFR) and Repurchase Agreement facility in 2001 and Central Bank Bill in 2005, alongside the existing Treasury bills, to enhance active open market operations (OMO). Theoretically, it was expected that a change in the BPNG's policy rate (KFR) based on the monthly assessment of economic fundamentals should be supported by the conduct of CBB auction via the OMO. Hence, the interest rates determined in the money market should eventually impact the commercial bank

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retail deposit rates, which then impact the savings and consumption behavior of the economic agents. However, in recent years, BPNG's attempt to influence the investment behavior of economic agent through its influence on the commercial bank lending rate has been limited. This is the result of the existence of excess liquidity, leading to a lack of interbank lending activities, which transact at the KFR.[1] The effectiveness of the interest rate transmission mechanism depends on the size and speed of the pass-through of the movement in the policy rate into the money market interest rates. To the author's best knowledge, there is no record of similar work done on the interest rate transmission in Papua New Guinea (PNG). [David et al, 2006] discuss the overall transmission of monetary policy in PNG. Their findings reveal results contradicting the theory behind the relationship between interest rates and inflation. This result provides renewed motivation to revisit the study and assess the degree of interest rate pass-through in PNG to ascertain the effectiveness of monetary policy transmission process through the interest rate channel. This paper seeks to employ an Error Correction Modelling (ECM) methodology to perform empirical analysis of the interest rate transmission. The remainder of the paper is structured as follows. Section 2 provides an overview on interest rate movements in PNG. Section 3 covers the relevant literature, while section 4 discusses the data. The statistical and econometric procedures applied in quantitative analysis as well as the theoretical modelling framework are discussed in section 5. Section 6 discusses the results of the study. Finally section 8 draws conclusions and possible areas of further research.

2 Interest rates in PNG

The Central Bank Act 2000 provides BPNG the power to conduct the country's monetary policy through the use of appropriate policy instruments applicable to deliver the ultimate objective of controlling inflation and providing adequate support for economic growth. Such instruments come in different forms, ranging from market oriented policy instruments to the non-market oriented policy instruments and including the Minimum liquid asset requirement (MLAR), the Cash Reserve requirement (CRR) of the commercial banks' deposit liabilities, bank rate, refinancing facilities and OMO. The policy instruments the Bank uses

[1] More accurately, interbank lending occurs at a fixed margin from the KFR.

are classified as direct and indirect policy instruments (see [Kauzi et al, 2007]). Direct instruments are Bank-imposed controls that affect the monetary target itself, while indirect instruments influence the monetary target through their impact on key intermediate targets such as bank liquidity requirements and short-term interest rates. The focus of this paper is short-term interest rates. The main interest rate instruments of the central bank are KFR and Repurchase Agreement (Repo) rate introduced in 2001. The KFR is a policy rate set monthly by the BPNG to signal the stance of monetary policy based on the assessment of the economic fundamentals. The repo rate is usually set at margin above the KFR and it provides alternative funding sources for commercial banks.[2] In recent times, the repo facility has not been actively used, due to high cost associated with the implementation of the facility to control excess liquidity in the banking system. In addition, high levels of liquidity in the banking system have resulted in a lack of interbank lending activities. In the interbank market, the KFR is used as the cost of transactions, so the borrowing commercial bank uses this rate as a bench mark to mark-up their retail lending rates accordingly. Due to lack of interbank activities, it seems reasonable to conclude that the Central Bank's ability to control the investment behavior of economic agents is very limited through this particular interest rate channel. Therefore, the only possibility for a functioning interest rate channel exists through the OMO, where the BPNG is able to affect the commercial bank retail deposit rates via Central Bank Bill (CBB) auction. At times, the short term money market CBB interest rate and commercial bank deposit rate experienced significant and persistent deviations from the KFR. Chart 1 shows that, between 2005 and 2009, these two rates tend to move broadly in concert with the KFR until recently since 2010, they have significantly diverged below the KFR level towards the zero level partly influenced by high level of liquidity in the system. KFR being only the policy signalling rate rather than a securitised market rate, the ability to influence money market rate is limited to market perspective. Furthermore, the widening interest margin exhibits the risk appetite and market power exercised by the commercial banks as a result of imperfect competition and banking sector domination. However, Chart 1 also demonstrates evidence of a positive correlation between the money market CBB rate and commercial bank retail deposit rate, which is the subject to this study.

[2]It should be noted that the repo is not currently collateralized in PNG, and is thus more like a traditional discount window.

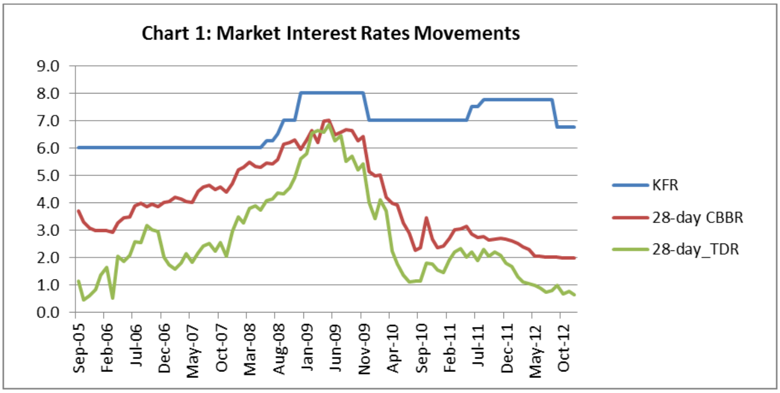

Figure 1: Market interest rate movements

3 Literature review

To the author's best knowledge, the only work relating to similar considerations for PNG is [David et al, 2006], which explores the overall monetary policy transmission and sets the foundation for this paper. [David et al, 2006] investigated the interest rate channel in PNG in several stages. Firstly, they investigate the correlation between the KFR, headline inflation rate and 28-day Treasury bill interest rate. Secondly, they adapted a Distributed lag model (ADL) in the regression analysis to test the relationships between different maturity term Treasury bill interest rates and inflation, to test if the policy transmission through the interest rate channel is effective to curtail inflationary pressure. The findings tend to be contradictory to the theoretical concept and prior expectations. According to most studies, market interest rates adjustments tend to focus on the short-run. The transmission of interest rate changes through the interest rate channel should ideally take place over a relatively short period of time ([Goodfriend, 1991]), as a faster transmission would strengthen the impact of monetary policy on the real economy. However, interest rate pass-through is not always as fast and complete as expected; most empirical studies found the short-run interest rate adjustments to be sluggish and incomplete for most developing and emerging economies. For example, [Bogoev et al, 2011], when investigating the interest rate pass-through in South-East Europe using the ECM technique found that for most countries in question, the cointegrated long-run coefficient was far from complete and short-run adjustments for lending rates were also slow and sluggish, implying that the domestic monetary policy had little impact on the economy through the interest rate channel. [Lowe, 2005] demonstrates mixed findings on the relationships between the cash rate and various classes of deposit rates through the ECM process. The adjustment in rates appeared to be slower than that for money-market rates. The degree of interest rate pass-through and the speed of adjustment depend on a number of systematic and non-systematic factors. Some of these factors were discussed by [Muhammad, 2010] when studying Nigeria's liberalized financial system (1989 to 2008). These include: monetary policy orientation (either liberal or control regime), financial structure and its level of development, banking sector concentration and bank size, openness of the financial market, asymmetric information and and menu costs. [Richard, 2005] for instance, found that deposit rates banks offer is affected by the market structure. The size of the banks and level of market share each bank constitutes determines the level of competitiveness and the ability to price deposit rates. Large banks have dominance over the small banks. All in all, only the few papers highlighted in this section set some prior expectations on the current study.

4 Data

The data used are time series obtained from the Quarterly Economics Bulletin (QEB) publications and BPNG, Monetary policy unit database. We focus on the short term money market CBB rate and commercial bank term deposit rate (TDR). The data series for both interest rates range from 2001 (inception of the KFR) to December 2012. The 28-day CBB was only introduced in September 2005. As such, prior to 2005, the CBB rate was spliced together with the 28 day Treasury Bill rate, which is the price for an almost identical security.

5 Methodology

5.1 Econometric methodology

Provided below is the chronology of the econometric procedure carried out during the quantitative data analysis.

1. Unit root test - the natural test for any time series data, to establish the

stationarity of the data prior to using these data in any further econometric test and analysis in order to avoid spurious regression results. Unit roots test are carried out to examine whether the variables are stationary at levels (I(0)), or at the mth-difference (I(m)). There are several unit root tests available; we adopt the Augmented Dickey-Fuller (ADF) and Kwiatkowski-Philips-Schmidt-Shin (KPSS) tests. This is in order to vary the null hypothesis of the unit root test, (the ADF has a null hypothesis that the variable has a unit root, whilst KPSS has a null hypothesis of stationarity).

2. Cointegration test - Two times series variables that are found to be integrated of the same order may be tested for cointegration. The Engle-Granger test is used to test for the existence of the cointegration relationship.

3. Error Correction Analysis - Given a cointegration relationship, an ECM technique is adapted to investigate the short-run dynamics around a possible long-term equilibrium between the time series variables. General to specific testing is used.

4. Residual Diagnostic Tests - The model is tested for the Gauss-Markov conditions through the residual diagnostics test for normality, serial correlation and heteroskedasticity.

5.2 Theoretical framework

This paper adapts the interest cost refinancing approach used by [Bogoev et al, 2011] as the theoretical model framework for current interest rate setting. This is based on the traditional concept that commercial banks depend on money market to refinance the interest cost by matching the interest paying liabilities to interest earning assets. Therefore the long-run regression for interest rate setting model can be represented as below:

$$tdi_t = \alpha_0 + \delta cbbi_t + \epsilon_t \tag{1}$$

,where tdi_t is the commercial bank retail deposit interest rate, $cbbi_t$ is the wholesale CBB interest rate and t subscript denotes time. The long-run coefficient between the interest rates is represented by δ, while ϵ_t is the error term. Intuitively, the prior expectation is that δ¿0 to demonstrate the positive relationship between the commercial bank short term deposit rate and the money market CBB rate. Due to imperfect competition and banking sector domination, we expect that the long-run coefficient to be $0 < \delta < 1$. If δ is close to zero, the degree of long-run relationship is very low, however, for values greater than or equal to 1 would indicate over-shooting. The α_0 represents constant which embodies the commercial bank mark-down on deposit rate. Mark-down refers to the degree to which a commercial bank market ability to determine the price of its deposits in relation to the price of the corresponding money market security interest rate, i.e. the refinancing cost. Therefore, the value of mark-down is expected to be negative.

A long-run coefficient of one signifies a robust and complete pass-through effect that would imply that the monetary policy targeting through the short term interest rate is very high. However, in the real world, the pass-through is not always complete, and we may expect a coefficient of between 1 and 0.5.

6 Results

6.1 Unit root tests and long-run relationship

Prior to using the econometric analysis, all variables are subject to ADF and KPSS unit root tests to verify their time series properties. The test results found none of the variables to be stationary at levels.[3] Therefore to avoid spurious regression, unit root tests were carried out on first differences confirmed stationary of the variables at 1 and 10 percent significant levels, respectively, by ADF and KPSS. The ADF test after first difference rejected the null hypothesis of variable has unit root for both variables at 1 percent significance level, while KPSS at 10 percent significance level after first difference reject the null hypothesis of variables are stationary. Hence it was concluded that all the series were I(1) variables or integrated of the same order.

Given that all interest rates used are I(1), it is appropriate to test whether or not these variables are cointegrated. This was done using the Engle-Granger cointegration test on the long-run regression equation 1. The results of equation 1 and its cointegration test are provided below.

[3] See Appendix A for detailed results from the unit root tests.

Dependent Variable: TDI
Method: Fully Modified Least Squares (FMOLS)
Date: 04/22/13 Time: 08:52
Sample: 2005M07 2012M12
Included observations: 90
Cointegrating equation deterministics: C
Long-run covariance estimate (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CBBI	1.059677	0.086220	12.29045	0.0000
C	-1.580274	0.368448	-4.288999	0.0000

R-squared	0.841832	Mean dependent var	2.671333
Adjusted R-squared	0.840034	S.D. dependent var	1.692652
S.E. of regression	0.676988	Sum squared resid	40.33156
Durbin-Watson stat	0.415669	Long-run variance	1.422590

Figure 2: Long run regression results

Cointegration Test - Engle-Granger
Date: 04/22/13 Time: 14:07
Equation: COINT_EQ2
Specification: TDI CBBI C
Cointegrating equation deterministics: C
Null hypothesis: Series are not cointegrated
Automatic lag specification (lag=0 based on Schwarz Info Criterion, maxlag=8)

	Value	Prob.*
Engle-Granger tau-statistic	-3.543616	0.0358
Engle-Granger z-statistic	-20.28025	0.0395

Figure 3: Cointegration test results

As such, the long run relationship is given by:

$$tdi_t = -1.58 + 1.06cbbi_t + \hat{\epsilon}_t \tag{2}$$

The results reflected by both τ and z statistics have probability values highly significant to reject the null hypothesis of series are not cointegrated. Thus we find a cointegrating relationship between the short term CBB rate and commercial bank term deposit rate. Accordingly, we found the long-run relationship between the CBBI and TDI to be one on one as reflected by a coefficient of 1.06. The negative constant coefficient of 1.58 exhibits the commercial bank mark-down (see [Bogoev et al, 2011]) on the price for deposit rate. The high degree of mark-down significantly implies that commercial banks have high level of liquidity already in the system to meet their liability obligations and investment plans. This evidence confirms the current PNG's experience of excess liquidity in the banking system caused by large build ups of deposits in the central government trust accounts held with the commercial banks. In addition, it also suggests that commercial banks extract large interest profit from marked down on deposit prices due to imperfect market competition and banking sector domination of the financial sector.

6.2 6.2 Establishing the ECM model

Having shown that there is a long-run equilibrium relationship between these interest rates, we extended our analysis to investigate the short-run dynamics and to tie the short term behavior of the dependent variable to its long run value using the error correction mechanism suggested by Engle and Granger. Therefore the ECM setting in this regard is specified as equation 3 and represented subsequently.

$$\Delta tdi_t = c_1 + \sum_{i=1}^{m} \alpha_i \Delta tddi_t - i + \sum_{i=0}^{n} \beta_i \Delta cbbi_t - i + \gamma\hat{\epsilon}_{t-1} + u_t$$

,where Δ is the first difference operator. The lag lengths m and n are determined intuitively based on the size of the sample; the term γ is the Error Correction Term (ECT) that captures the speed of adjustment towards long-run equilibrium. When $\gamma \in [-1, 0]$, this confirms presence of an equilibrium-restoring relationship. The variable $\gamma\hat{\epsilon}_{t-1}$ is the residual from the cointegrating regression

Dependent Variable: DTDI
Method: Least Squares
Date: 04/22/13 Time: 14:33
Sample (adjusted): 2005M08 2012M12
Included observations: 89 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DCBBI	0.735344	0.120852	6.084653	0.0000
DCBBI(-1)	0.239917	0.120329	1.993841	0.0493
ECT(-1)	-0.200349	0.061606	-3.252113	0.0016

R-squared	0.355811	Mean dependent var	-0.012809
Adjusted R-squared	0.340829	S.D. dependent var	0.477505
S.E. of regression	0.387683	Akaike info criterion	0.975871
Sum squared resid	12.92566	Schwarz criterion	1.059757
Log likelihood	-40.42625	Hannan-Quinn criter.	1.009683
Durbin-Watson stat	2.270055		

Figure 4: Error correction regression results

based on the fully-modified OLS estimation of Equation 1. The error term u_t should normally distributed and have a zero mean disturbance and a constant variance.

The effectiveness of the interest rate transmission mechanism depends on the coefficients of the short-run dynamic and the speed of adjustment of the shock in the endogenous interest rate to restore long-run equilibrium. A quick and complete interest rate long-run pass-through is said to occur when a change in the short term money market interest rate has a one for one change in the commercial bank term deposit rate, which enhances the transmission of the central bank's actions to real economy. The opposite is true for the transmission that is sluggish and incomplete.

The ECM regression equation 3 was run on a four months lag periods in view of the quarterly computation of the inflation rate. Following the general to specific procedures of screening and omitting insignificant variables, provided below is the final summary of the model outcome of the analysis.

6.3 Discussion of results

$$\Delta tdi_t = 0.24\Delta cbbi_{t-1} + 0.74\Delta cbbi_t - 0.20ECT_{t-1} + \hat{u}_t \tag{3}$$

The estimate coefficient for ECT is negative as expected, signifying an equilibrium restoring relationship. A value of -0.20 suggests a slow and sluggish restoration of long-run equilibrium to a shock. Explicitly, this means that should there be a shock in the economy that causes the CBBR to increase or decrease in the economy, the market adjustment mechanism will eliminate 20 percent of the shock in the short-run, while deferring the outstanding 80 percent of the shock to be adjusted in future before a full restoration of the long-run equilibrium is established. For clarity, dynamic multipliers are employed to fully analysis the short-run dynamics of the model. The adjusted R^2 value of 0.34 for the ECM indicates that the model explains only 34 percent of the variation in the short term commercial bank term deposit rate with respect to the changes in the corresponding CBB rate. This implies that there are other factors such as imperfect banking sector competition, interest rate risk averse, behavior of commercial banks and asymmetric information among others also affect the interest rate transmission process. This constitutes the remaining 63 percent of the unexplained variations captured by the error term u_t. Furthermore, model testing for the Gauss-Markov conditions found that only the normality test failed, whilst the other tests for serial correlation and heteroskedasticity confirmed no serial correlation or heteroskedasticity.[4] According to the results, the Jarque Bera test for normality with probability value of 0.04 failed not to reject null hypothesis of errors are normally distributed. The Breusch Godfrey LM test for serial correlation with probability value of 0.70 was not significant to reject null hypothesis of no residual autocorrelation. Finally, the probability values of 0.97 and 0.92 for the Breusch-Pagan-Godfrey and White tests, respectively, both were insignificant to reject null hypothesis of no heteroskedasticity in the residuals.

6.4 Dynamic multipliers

In this section, we try to examine the impulse response of the short term commercial bank term deposit rate to a 1 percent increase in the CBB rate. The underlying purpose of this exercise is to test the level of asymmetric adjustments of the relationship between the two interest rates alluded in section 6.2. At time (t) if the CBB rate increases by 1 percent to 5 percent, the short-run impact multiplier indicates the commercial TD rate will increase by about 0.74 percent to 3.74 percent in the same month, while the remaining 0.3 percent of the pass-through will be distributed to be adjusted in future. The ECT value

[4] See Appendix B.

of -0.20 indicates that the market would take about five months to allow for the full adjustment mechanism of the shock to take effect to restore the long-run equilibrium. This alludes that the short-run adjustment in TDI in response to movement in the CBBR is close to robust and quick. However, the speed of adjustment is slow and weak reflecting that the market is less sensitive to react quickly to shocks in the economy.

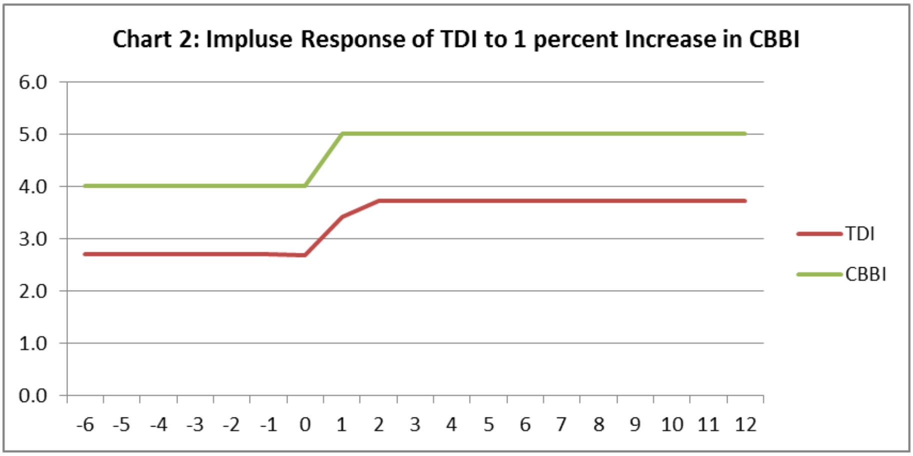

Figure 5: Dynamic multiplier

7 Conclusion

In light of the inactive interbank market and absence of secondary market facilities in PNG, the commercial banks depend highly on OMO facility to refinance interest cost of the liabilities (deposits). In order to provide insight into this relationship, we investigated the link between the short term CBB interest rate and the corresponding term deposit rate. Following the protocol of econometric test procedures, both ADF and KPSS unit root tests confirmed the variables to be I(1).The Engle-Granger cointegration test found a cointegrating relationship between the variables. The paper found the long-run coefficient value of 1.06, reflecting a one on one long-run relationship between the short term money market CBB rate and the corresponding commercial bank retail term deposit rate. Strikingly, while holding other things constant, the high value of -1.58 for markdown on deposit rate confirms evidence of high level of liquidity in the banking system and imperfect market competition and banking sector domination of the financial sector in the country.

The short-run dynamic analysis found the pass-through effect to be robust and high with the impact multiplier value of 0.74. However, the low coefficient value of -0.20 for the ECT result signifies that the robustness of the market to self-adjust from shock to restore the long-run equilibrium between deposit and CBB rates is slow and sluggish. Plotting an impulse response function demonstrates that the market would take about five months to allow for the full adjustment mechanism of the shock to take effect to restore the long-run equilibrium.

The lower value of the adjusted R^2 for the error correction equation confirms the suggestions by other studies that there are several other factors affecting the interest rate transmission mechanism. These include the lack of competition in the financial system between the commercial banks and non-bank financial institutions, efficiency and development of the financial structure, banks collusive behavior, customer irrationality and menu costs of commercial banks amongst other things. These considerations are, however, beyond the scope of the current study, but offer valuable opportunities for future research within the context of PNG.

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A Unit roots tests

Unit Root Test

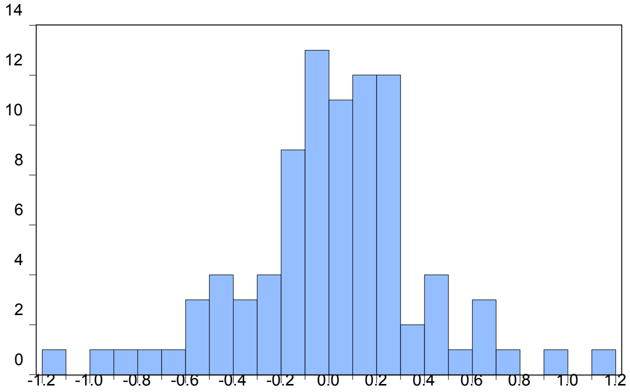
	At Levels		**First Difference**		**Null Hypothesis**
Test	TDI	CBBI	DTDI	DCBBI	
ADF	-2.64(-2.58)**	-2.38(-2.58)**	-14.59(-3.47)*	-5.20(-3.47)*	Has unit roots
KPSS	0.89(0.74)*	1.09(0.74)*	0.17(0.35)**	0.13(0.35)**	Stationary

*Note: */** denote the statistical significance levels of the t-statistics at 1% & 10%, respectively, while the corresponding values in the brackets are critical values. Intercept or constant was included in the test equation.*

Source: E-view results obtained by the author

Figure 6: Unit root test results

B Error correction model - residual diagnostic tests



Series: Residuals
Sample 2005M08 2012M12
Observations 89

Mean	0.012592
Median	0.034736
Maximum	1.154582
Minimum	-1.140826
Std. Dev.	0.383043
Skewness	-0.253595
Kurtosis	4.227002
Jarque-Bera	6.536962
Probability	0.038064

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.683527	Prob. F(8,78)	0.7047
Obs*R-squared	5.739709	Prob. Chi-Square(8)	0.6764

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.079772	Prob. F(3,85)	0.9708
Obs*R-squared	0.249875	Prob. Chi-Square(3)	0.9692
Scaled explained SS	0.372235	Prob. Chi-Square(3)	0.9459

Heteroskedasticity Test: White

F-statistic	0.327948	Prob. F(6,82)	0.9205
Obs*R-squared	2.085614	Prob. Chi-Square(6)	0.9117
Scaled explained SS	3.106908	Prob. Chi-Square(6)	0.7953

Figure 7: Residual diagnostic test results

Part 3

Palm oil exports and relative prices

Palm oil exports and relative prices in Papua New Guinea

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May 2013

1 Introduction

The aim of this paper is to estimate the relationship between the price of palm oil and PNG's palm oil export volumes.

The palm oil industry is a very important industry in terms of its contribution to the economy. Palm oil is PNG's leading agricultural commodity, accounting for around 40% of agricultural export earnings over the last decade. A large palm oil project such as, New Britain Palm Oil Limited, is one of the major sources of infrastructure development in PNG's rural economy. Many rural communities rely on infrastructure such as roads, ports, healthcare, law enforcement and construction projects funded by agricultural revenues and resource industry investment. Employment, export sales and government revenue resulting from the palm oil industry are high, and are expected to increase with greater industry growth. In 2007 export earnings from palm oil reached K640 million. Around 166,000 people currently live in rural households that produce palm oil, with many more deriving incomes from spin-off activities.

This paper tries to analyze the relationship between the world prices of palm oil and PNG's palm oil export volumes. There are several factors that affect palm oil supply, such as weather, infrastructure, land, labor and other variables, which are held constant in this paper.

The outline of the paper is as follows. We begin with a literature review, followed by a description of the data. We briefly discuss the theoretical framework,

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followed by the econometric methodology, which includes testing for unit roots and cointegration. In the absence of cointegration, we specify a short-run model and estimate it using a general to specific methodology.

2 Literature review

Other papers have attempted to examine the palm oil supply responsiveness to prices. [Fleming, 1999] examined three smallholder palm oil locations in PNG and their responsiveness to prices. He used world prices of palm oil, the exchange rate and their lags as variables for determining the supply response in PNG. [Aba et al, 2013] included more variables, including the ratio of export prices of palm oil to the domestic price index, trade-weighted income levels of major importers of PNG's palm oil exports, southern oscillation index capturing weather patterns in PNG and a trend variable. For the current paper, the price variable will be the only variable used.

3 Data

Palm oil export price data was taken from the Quarterly Economic Bulleting (QEB) source, Bank of Papua New Guinea (BPNG) and commodity boards. The food price index was derived from the consumer price index (CPI) data, National Statistical Office. The relative price series was then created by dividing palm oil prices by food prices and multiplying by 100. Palm oil export volumes were obtained from the QEB and commodity boards. All data runs through the period 1996 through 2011, and is on an annual frequency.

4 Theoretical framework

The main assumption is that palm oil export volumes are influenced by either high or low world prices. We expect to see palm oil prices having a positive relationship with export volumes. Higher prices will encourage producers to supply more to the market, while at lower prices, the producers will slow production: furthermore, some smallholders and villagers switch to other cash crops, tend to their food gardens or stop producing. Anecdotal evidence suggests that, for PNG, palm oil exports volumes have increased regardless of price fluctuations.

The upward trend for palm oil supply is driven by global demand, which is expected to increase by 30% in 2011 and onwards. This reflects growing consumption for palm oil as both a food product and as a feedstock for bio-fuel.

5 Empirical methodology

5.1 Unit root testing

Before any analysis is done, graphing both palm oil volumes and relative price variables is useful for initial observation and to help interpret the results after the analysis. The first process of the analysis is to test both variables for unit roots. This is done using the Augmented Dickey Fuller and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) statistic tests. The unit root tests are done to determine if both variables are stationary or not. If the unit root tests prove that the variables are integrated and of the same order, then the next step is to test both palm oil volumes and prices for a cointegrating relationship. This is done using the Engle and Granger two-step procedure. If variables are cointegrated, this implies an error correction representation of the model exists. Cointegration testing is done to establish if there is any long term relationship between palm oil volumes and prices. However, if the variables are integrated of different orders, cointegration analysis is not valid. In this case, first differences are taken of the non-stationary series and any stationary series are left at levels. This is because ordinary least squares (OLS) regression is not valid in the presence of non-stationarity.

Relative price was used in place of world palm oil price to show the opportunity cost of either producing palm oil for export or for food production. The relative price series for palm oil was constructed by dividing world palm oil prices by the food price Index from the CPI.

5.1.1 Eye-balling

Before analysis, we plot both variables on graphs for observation, to determine whether to include trend and constant terms in the unit root tests.

From observing the graph, palm oil export volume clearly has an upward trend. The relative price series for palm oil was constructed using the food price index from the CPI and world oil palm prices. To compute relative prices we divide

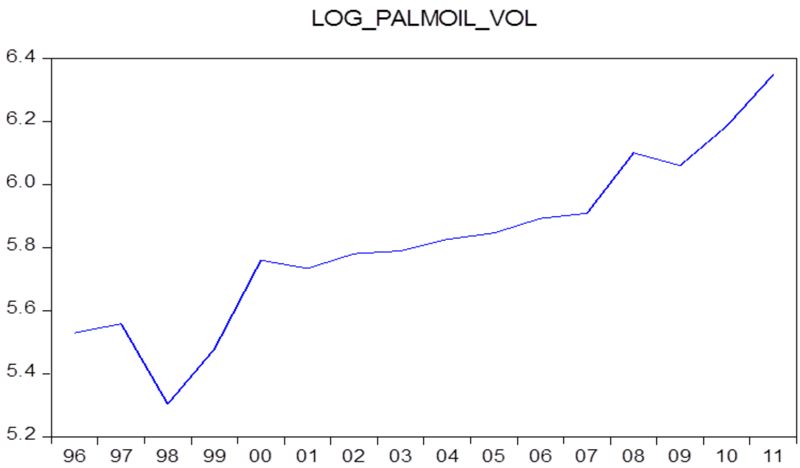

Figure 1: Log of palm oil volumes ('000 tonnes)

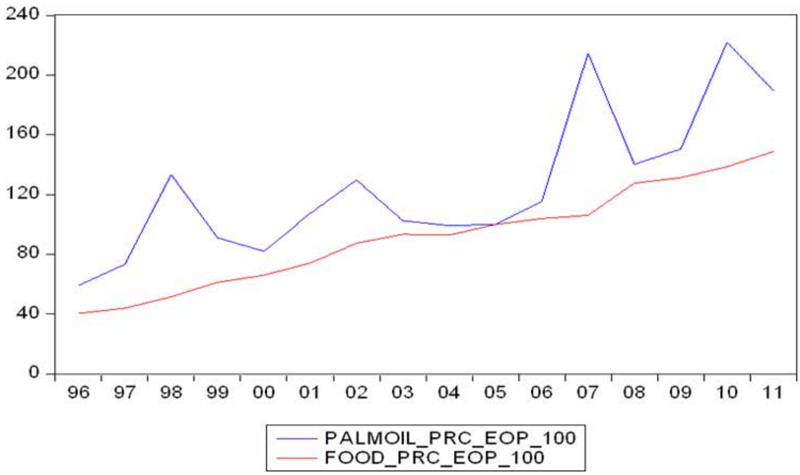

Figure 2: Palm oil, food prices (Kina per tonne)

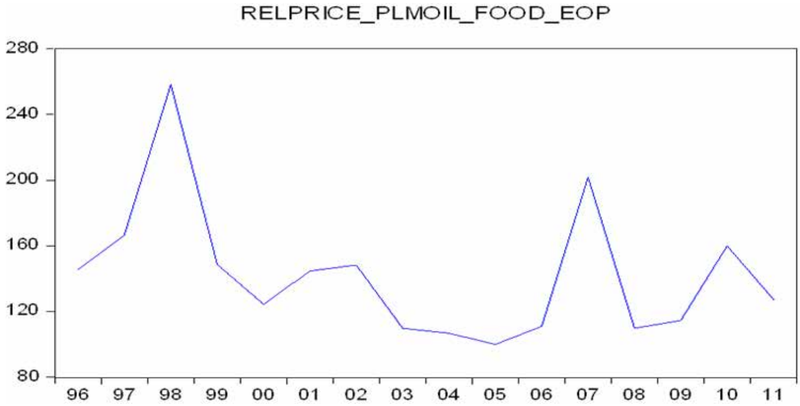

Figure 3: Relative prices

palm oil prices by food prices and multiply by 100. From observation we can see both palm oil and food prices trending upwards. Palm oil prices tend to be higher and are rising faster than food prices.

5.1.2 ADF, KPSS tests

The Augmented Dickey Fuller (ADF) is used to test for unit roots in both variables. The Kwiatkowski-Phillips-Schmidt-Shin test, which reverses the null hypothesis to that of stationarity, is also used. From the eye-balling exercise, we see that palm oil volume has a trend, hence a linear trend should be used in the unit root test. The high p-value suggests we should not reject the null hypothesis, and so palm oil volume has a unit root. From the KPSS test, the LM-Stat (0.26) is higher than the 1% critical level, suggesting that the null hypothesis should be rejected. Palm oil volume is non-stationary. Both tests prove that palm oil volume has a unit root.

The relative price of palm oil has a low p-value (0.0640) in the ADF test, since any p-value lower than 0.05 is considered low, while a p-value closer to 0.1 is considered high. At the 5% level it has a unit root. At the 10% level, it doesn't. Even though the evidence is weak, we will proceed as though palm oil prices have a unit root. From the KPSS test, however, palm oil relative prices has an LM-Stat of (0.33). This is lower than the 5% or 10% critical levels or 0.05 or 0.10, meaning the P-value is high. The null hypothesis isn't rejected; relative palm oil price is stationary.

Null Hypothesis: LOG_PALMOIL_VOL has a unit root			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.96088	0.1734
Test critical values:	1% level	-4.72836	
	5% level	-3.75974	
	10% level	-3.32498	

Null Hypothesis: LOG_PALMOIL_VOL is stationary		
		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.263500
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

Null Hypothesis: LOG_RELPRICE_PO_FD_EOP has a unit root			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.94081	0.0640
Test critical values:	1% level	-3.95915	
	5% level	-3.081	
	10% level	-2.68133	

Null Hypothesis: LOG_RELPRICE_PO_FD_EOP is stationary		
		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.330303
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

Figure 4: Unit root test results

Dependent Variable: LOG_PALMOIL_VOL
Method: Fully Modified Least Squares (FMOLS)
Date: 05/08/13 Time: 16:24
Sample (adjusted): 1997 2011
Included observations: 15 after adjustments
Cointegrating equation deterministics: C
Long-run covariance estimate (Bartlett kernel, Newey-West fixed bandwidth = 3.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG_RELPRICE_PO_FD_EOP	-0.677838	0.352903	-1.920749	0.0770
C	9.177372	1.739173	5.276861	0.0001

R-squared	0.123807	Mean dependent var	5.838096
Adjusted R-squared	0.056408	S.D. dependent var	0.270491
S.E. of regression	0.262751	Sum squared resid	0.897497
Durbin-Watson stat	0.535662	Long-run variance	0.122243

Cointegration Test - Engle-Granger
Date: 05/08/13 Time: 16:26
Equation: UNTITLED
Specification: LOG_PALMOIL_VOL LOG_RELPRICE_PO_FD_EOP C
Cointegrating equation deterministics: C
Null hypothesis: Series are not cointegrated
Automatic lag specification (lag=0 based on Schwarz Info Criterion, maxlag=2)

	Value	Prob.*
Engle-Granger tau-statistic	-0.557012	0.9604
Engle-Granger z-statistic	-1.533683	0.9538

*MacKinnon (1996) p-values.
Warning: p-values may not be accurate for fewer than 20 observations.

Figure 5: Cointegration test results

5.2 Testing for Cointegration

Since there is only weak evidence that both variables are integrated of the same order, it is unlikely that they would be cointegrated. However, the Engle Granger two-step cointegration test is performed anyway. This is to test if there's a long-run relationship between palm oil volumes and prices.

5.3 Re-specification of model

In the absence of cointegration, we re-specify a short run model. Since palm oil volumes are I(1), they should be first differenced, in order to render the series

Dependent Variable: DLOG_PALMOIL_VOL				
Method: Least Squares				
Date: 04/29/13 Time: 11:56				
Sample (adjusted): 1997 2011				
Included observations: 15 after adjustments				
	Coefficient	Std. Error	t-Statistic	Prob.
LOG_RELPRICE_PO_FD_EOP(-1)	0.011433	0.006495	1.760309	0.1002
R-squared	0.013619	Mean dependent v	0.054656	
Adjusted R-squared	0.013619	S.D. dependent var	0.125043	
S.E. of regression	0.124189	Akaike info criterio	-1.26968	
Sum squared resid	0.215921	Schwarz criterion	-1.22248	
Log likelihood	10.52262	Hannan-Quinn crite	-1.27019	
Durbin-Watson stat	2.247849			

Figure 6: Final regression results

stationary. Relative prices are stationary, and hence can remain in level terms. We follow a general to specific modelling procedure. For this, two lags of each variable are added to the model; this is due to the limited number of observations. After the reduction process, only variables with low p-values are left, while variables which are insignificant are disregarded.

6 Discussion of results

The relative price of palm oil coefficient has the expected positive sign. This would indicate that a one percent increase in relative prices of palm oil could lead to a 0.012 percentage points in the growth of palm oil volumes. The coefficient is small and insignificant, while the R^2 is also small. The relative price variable isn't significant in the model.

The results from the model, suggest that a price shock to palm oil is not the main factor but that there are other factors that contribute to the palm oil export volumes. Weather, infrastructure, trading partners or world demand and technology are other factors that play a role in determining palm oil exports from PNG as well. These results go in line with [Aba et al, 2013]. The paper's findings suggested that palm oil prices have little effect on palm oil volumes in the short or long run. The other factors, such as favorable weather, the need for income, tend to be the main driving force for small producers to increase palm oil supply regardless of fluctuations in relative price. The need from income to pay for food, other durable goods, meeting personal or community obligations

and other financial costs. World demand for palm oil, also dictates how much we produce; an increase in incomes of our trading partners will drive demand for palm oil exports. Price fluctuations have little effect on volumes, or producer's decision to produce palm oil.
Another contributing factor to the steady increase in export volumes over the years in PNG has been companies' involvement in research and technology, in growth methods and finding the best palm oil species, credit schemes for smallholders, development of infrastructure in plantations and the smallholder's blocks. Finally, favorable weather conditions have also contributed to increased oil palm been exported overseas. Again, the aim of this paper was to see the price effect on export volumes. From the findings, price effects on palm oil volumes are negligible. .

7 Conclusion

This paper analyzed the link between palm oil volumes and relative palm oil prices. It found only a limited price effect in the short run, with no long run relationship holding between the variables. A more detailed qualitative and quantitative analysis was done on palm oil supply response by [Aba et al, 2013]. This working paper ran an Error Correction model (ECM) and includes other variables besides the price variable, such as the trade-weighted income levels of major importers of PNG's palm oil exports, southern oscillation index capturing weather patterns in PNG and a trend variable. The findings of the paper revealed that the overall supply response to changes in international prices is inelastic in the palm oil industry. Non-price factors, such as weather patterns and income levels, play an important role in determining the production and supply of palm oil.

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Part 4

Estimating the money multiplier

The money multiplier in Papua New Guinea

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1 Introduction

The idea that monetary authorities are able to influence the level of the broad money stock through reserve money management was originally developed by [Brunner, 1961]. Since stability is a prerequisite of predictability, stability of the money multiplier is of great interest to Central Banks and worth testing. For this ratio (money multiplier) to exhibit stability, it should be stationary, i.e. we test the stability of the ratio using the concept of stationarity. Also both reserve money (M_0) and money supply should be cointegrated ([Sahinbeyoglu, 1995]). The Bank of PNG in the pursuit of its mandate of price stability, conducts monetary policy using the reserve money framework. That is, controlling reserve money through its open market operations (OMOs) to influence monetary aggregates as part of the monetary policy transmission process. Using empirical data, this paper aims to ascertain if there is a long run relationship between M_0 and the monetary aggregates, particularly M_1 (narrow money) and M_3 (broad money) in PNG. If so, then the money multiplier works in PNG and BPNG has been successful in using the reserve money framework in its monetary policy operations in meeting its objective of price stability. This paper tests for stationarity using the Augmented Dickey Fuller (ADF) and the Kwiatkowski-Philips-Schmidt-Shin (KPSS) test. It further tests for cointegration between the variables, using the Engle-Granger two step approach, which can then be represented using an Error Correction Model (ECM) if cointegration holds. If cointegration fails to hold then the paper will explore the option of estimating a short-run function using a general to specific approach.

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2 Literature review

The money multiplier model first developed by [Brunner, 1961] and later by [Brunner et al, 1964] has been the standard model in explaining monetary policy actions and its impact on other macroeconomic variables. It is argued that monetary authorities are able to control the monetary base and subsequently the supply of money and output. I.e. reserve money is exogenous since it is the monetary liability of the Central bank it can be controlled. In order for this to hold, there should be a long run relationship between monetary base and money supply. Studies undertaken are vast and growing, recently more so in developing economies that use money supply targets with results showing varying degrees of success . The bank of Turkey in the 70s and 80s showed that reserve money was found to be a major contributor to changes in Money Supply in Turkey ([Gökbudak, 1995]). For the East African countries that use the money multiplier in their monetary policy framework, a case study on Tanzania (using data from 2001 to 2009) showed the money multiplier to be stable in the long run with average broad money growing one-on-one with reserve money ([Adam et al., 2010]). [Jha et al., 2000], using a residual based approach over the period 1980 and 1990 to test for cointegration for India, found neither M_1 nor M_3 to be cointegrated with reserve money. However, when analysis was performed for data over periods where financial reforms were undertaken, evidence of cointegration was found. Using monthly data for the period 1972 to 1990, [Khan, 2009] showed that the money multiplier generally holds for Pakistan. For the pacific island countries, little work has been done on the multiplier effect despite many central banks in the region using or targeting the money supply in their monetary policy framework.

3 Data

The examination period is from January 2001 to June 2012 using monthly unadjusted monetary data for PNG in this analysis. The data are nominal values expressed in millions of kina (local currency). The start of the sample period coincides with the establishment of the independence of the Central Bank. All data are converted to logs. From eyeballing the data, Chart 1 shows log broad money and log reserve money generally trending upwards in time but with a fairly wide margin with log reserve money showing fluctuations and log broad

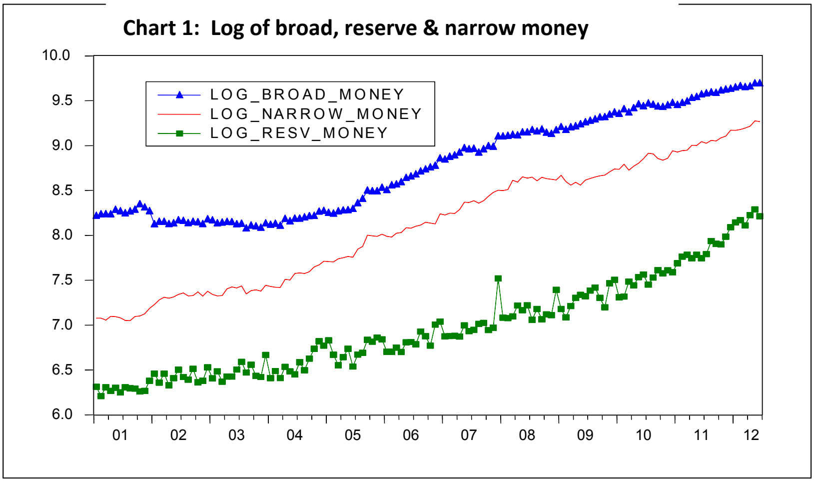

Figure 1: Graphing the money aggregates

money showing a much smoother upward trend. For narrow money and reserve money despite the narrow margins, the two don't seem to show any real co-movements other than a general upward trend.

For the money multipliers, two are derived using the ratios of M_1 and M_0 and M_3 and M_0 the former denoted as κ_2 and the latter as κ_1 . In Chart 2, the multiplier κ_1 doesn't show a clear time trend nor does it fluctuate around a mean, although it trends closely with κ_2 after 2004. The multiplier κ_2 shows two distinct movements; a period where it trends upwards from 2001 to 2008, and then downwards thereafter.

4 Theoretical framework

The investigation into the long-run relationship between monetary aggregates, such as M_1 and M_3 and M_0 has been has been widely discussed and debated particularly amongst those who use monetary aggregates as their policy target variable. The ability to control M_0 by monetary authorities and the stability of money multiplier is of great interest with critics arguing that this cannot be attained due to other factors at play ([Darbah, 2000]). Nevertheless, it is widely stated and empirically tested, which this paper aims to determine that that if the ratio of M_3 to M_0 (and M_1 to M_0) is stable over time, then this would

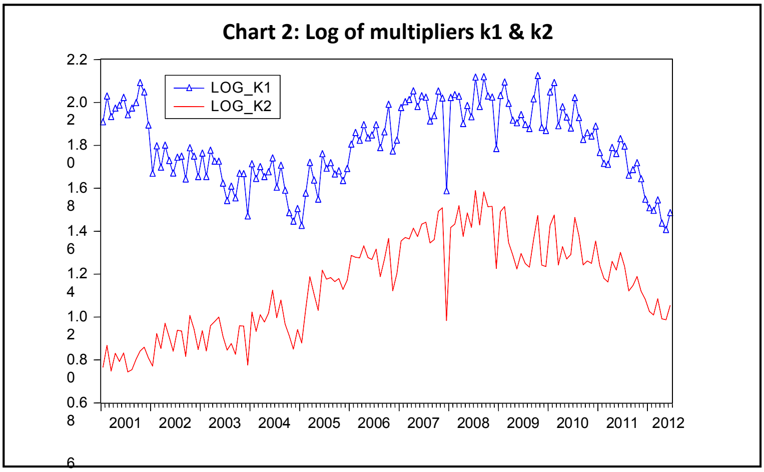

Figure 2: Graphing the multipliers

also mean that the relationship between M_1 and M_0 and M_3 and M_0 are also cointegrated. The money multiplier represents the link between the monetary base and the money supply. If the multiplier is constant or predictable, the change in money supply equals the multiplier times the change in monetary base ([Hassan et al., 2002]).

It is assumed that if monetary authorities have the ability to control reserve money (M_0) to influence the growth monetary aggregates, then there should be a positive relation between both variables in the long run, i.e. a controlled fall in M_0 should see a corresponding fall in M_3 , while a rise in M_0 should see an increase in M_3 .

According to the standard money multiplier model used, money supply M_3 is a product of reserve money (M_0) and the money multiplier m which can be expressed in the form:

$$M_3 = mM_0 \tag{1}$$

,where M_3 is defined by the BPNG as consisting of M_1 (which is made up of of currency outside depository corporations C and transferable deposits td) and quasi money (other deposits) od.

$$M_3 = C + td + od \tag{2}$$

Figure 3: The transmission mechanism of monetary policy

M_0 , according to BPNG's description, consists of currency holdings of commercial banks with BPNG, K, their deposits with BPNG, D, and currency in circulation, c.

$$M_0 = K + D + c \tag{3}$$

Substituting equation 3 into equation 1, and solving for m gives us:

$$m = \frac{M_3}{M_0} \tag{4}$$

$$= \frac{C + td + od}{K + D + c} \tag{5}$$

In the conduct of the Bank's weekly open market operations it tries to influence the level of commercial banks ESA balances (a major component of D in M_0) to manage the level of excess funds which may lead to growth in private sector credit and a subsequent growth in M_3 . Ultimately the transmission process via the money multiplier approach is depicted with the help of a simple diagram.

5 Empirical methodology

Most of the empirical research concerning the stability and predictability of the money multiplier used time series techniques and rightly so, as monetary data exhibit a stochastic process. Logs on monthly unadjusted data on M_0 , M_1 and M_3 , with multipliers κ_1 and κ_2 over the sample period. M_0 broadly consists of currency in circulation plus commercial banks' exchange settlement accounts; M_1 is made up of currency outside deposit taking institutions plus transferable (demand) deposits, while M_3 consists of M_1 plus other (term) deposits. For the methodological approach used in this paper, we first test for stationarity for the variables, since Ordinary Least Squares (OLS) is the preferred method of regression. This is also important for the multipliers, as stationarity for the multipliers also provides an early indication that a long-run relationship holds

			T - Statistics		
Variable	log_M0	log_M1	log_M3*	log_k1	log_k2
ADF test statistics	-2.335743	-2.807235	-2.356557	-1.474619	-1.598372
Test critical values					
1% level	-4.026942	-4.026942	-4.026942	-3.479281	-3.479656
5% level	-3.443201	-3.442955	-3.442955	-2.882910	-2.883073
10% level	-3.146309	-3.146165	-3.146165	-2.578244	-2.578331

Figure 4: ADF Test at levels, including trend and intercept (excludes trend for multipliers) at 8 lags

between the variables and are cointegrated. Even if the multipliers are non-stationary, we further test for cointegration between the variables, using the Engle-Granger two step approach. If cointegration holds, then there exist a long run relationship, hence the short and long-run relationship can be represented using an Error Correction Model (ECM). If cointegration fails to hold, then we move to estimate a short-run function by differentiation to satisfy the conditions of OLS, before using a general to specific approach.

5.1 Testing for stationarity

Before proceeding to run OLS regression we first test for stationarity (unit root test) on the variables at levels to avoid running a spurious regression - a problem encountered when regressing two non-stationary variables. For the multipliers, stationarity would imply a stable relationship between the respective monetary aggregates. This analysis is done on Eviews7 using the Augmented Dickey-Fuller (ADF) unit root test and the Kwiatkowski-Philips-Schmidt-Shin (KPSS) test for stationarity. The results generated are depicted in the tables below.

The results show that for the ADF unit root test indicate the presence of a unit root at the one percent level for both multipliers. The monetary aggregates M_0 , M_1 and M_3 also indicate the presence of a unit root at the one percent level. In the case of the KPSS tests, the money multiplier results are mixed; κ_1 has a p value greater than the critical values so we do not reject the null that it is stationary - it is stationary, while κ_2 with a low p value indicates that we reject the null - it is non-stationary. The monetary aggregates exhibit p values less than the critical values indicating that we reject the null; we reject that the

			LM - Stat		
Variable	log_M0	log_M1	log_M3*	log_k1	log_k2
KPSS test statistics	0.312357	1.35967	0.221055	0.217647	0.975310
Asymptotic critical values					
1% level	0.216000	0.216000	0.216000	0.739000	0.739000
5% level	0.146000	0.146000	0.146000	0.463000	0.463000
10% level	0.119000	0.119000	0.119000	0.347000	0.347000

Figure 5: KPSS Test at levels including trend and intercept (excludes trend for multipliers)

	ADF test				KPSS test		
Variable	dlog_M0	dlog_M1	dlog_M3*	variable	dlog_M0	dlog_M1	dlog_M3*
ADF test statistics	-10.90668	-14.20553	-12.8885	KPSS test statistics	0.316032	0.096790	0.5040273
1% level	-3.479656	-3.478911	-3.478911	1%	0.739000	0.739000	0.739000
5% level	-2.883073	-2882748	-2.882748	5%	0.463000	0.463000	0.463000
10% level	-2.578331	-2.578158	-2.578158	10%	0.347000	0.347000	0.347000

Figure 6: ADF, KPSS Test results for first differences series

variables are stationary - monetary aggregates are non-stationary. Both tests indicate that monetary aggregates and multipliers in the sample period are unit root and are non-stationary, with the exception of κ_1 . The variables are said to be integrated of order one I(1) as taking the first difference has found them to be stationary for all test; hence the following:

1. $\ln M_3$, $\ln M_0$, $\ln M_1 \sim$ I(1)
2. $\ln\kappa_1$, $\ln\kappa_2 \sim$ I(1)

5.2 Testing for cointegration

The non-stationarity of the money multipliers does not necessarily rule out the possibility that a long run relationship between M_0 and the monetary aggregates of M_1 and M_3 exist. The conflicting results of κ_1 in particular, warrants further examination by testing for cointegration between the variables. We employ the Engle-Granger cointegration test, first estimating the long-run relationship using fully modified least squares (FMOLs). Figure 7 shows the results for M_0 and M_1 , and figure 8 for M_3 and M_1 .

Cointegration **Test - Engle-Granger**
Date: 08/24/12 Time: 10:09
Equation: UNTITLED
Specification: LOG_NARROW_MONEY LOG_RESV_MONEY C
Cointegrating equation deterministics: C
Null hypothesis: Series are not cointegrated
Automatic lag specification (lag=3 based on Schwarz Info Criterion, maxlag=13)

	Value	Prob.*
Engle-Granger tau-statistic	-1.053182	0.8918
Engle-Granger z-statistic	-3.470378	0.8461

*MacKinnon (1996) p-values.

Intermediate Results:

Rho - 1	-0.060167
Rho S.E.	0.057129
Residual variance	0.012989
Long-run residual variance	0.002407
Number of lags	3
Number of observations	134
Number of stochastic trends**	2

**Number of stochastic trends in asymptotic distribution.

Figure 7: Testing M_0 and M_1 for cointegration

Cointegration Test - **Engle-Granger**
Date: 08/24/12 Time: 10:44
Equation: UNTITLED
Specification: LOG_BROAD_MONEY LOG_RESV_MONEY C
Cointegrating equation deterministics: C
Null hypothesis: Series are not cointegrated
Automatic lag specification (lag=2 based on Schwarz Info Criterion, maxlag=13)

	Value	Prob.*
Engle-Granger tau-statistic	-1.517388	0.7567
Engle-Granger z-statistic	-6.179417	0.6306

*MacKinnon (1996) p-values.

Intermediate Results:

Rho - 1	-0.077624
Rho S.E.	0.051156
Residual variance	0.009218
Long-run residual variance	0.003205
Number of lags	2
Number of observations	135
Number of stochastic trends**	2

**Number of stochastic trends in asymptotic distribution.

Figure 8: Testing M_3 and M_1 for cointegration

In the first case, the results from the Engel-Granger τ-statistics shows a high p value of 0.8918. This means that we do not reject the null hypothesis; the series of M_0 and M_1 are not cointegrated. In the second case, the results from the Engle-Granger τ-statistics also indicate a significant p value of 0.7567 which implies that we do not reject the null hypothesis; the series of M_0 and M_3 are not cointegrated. At this juncture, this puts to rest the claim that the variables are not cointegrated, hence it is not possible to model the relationship using error correction model.

5.3 Looking at a short-run relationship

Since a long run-relationship fails to exist between the variables we move to estimate a short run relationship. Recall that table 6 verified that the variables are stationary at first differences. Thus, having satisfied the conditions for stationarity, we move to run a general to specific OLS regression of the first difference of the variables with a 4-month lag period and a constant. We start by regressing dlog_broad money and dlog_reserve money then dlog_narrow money and dlog_reserve money then compare the results. The variables are first difference stationary and so are expressed in the following form:

$$\Delta y_t = lnM_{3,t} - lnM_{3,t-1} \quad (6)$$

$$\Delta x_t = lnM_{1,t} - lnM_{1,t-1} \quad (7)$$

$$\Delta z_t = lnM_{0,t} - lnM_{0,t-1} \quad (8)$$

With the general short run regression model expressed as:

$$\Delta y_t = \alpha + \sum_{i=1}^{m} \alpha_i \Delta y_{t-i} + \sum_{j=1}^{n} \beta_i \Delta z_{t-j} + \epsilon_t \quad (9)$$

$$\Delta x_t = \gamma + \sum_{i=1}^{m} \delta_i \Delta x_{t-i} + \sum_{j=1}^{n} \mu_i \Delta z_{t-j} + u_t \quad (10)$$

5.4 Estimation results and discussion

For details on the over-specified models, see Appendix A. Tables 9 and 10 give details of the final model estimations.

Dependent Variable: DLOG_BROAD_MONEY
Method: Least Squares
Date: 04/14/13 Time: 22:50
Sample (adjusted): 2001M02 2012M06
Included observations: 137 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG_RESV_MONEY(-1)	-0.068726	0.022311	-3.080434	0.0025
C	0.009831	0.002581	3.808251	0.0002

R-squared	0.065673	Mean dependent var	0.010784
Adjusted R-squared	0.058752	S.D. dependent var	0.030919
S.E. of regression	0.029997	Akaike info criterion	-4.160929
Sum squared resid	0.121478	Schwarz criterion	-4.118302
Log likelihood	287.0237	Hannan-Quinn criter.	-4.143607
F-statistic	9.489073	Durbin-Watson stat	2.160116
Prob(F-statistic)	0.002505		

Figure 9: Final regression, broad money

Dependent Variable: DLOG_NARROW_MONEY
Method: Least Squares
Date: 08/30/12 Time: 15:07
Sample (adjusted): 2001M05 2012M06
Included observations: 134 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG_NARROW_MONEY(-1)	-0.203815	0.084134	-2.422520	0.0168
DLOG_NARROW_MONEY(-3)	-0.144757	0.083632	-1.730880	0.0859
DLOG_RESV_MONEY(-1)	-0.070223	0.028087	-2.500222	0.0137
DLOG_RESV_MONEY(-2)	-0.063901	0.028325	-2.255984	0.0258
C	0.019898	0.003525	5.645461	0.0000

R-squared	0.112488	Mean dependent var	0.016197
Adjusted R-squared	0.084968	S.D. dependent var	0.036000
S.E. of regression	0.034437	Akaike info criterion	-3.862797
Sum squared resid	0.152978	Schwarz criterion	-3.754669
Log likelihood	263.8074	Hannan-Quinn criter.	-3.818857
F-statistic	4.087525	Durbin-Watson stat	1.999338
Prob(F-statistic)	0.003750		

Figure 10: Final regression, narrow money

From the general to specific approach we narrow the independent variables (regressors) down to one. In the first case, reserve money lag 1 has a coefficient that is significant. The estimated specific regression model is expressed in the form:

$$\Delta y_t = -0.01 - 0.07\Delta z_{t-1} + \hat{\epsilon}_t \tag{11}$$

The results indicate that if the growth rate of reserve money goes up by 1 percentage point then the growth rate of broad money one period ahead goes down by 0.07 percentage points. The sign on this coefficient is not in line with our intuition, which would suggest a positive correlation. The significantly low adjusted R squared indicates that the variable has little explanatory powers in terms of explaining the underlying movement in broad money.

In the second case, using the general to specific approach, we narrow the independent variables (regressors) down to four; narrow money at 1 and 3 period lag and reserve money 1 and 2 period lag have coefficients that are statistical significant. This estimated equation is expressed as:

$$\Delta x_t = 0.02 - 0.20\Delta x_{t-1} - 0.14\Delta x_{t-3} - 0.07\Delta z_{t-1} - 0.06\Delta z_{t-2} + \hat{u}_t \tag{12}$$

The value of narrow money 1 and 3 months prior and the value of reserve money 1 and 2 month prior all have a negative effect on narrow money in current period. While the coefficients are statistically significant their magnitudes are quite small. To interpret the results, we would need to compute dynamic multipliers for the model, which is beyond the scope of this project. The R squared indicates that the regressors explain around 10 percent of the underlying movements in narrow money.

6 Conclusion

The link between the monetary base and the money supply of M1 and M3* via the money multiplier is not stable in PNG, as indicated by the tests for cointegration, demonstrating that a long run relationship between reserve money and broad does not exist. There are several possible factors that may explain this lack of transmission. For instance, the net foreign assets and net credit to Government components of money supply are largely uncontrolled by the Central bank. This item makes up a significant part of money supply and uncontrolled growth in this variable greatly impacts the level of reserve money. Recent indications are that with weak credit growth and relatively high lending rates may have also contributed to the lack of pass through.

Results from the analysis show that for the broad money aggregate; if the growth rate of reserve money goes up by 1 percentage point the growth rate of broad money one period ahead goes down by 0.07 percentage points. This may suggest that commercial bank's demand for deposits declines when their ESA balances from past period increases; it is a cost (interest cost) for banks to hold more deposits while they continue to maintain high interest free reserves assets on their ESA balances. In addition, this may explain the conduct of money market operations of the Bank of PNG which is backward looking; it views past build-up in commercial bank's ESA balances before offering the sale of its bills. The growth in narrow money also showed a similar inverse relationship with past movements in growth in narrow money and reserve money, although the magnitude of the coefficients is quite small.

Further empirical work can be undertaken by looking at the specific components of reserve money (i.e. currency holdings of commercial banks with BPNG, their deposits with BPNG and currency in circulation) and regressed against money supply aggregates. Also, the short run relationship can be further examined by computing dynamic multipliers for the model. The data may also be re-examined for any structural breaks.

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A Over specified equation results

Dependent Variable: DLOG_BROAD_MONEY
Method: Least Squares
Date: 08/30/12 Time: 10:12
Sample (adjusted): 2001M06 2012M05
Included observations: 132 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG_BROAD_MONEY(-1)	-0.064446	0.090172	-0.714695	0.4762
DLOG_BROAD_MONEY(-2)	0.151163	0.091996	1.643149	0.1029
DLOG_BROAD_MONEY(-3)	-0.004208	0.092245	-0.045613	0.9637
DLOG_BROAD_MONEY(-4)	-0.013763	0.089991	-0.152934	0.8787
DLOG_RESV_MONEY	0.031857	0.028064	1.135141	0.2585
DLOG_RESV_MONEY(-1)	-0.064184	0.032736	-1.960645	0.0522
DLOG_RESV_MONEY(-2)	-0.029616	0.034772	-0.851727	0.3960
DLOG_RESV_MONEY(-3)	-0.001485	0.033185	-0.044740	0.9644
DLOG_RESV_MONEY(-4)	-0.003354	0.028553	-0.117449	0.9067
C	0.008927	0.003575	2.496963	0.0139

R-squared	0.108409	Mean dependent var	0.010662
Adjusted R-squared	0.042636	S.D. dependent var	0.031281
S.E. of regression	0.030607	Akaike info criterion	-4.062456
Sum squared resid	0.114287	Schwarz criterion	-3.844062
Log likelihood	278.1221	Hannan-Quinn criter.	-3.973711
F-statistic	1.648227	Durbin-Watson stat	1.976671
Prob(F-statistic)	0.108982		

Figure 11: Over specified regression, broad money

Dependent Variable: DLOG_NARROW_MONEY
Method: Least Squares
Date: 08/30/12 Time: 14:57
Sample (adjusted): 2001M06 2012M05
Included observations: 132 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG_NARROW_MONEY(-1)	-0.205381	0.091226	-2.251344	0.0262
DLOG_NARROW_MONEY(-2)	0.001032	0.092538	0.011150	0.9911
DLOG_NARROW_MONEY(-3)	-0.168049	0.091231	-1.842022	0.0679
DLOG_NARROW_MONEY(-4)	-0.063063	0.088994	-0.708618	0.4799
DLOG_RESV_MONEY	-0.011359	0.032341	-0.351242	0.7260
DLOG_RESV_MONEY(-1)	-0.079913	0.037896	-2.108777	0.0370
DLOG_RESV_MONEY(-2)	-0.085125	0.040618	-2.095735	0.0382
DLOG_RESV_MONEY(-3)	-0.022382	0.038707	-0.578236	0.5642
DLOG_RESV_MONEY(-4)	-0.037409	0.032580	-1.148212	0.2531
C	0.019986	0.004657	4.291813	0.0000

R-squared	0.124510	Mean dependent var	0.016525
Adjusted R-squared	0.059924	S.D. dependent var	0.036172
S.E. of regression	0.035071	Akaike info criterion	-3.790126
Sum squared resid	0.150061	Schwarz criterion	-3.571732
Log likelihood	260.1483	Hannan-Quinn criter.	-3.701380
F-statistic	1.927831	Durbin-Watson stat	1.974919
Prob(F-statistic)	0.053981		

Figure 12: Over specified regression, narrow money