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Monetary Policy Transmission Mechanisms in Papua New Guinea

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Abstract

Monetary policy affects the economy through different transmission channels. For central banks, understanding this process is important in assessing the operations of monetary policy and its effectiveness. In general, five transmission channels are discussed in economic literature. These are the interest rate, the exchange rate, the credit, the asset price, and the expectations channels. The first two channels are perceived to be the relevant ones regarding monetary policy in Papua New Guinea (PNG). The empirical investigation uses Ordinary Least Square (OLS) regression analysis to examine the transmission process in PNG. The results suggest that changes in the kina exchange rates are transmitted to inflation, the variable of concern, more directly than the transmission from interest rate to inflation in the PNG economy.

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Monetary Policy Transmission Mechanisms in Papua New Guinea

1. Introduction

The monetary policy transmission mechanism is the process of the flow-on effects of a change in the value (level or rate) of a monetary policy instrument to an intermediate economic target variable. The change in the intermediate target via changes in a monetary variable ultimately leads to a change in a final target variable such as output and employment. In this context, inflation can be regarded either as an intermediate target if it influences demand, output and employment or as a final variable if the above final variables then influence prices. The direction of change could be both ways if there is a first and a second round effect. From the perspective of a central bank and its monetary policy stance, the monetary variable (e.g., money supply, interest rate) in the above chain can be regarded as an intermediate monetary target variable and inflation can be taken as the final target variable of monetary policy.

Monetary policy is either the direct control or indirect influence of monetary variables such as money supply and interest rates by the monetary authority to affect macroeconomic variables, including the price level and output. A change to a particular monetary policy instrument indicates the stance in domestic monetary policy. To achieve the goal of monetary policy, the monetary authority must have an understanding of the channels through which changes in a monetary instrument lead to changes in key economic variables. The transmission process therefore, provides a good indication of the influence of monetary policy on overall economic activity. With an understanding of the transmission process, monetary authorities can then formulate and implement appropriate monetary policy to achieve their objectives. Under the *Central Banking Act 2000*, the objective of monetary policy in Papua New Guinea (PNG) is that of achieving and maintaining price stability.[1]

[1] Price stability is defined in the Monetary Policy Statement (MPS) of 31st January 2005 as low and gradual change in the price level and thus low inflation attained over a reasonable period of time. Readers can refer to the MPS, which is reproduced in the December 2004 Quarterly Economic Bulletin.

Monetary authorities use both direct and indirect instruments to conduct monetary policy. Direct instruments are statutory requirements and have a direct and immediate impact on monetary aggregates, by mainly influencing the volume of money. Indirect instruments, on the other hand, are market-based and are used to influence economic variables, mainly through pricing mechanisms such as interest rates to influence various monetary aggregates. The direct instruments used by the Bank of PNG (BPNG) include the Minimum Liquid Asset Ratio (MLAR)[2] and Cash Reserve Requirement (CRR)[3]. Indirect instruments include Open Market Operations (OMOs)[4], which involves trade in government securities and Central Bank Bills[5], Repurchase Agreements (Repos)[6], the foreign currency market, and moral suasion. Adjustment to a monetary policy instrument affects intermediate monetary target variables. In PNG, intermediate monetary target variables have included money supply, credit growth, and interest rates. Changes in these monetary variables then influence intermediate (economic) target variables such as income and consumption, which in turn affect the final target variables of output and employment. However, this may not be the only direction of influence; it could also go from output and employment to income and consumption.

In this paper, we take inflation as the final target variable in the transmission process in so far as the role of monetary policy is concerned. Our discussion of the transmission process will run from a policy instrument to inflation via other monetary variables. We do this because not only are the final variables such as output outside of BPNG's direct influence but also because the link from income and consumption to the level of activity and aggregate demand and eventually to inflation is complicated. Although this process can be

[2] A prudential requirement imposed on commercial banks to hold liquid assets as a percentage of total deposits and other prescribed liabilities at all times.
[3] A requirement imposed on commercial banks to hold cash as a percentage of total deposits and other prescribed liabilities at all times at BPNG.
[4] Operations of liquidity management conducted by BPNG with commercial banks and other financial intermediaries involving government securities, Kina Facility, Repo and foreign exchange trading to influence short-term interest rates.
[5] A monetary policy instrument introduced by BPNG in August 2004, which works in the same manner as Treasury bills for liquidity management.

influenced by monetary policy to an extent, it is more tenuous and intricate involving other policies such as those of fiscal and wages. In addition, some of the data necessary to properly examine the detailed relationships are lacking. We want to keep the story simple by concentrating on the link from monetary variables to inflation. Where the exchange rate is intentionally used (through foreign exchange market intervention) for price stability reason for instance, we will treat exchange rate as a policy instrument.

The aim of this paper is to shed some light on the nature and strength of the monetary policy transmission processes in the PNG economy. The rest of the paper has two main sections and a short conclusion. Section 2 provides a theoretical overview of the five monetary transmission channels. The discussion of the transmission process starts from a monetary policy instrument right through to a final target variable as seen in theory. Where appropriate these are related to the experiences in PNG. Section 3 provides an empirical analysis in the form of graphical illustration of key variables followed by ordinary least squares (OLS) regression analyses of the interest rate and exchange rate channels. In both parts of section 3, our work does not cover the many links in between the change to a monetary policy instrument and the final stages of output, employment, and stability in the market that theory talks about. We simply take inflation as a final variable being influenced by changes to a monetary policy instrument and an intermediate monetary variable.

2. The Transmission Channels - Theory

Five transmission channels have received attention in economic literature. These are the interest rate, the exchange rate, the credit, the asset price and the expectations channels. Whilst all these will be discussed in turn, the interest rate and exchange rate channels will receive more attention because of their perceived relevance and applicability in PNG and because of data availability. It is through these two channels that monetary policy is perceived to work in the PNG

[6] A money market instrument used by BPNG to lend or borrow from the commercial banks, for liquidity management, and is unwound on maturity. The transactions range from overnight to 14 days and can be either collateralised or unsecured (e.g., with Treasury bills).

economy. The discussion in the theoretical review will set the basis for the selection of variables for our analysis in the empirical section.

2.1 Interest Rate Channel

In the interest rate channel, the key policy short-term nominal interest rate is influenced, controlled or set at a desired level by the central bank. An adjustment in this policy interest rate, which signals a change in the stance of monetary policy, triggers changes in the other term structure of interest rates by affecting the supply and demand of liquidity in the banking system.

The expectation hypothesis regarding the term structure of interest rates states that the long-run interest rate is the average of the expected future short-term interest rates. Changes in short-term interest rates will thus cause a change in long-term interest rate. This will then influence price variables in the financial market and real sector variables, including final output.

There are three ways a change in interest rate, as a result of a change in the monetary policy stance[7], can transmit changes to output and inflation: substitution effect; income effect; and change in capital cost.

The substitution effect occurs when a rise (fall) in interest rate attracts (reduces) savings and relatively less (more) is spent on consumption.

The income effect as stipulated by Milton Friedman's permanent income hypothesis is that consumers' decisions are based on current and discounted future incomes (Dornbusch and Fischer, 1994, p307). Higher (lower) interest rate reduces (increases) future discounted income and therefore consumption will fall (rise). However, if consumers are net creditors, a tight monetary policy should increase their wealth and therefore income. On the other hand, if consumers are net debtors, the rise in interest rate should reduce their cash flow and they will spend less.

From another perspective, money-demand increases with income and decreases with interest rates. An increase (a fall) in interest rate therefore leads

[7] Changes in market interest rates can be caused by other factors such as increased demand for loanable funds with supply being constant, without a change in the monetary policy stance. But in our framework the discussion starts with a change in monetary policy and the instrument for it.

to a decline (an increase) in price at a given level of income. If the money supply is fixed, a rise in aggregate income, through an increase in the demand for liquidity, raises the interest rate at which the quantity of money demanded equals the supply. A higher price level reduces real money balances. Thus, for a given level of income, the interest rate at which the quantity of money demanded equals the supply rises.

The substitution and income effects, singularly or collectively, of a rise (fall) in interest rate is a reduction (an increase) in aggregate consumption. The fall (rise) in consumption, reflecting a decline (an increase) in aggregate demand, would in turn cause the output gap to fall (increase) and lead to a fall (an increase) in inflation. The substitution and income effects are illustrated in the following schematic diagram.

Δ MP → Δ Short-term interest rate (i) → Δ Deposit (i) → Substitution & Income effect → Δ Consumption → Δ Output (Y) → Δ Inflation

Along Keynesian lines, the cost of capital transmission is as follows. A tight (easy) monetary policy leads to a rise (fall) in real interest rate, which then raises (lowers) the cost of capital, thereby causing a decline (an increase) in investment spending and resulting in a decline (an increase) in aggregate demand. The fall (rise) in aggregate investment and demand will cause a fall in the output gap, which will in turn lead to a fall (rise) in inflation. This is shown in the following schematic diagram.

Δ MP → Δ Short-term interest rate (i) → Δ Lending (i) → Δ Cost of capital → Δ Investment (I) → Δ Output (Y) → Δ Inflation

In PNG, the policy instrument at the first step of the interest rate channel is the official signaling rate, the Kina Facility Rate (KFR). BPNG announces on the first Monday of each month the level of the KFR, signaling its stance of monetary policy. It next sets the Repurchase Agreement Facility (repo) rate for commercial banks at a margin from the KFR. BPNG then uses the weekly Treasury Bills and

Central Bank Bill (CBB) auction to influence the interest rates of the different maturities, particularly the 28-day bill, to be in line with the KFR by setting the volume of the Bills to be sold and influencing the level of funds in the commercial banks' Exchange Settlement Accounts (ESAs).

In the second stage, commercial banks adjust their Indicator Lending Rates (ILRs) in response to the change in the KFR and the consequent Treasury bills' rates, although not necessarily by the exact magnitude of change. The change in the Repo rate, the Treasury bill rates and the ILR will lead to a realignment of commercial banks' deposit and lending rates. Theoretically, the changes in the deposit and lending rates then affect decisions on savings and borrowings, which will impact on aggregate investment, demand and the output gap, and finally on inflation.[8]

2.2 Exchange Rate Channel

In small open economies, movements in exchange rates influence both the prices and volumes of exports and imports. Changes in the trade account can then impact on aggregate demand and final output. The extent of the movements in the domestic currency's foreign currency values depends on the exchange rate regime of the country. We discuss the exchange rate channel in the context of a floating exchange rate regime, as that is the current system in PNG.

Under the floating exchange rate regime, changes in the kina exchange rates can come about from three main sources. These are: a) the external appreciation or depreciation of the currencies of the key trading partners of PNG; b) fluctuations in the volumes and values of exports and imports; and c) changes in both domestic monetary and fiscal policies.

PNG has no control over the first cause of change. It is in the second and third areas that authorities could make decisions to influence the variables involved to exert some level of influence on movements of the nominal kina exchange rates.

Changes in the kina exchange rates can transmit influential changes in the economy. An appreciation (depreciation) of the kina against a key currency such as the US or Australian dollar due to external market forces would translate to a decline (an increase) in the prices of PNG's imports. Lower (higher) import prices would lead to lower (higher) domestic prices, which in turn will result in a fall (rise) in domestic inflation, *ceteris paribus*. On the other hand, foreign currency prices of PNG's exports would rise (fall) leading to a decline (rise) in external demand, which in turn should induce a negative (positive) change in the balance of payments position.

Domestically, the monetary policy stance of BPNG, given no change in the fiscal position, can dictate liquidity management, which in turn could impact on the nominal exchange rate. BPNG can influence the exchange rate through intervention in the foreign exchange market (buying and selling kina in exchange for foreign currency) or through interest rate movements. Interest rate movements affect the exchange rate by altering the relative returns on domestic and foreign investment assets. If the monetary policy stance is one of tightening, then BPNG would absorb the excess liquidity through the sale of Treasury bills and CBBs, one of its OMOs. This can force the interest rates to move up, making the return on domestic assets attractive relative to foreign assets, thereby, causing an increase in the demand for kina and exerting an upward pressure on the exchange rate. Alternatively, BPNG can buy kina with foreign currency, to help stabilise or exert upward pressure on the kina exchange rate. BPNG has intervened in the foreign exchange market to stabilise the exchange rate while the underlying market trend was for the kina to depreciate or to appreciate. In addition, BPNG's intervention in some instances was to enable the commercial banks to meet their foreign exchange exposure limits. Where it intentionally intervenes in the foreign exchange market, the exchange rate can be regarded as a policy instrument.

A change in the fiscal stance, government expenditure relative to revenue in particular, as well as the source of financing can also impact on exchange

[8] A view held by many, including the former Director of the Institute of National Affairs John Millet, is that inflation in PNG is cost-push more than demand-pull.

rate. This can happen if an increase in government expenditure is financed domestically, for instance, through the sale of Treasury bills. A rise in the issuance of Treasury bills will diffuse liquidity in the banking system and that could exert upward pressure on the nominal exchange rate. On the other hand, an increase in foreign exchange flows via the central bank can lead to an increase in liquidity in the banking system (when the central bank pays out kina). If there is a net increase in the liquidity level of the banking system and a large part of government funds are spent on imports, there will be a downward pressure on the nominal exchange rate.

Below is a schematic diagram of the transmission from a change in monetary policy to the exchange rate, which then influences exports and imports, then output and finally inflation.

Δ MP → Δ Short-term interest rate (i) → Exchange rate Depreciation (Appreciation) ↔ Δ Export (Import) → Δ Output (Y) → Δ Inflation

Given the openness of the small PNG economy, inflation is perceived to be more directly linked to exchange rate movements via the prices of imports and exports than through the output gap. With respect to domestic factors, movements in the exchange rate are perceived to be caused more by movements in the trade account and central bank intervention than through interest rate differentials between PNG and foreign countries. For this channel therefore, we will examine the link between exchange rate and inflation in the empirical section to see how strong it is.

2.3 Credit Channel

The main mechanism of the credit channel is the lending activity of commercial banks and other financial institutions. The transmission process here is the same as that of the cost of capital in the interest rate channel (refer to the second schematic diagram on page 6). Lending by commercial banks influence growth in credit which in turn leads to an increase in money supply as well as contributing

to investment and activity. Credit growth depends on interest rate among other things.

Commercial banks are better placed to deal with certain types of borrowers, such as small firms where the problems of 'asymmetric information' can be especially pronounced. Large firms are in a rather different situation to small firms, since they can directly access credit markets, by issuing stocks and bonds, without going through the banks. However, large firms in PNG may not have this option as the financial market is less developed.

The basic idea is that financial institutions may re-evaluate their credit criteria and therefore reduce their extension of credit. Much of the literature has been focused on whether bank-dependent firms are affected differently, compared to firms that have access to capital markets. That is, firms that can issue their own commercial paper to raise needed capital. In PNG, there is probably a similar dichotomy, but between firms that have access to foreign lending institutions (for example, the large mining companies) and those that do not.

2.4 Asset Price Channel

The transmission mechanism of the asset price channel is from a change in monetary policy to a change in investment spending through the impact on stock prices. James Tobin developed a theory of the link between monetary policy and the economy through stock prices and investment spending (Mishkin, 2001, p652). The theory is known as Tobin's 'q' theory, with q defined as the market value of a firm divided by the firm's replacement cost of capital. It states that if q is high, the market price of the firm is high relative to the replacement cost of capital. New plant and capital equipment are therefore cheap relative to the market value of business firms. In this situation, companies can issue stock and get a high price for it relative to the cost of the plant and equipment they are buying. Investment spending will tend to rise because the firm can buy more new investment goods with a given amount of stock. On the other hand, when q is low, the firm will refrain from purchasing new investment goods. This is because the market value of the firm is low relative to the cost of capital. To

acquire capital when *q* is low, a company can instead buy another firm cheaply and obtain old capital.

An important link exists between Tobin's *q* theory and investment spending, and between share prices and interest rates (*ibid*, p653). When monetary policy is eased, the public would have more money to spend. The stock market is an avenue in which the public can spend some of this money. This would increase the demand for stocks and result in their prices rising. Higher stock prices (Ps) will lead to a higher *q* and therefore increased investment spending (I). The following schematic diagram shows the monetary transmission mechanism through the asset price channel.

Δ MP → Δ Short-term interest rate (i) → Δ Stock prices (Ps) →
Δ *q* → Δ Investment (I) → Δ Output (Y) → Δ Inflation

This channel of monetary policy transmission is perceived to be weak in PNG as there is no or little link, if any, between monetary policy and stock prices. The link is not discussed in the formulation and implementation of monetary policy. Nor is it dwelled on enough in terms of information and discussion in the financial market. So there will not be any empirical analysis of this channel.

2.5 Expectations Channel

Although not explicitly discussed, the four channels described above involve inter-temporal decision-making, that is, decisions based on present and future economic conditions. In dealing with the interest rate channel, for example, long-term interest rates are thought to relate to expectations of future short-term interest rates. Expectations of future policy actions and their impact on interest rate can affect investment and consumption decisions. Expectation of inflation is therefore a crucial factor in the monetary policy transmission mechanism. Theoretically, changes in inflation expectations are transmitted into investment and consumption decisions, thus influencing aggregate demand and inflation, as well as other economic variables. As such, the ability of monetary policy in

influencing the inflation expectation is paramount to achieve price stability. Confidence in monetary policy can lead to expectations of stable inflation.

In an inflation-targeting framework for example, the more credible monetary policy is, the closer is the inflation expectation towards the inflation target that the central bank sets. If there is confidence in monetary policy that inflation will be kept low, economic agents and business firms will not consider it necessary to change the prices of their goods and services too often. They may, for instance, consider a rise in costs to be only temporary. In the same way, expectations of stable inflation can result in moderate price increases, which can aid in the central bank's aim of achieving price stability.

Projections of economic variables, which involve some elements of expectations, are used in monetary policy formulation in PNG. Firms are concerned about future inflation and interest rates. How that is then related to business and investment decisions taken by firms is not clear in terms of information and data on economic variables in the economy. Hence, the discussion on this channel ends here.

3. Empirical Analysis

We will now attempt to provide an empirical analysis of the extent of monetary policy transmission processes in the PNG economy. Our focus is on the first two channels, interest rate and exchange rate channels, because of data availability and as these are the two channels monetary policy is perceived to work through. First, we employ a two-dimensional graphical analysis between a policy instrument and a final variable for each of the two transmission channels and calculate the correlation coefficients for each of the relationships. Second, a regression analysis is used to examine in a more rigorous way the relationship between policy variables and outcomes. In each case, inflation, as measured by the Consumer Price Index (CPI), is taken as the final variable.

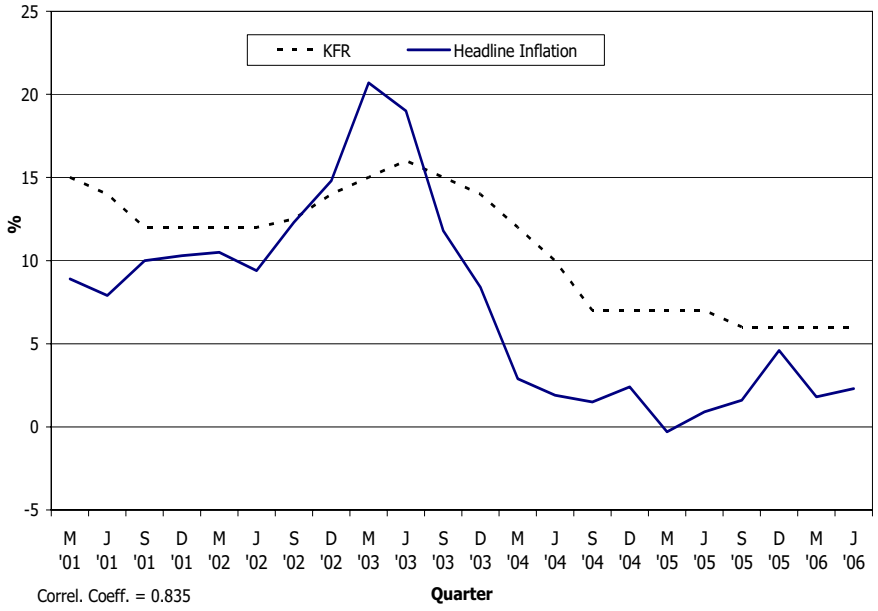
3.1 Kina Facility Rate (KFR) and Inflation

We examine the interest rate channel by assessing whether there is any linear association between the KFR, BPNG's policy interest rate, and headline inflation.

BPNG signals its stance of monetary policy through the KFR each month. The KFR is based on an assessment of realised macroeconomic developments (economic activity, fiscal effects, balance of payments, interest rates and inflation) and an outlook on inflation.

To provide some insights into the relationship between the KFR as the policy instrument and inflation as the final variable, figure 1 plots the KFR, since its introduction in 2001, against headline inflation.

Figure 1: KFR and Inflation



Sources: Bank of PNG and National Statistical Office (NSO).

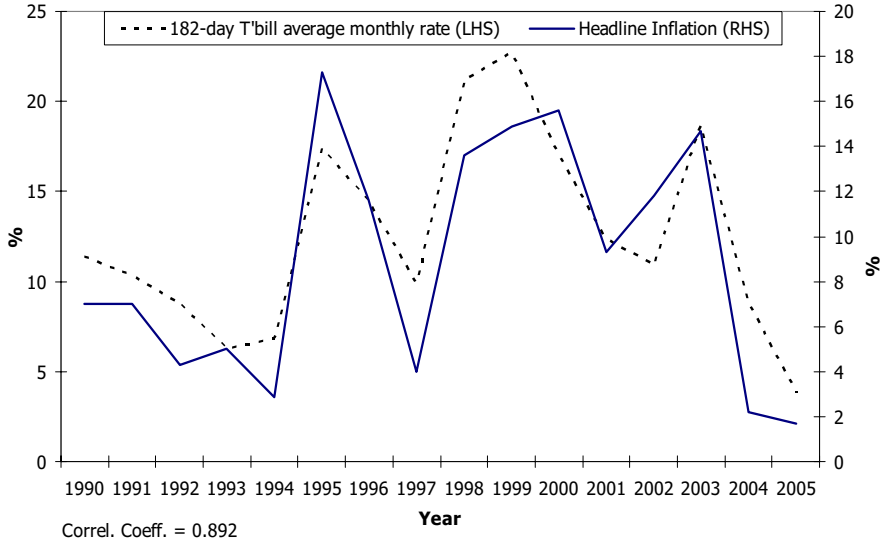
It appears from the figure that inflation moves in line with the KFR or vice versa. This is affirmed by a correlation coefficient of 0.835, which means there is a positive linear association between the two variables.

3.2 Open Market Operations (OMOs) and Inflation

BPNG's OMOs has included mainly the trade in government securities, specifically Treasury bills and Inscribed stock. More recently, the Central Bank Bill was

introduced. As discussed earlier, the next step in the interest rate transmission process, following the announcement of the KFR, is the use of the weekly Treasury bills auction by BPNG to influence market interest rates to be in line with the monetary policy stance. We therefore examine next whether there is any association between Treasury bill rates and inflation, as part of the interest rate channel.

Figure 2: Interest Rate (182-day Treasury bills) and Inflation



Correl. Coeff. = 0.892

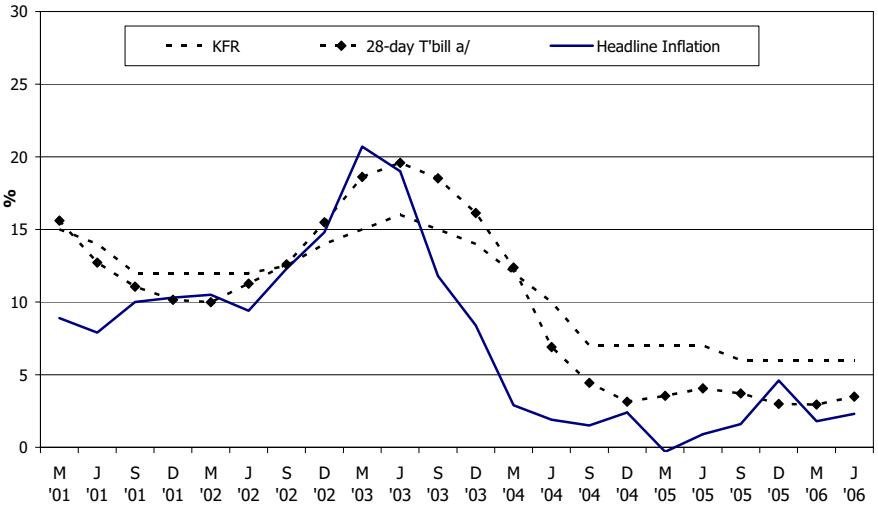
Sources: Bank of PNG and NSO.

Figure 2 depicts interest rate and inflation since 1990. The 182-day Treasury bill rate is plotted against headline inflation. There is a positive linear association between the 182-day Treasury bill rate and inflation as depicted by a correlation coefficient of 0.892 for the period reviewed.

A similar relationship is observed for the 28-day bill rate and headline inflation. Figure 3 shows the 28-day Treasury bill rate and inflation, as well as the monthly KFR. As shown in figure 3, there is also a positive association between the 28-day bill rate and inflation indicated by the correlation coefficient of 0.863. The stronger relationship in the 28-day bills, vis-à-vis the 182-day bills, reflects the consideration of inflation in the monthly KFR decision, and the

implementation of the monthly monetary policy stance through the 28-day bill rate.

Figure 3: 28-day Treasury bill rate and inflation



Correl. Coeff. CPI, 28-day bills 0.863
Correl. Coeff. KFR, CPI 0.835

a/ From September 2005, refers to 28-day CBB rates

Sources: Bank of PNG and NSO.

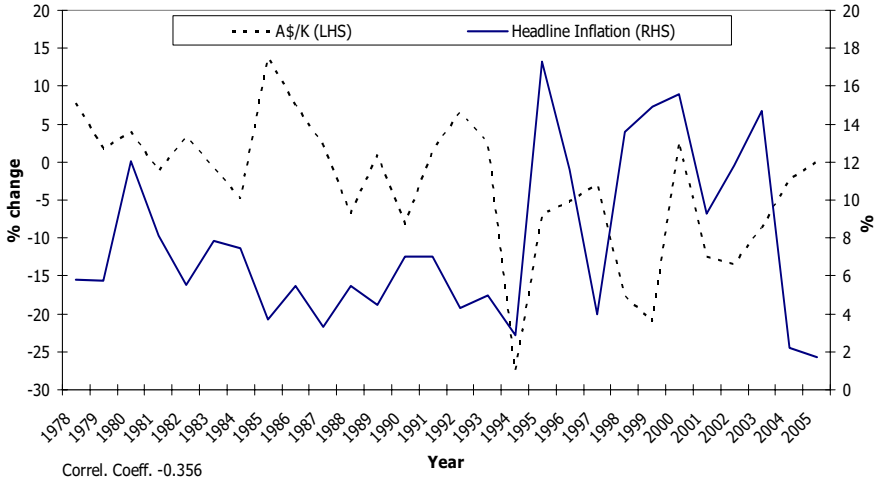
The positive association between the interest rates and inflation is in contradiction to theory. In theory, a rise in interest rate as a result of a tightening of monetary policy should lead to a fall in: money supply; aggregate investment; output gap; and consumption and eventually a fall, not a rise, in inflation. A possible reason for the positive association rather than negative association is provided in the next sub-section on OLS regression analysis.

3.3 Exchange Rate and Inflation

We now examine if there is any linear association between the nominal exchange rate and inflation for the exchange rate channel.

In figure 4, the Australian dollar/kina exchange rate is plotted against headline inflation. Australia is PNG's major trading partner, both as a source of imports and destination of exports.

Figure 4: Exchange Rate (A$/K) and Inflation



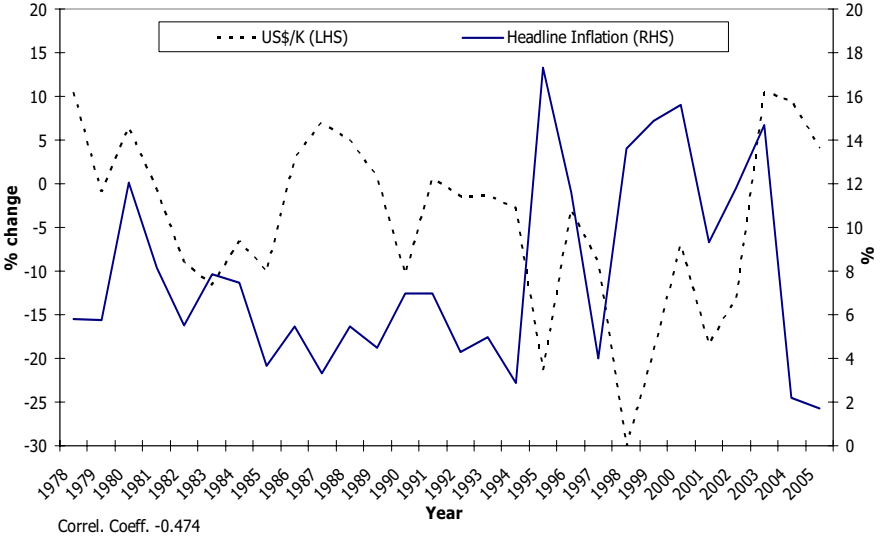
Sources: Bank of PNG and NSO.

It appears from the graph that the inverse association as discussed in theory does hold for PNG. This is supported by the correlation coefficient of -0.356 between the exchange rate and inflation over the twenty-eight year period.

A similar association exists between the US dollar/kina exchange rate and inflation, as shown in figure 5. Whilst much of the trade is done with Australia and neighbouring countries in Asia, the main currency of transaction is the US dollar. It is also the 'intervention' currency used by BPNG for its operations in the foreign exchange market.

As shown in figure 5, there is also a negative association between the US dollar to kina exchange rate and inflation, depicted by the correlation coefficient of -0.474. The stronger relationship of the US dollar, compared to the Australian dollar, reflects the prominence of the US dollar in international trade.

Figure 5: Exchange rate (US$/K) and Inflation



Besides the inverse relationship, there also appears to be a lag in the influence on inflation from a change in the exchange rate. Some light on this will be shed in the regression analysis.

3.4 Regression analysis

We further conduct regression analysis for the interest rate and exchange rate channels to complement the graphical analysis and to assess the extent of their influence on inflation.

In the search for the best results, OLS regressions were run on two functional forms of the chosen models; percentage change and first difference of the log of the variables. But for the write-up of the results, either one is use as both serve the same purpose, which is to solve for non-stationary problem in the variables, and give very similar results. Diagnostic tests for autocorrelation and heteroscedasticity are conducted on the error term to ensure the results are unbiased.

3.4(a) Interest rate channel

The thinking behind the chosen model is that after the KFR is set the Treasury bill auction will yield results with respect to the interest rates that are reflective of the stance of monetary policy. There will eventually be a realignment of commercial banks' deposit and lending rates, which will affect decisions on savings and borrowings. The impact of these on investment and thus output gap will ultimately influence inflation. As the process is tenuous, we just pick the key variables to examine if there are any statistical relationships. The model captures the key interest rates in the OMO and the objective variable, inflation as measured by the CPI. The model in general is;

$$cpi_t = \alpha_1 + \beta_1 tbill_t + \beta_2 tbill_{t-1} + \beta_3 tbill_{t-2} + ...\beta_n tbill_{t-n} + \varepsilon_t \qquad (1)$$

where:

cpi_t is the percentage change of the CPI_t from CPI_{t-1} or the first difference of $\log CPI_t$ and $\log CPI_{t-1}$;

α_t is the constant term;

$tbill_t$ is the percentage change in the Treasury bill rate in period t or the first difference of the log of the Treasury bill rate of 28, 63, 91 or 182-day Treasury bill weekly average rate;

$tbill_{t-1}$ to $tbill_{t-n}$ is the percentage change in the Treasury bill rate lagged by one period to $t-n$ period or the first difference of the log of Treasury bill rates of the respective maturities;

β_1 to β_n are the respective coefficients of the explanatory variables defined above; and

ε_t is the stochastic error or disturbance term.

Quarterly data of the variables for the period 1994(Q2) to 2005(Q1) are used. CPI as the dependent variable was run on the 28-day bill rate and its 1 to 3 period lags using both functional forms. The same exercise was repeated separately for the 63, 91 and 182-day Treasury bill rates.

In the various regressions that were run, very similar results were obtained for both functional forms. So, either one of them can be used for the discussion of the results. The key results are that:

(i) For all four maturities, the lagged rates are insignificant, especially 2 periods lag and higher, leaving only the current period rate in most cases and 1 period lag in one case as the significant independent variable; and

(ii) In contrast to *a priori* expectation, the sign of the coefficient of the independent variable is positive in each case.

The best of the regression results for each of the Treasury bill maturity are displayed in table 1.

Diagnostic tests were carried out. The Breusch-Godfrey serial correlation LM Test statistics show that the problem of autocorrelation. That is, the disturbance term of an observation is related to that of another observation is not present in the regressions that were run. The test statistics are all well above the 1.0 percent significance level so we accept the null hypothesis that there is no autocorrelation. Similarly, for the problem of heteroscedasticity, the White heteroscedasticity statistics are above the 1.0 percent significance level. So we reject the null hypothesis of varied variance of the error term.

We also carried out the Ramsey RESET test for omitted variables and model misspecification. As we have employed a simple approach of regressing the dependent variable on only one key independent variable in each regression, the tenuous transmission process that we alluded to earlier may not be well captured. The test statistics are all above the 1.0 percent significance level, which means that the explanatory variables are not significant and the problem does exist.

The following interpretations of the regression results are made.

Table 1: Results for Interest Rate Channel				
Variable	Coefficients for			
	28-day T'bill Rates	63-day T'bill Rates	91-day T'bill Rates	182-day T'bill Rates
Constant	0.011*** (0.001)	2.470*** (0.353)	2.461*** (0.364)	2.451*** (0.367)
Percentage change$_t$		0.068*** (0.047)	0.065*** (0.018)	0.061*** (0.017)
First difference of log_{t-1}	0.064*** (0.016)			
Estimation period	1994 Q3 – 2005 Q1	1994 Q2 – 2005 Q1	1994 Q2 – 2005 Q1	1994 Q2 – 2005 Q1
Adjusted R^2	0.26	0.26	0.22	0.21
Regression standard error	0.010	2.340	2.408	2.426
Diagnostic tests				
Serial correlation: Higher order – Breusch-Godfrey LM test	0.461	0.434	0.395	0.333
White heteroscedasticity test	0.231	0.274	0.227	0.238
Ramsey RESET test	0.5020	0.2391	0.4685	0.5247
Notes: Standard errors in parentheses. *** indicates significance at the 1% level.				
Source: Authors' calculations.				

The results show that in nearly all cases, the current period's Treasury bill interest rate is significant at the 1.0 percent significance level in influencing inflation and that the lagged interest rates are insignificant. However, the level of the influence is low and is contrary to theory. A 1.0 percent increase in any one of the Treasury bill rates will lead to an increase in inflation of around 0.06 of a percent instead of a decline in inflation as postulated by theory. There are two inferences to deduce from this. The first is about the direction of statistical dependence. In practice, the actual outcomes on inflation are taken into account in the setting of the KFR. This is filtered through in the determination of the Treasury bill rates. Prior to the introduction of the KFR in 2001, inflation was also a consideration in the volumes of Treasury bill on offer and therefore the determination of the rates. The positive coefficient of the interest rate appears to

capture the inbuilt knowledge of realised inflation prior to the determination of interest rates in the Treasury bill auction. The positive relationship between interest rate and inflation may be because the direction of statistical dependence is perhaps not from interest rate to inflation but from inflation to interest rate.[9] The second inference is about the uniformity in the magnitude of the coefficient. It is around 0.06 of a percent for all the Treasury bill maturities. This suggests that although the rates for the four maturities can be different they tend to move together in the same direction. That is, there is some positive correlation between the rates.

As far as the goodness of fit is concerned, the models can explain only 21 to 26 percent of variation in inflation, or rather the influence of inflation on the changes in Treasury bill rates as inferred above.

The low explanatory power of the models and the magnitude of the coefficients of the independent variables point to the problem of omitted variables and model misspecification as pointed out earlier. Even when longer lags of the explanatory variables were included in the regressions the results were no better.

3.4(b) Exchange rate channel

The rationale behind the model is that changes in the kina exchange rates influence the prices of imports and when importers pass the changes to consumers there can be changes in domestic inflation. Also, where monetary policy accounts for exchange rate movements in consideration of policy objectives and exchange rate is influenced by the central bank's actions, exchange rate can be considered a policy instrument as pointed out earlier. We therefore want to examine the extent of the transmission from exchange rate to inflation. The model is specified generally as:

$$cpi_t = \alpha_1 + \beta_1 exchrate_t + \beta_2 exchrate_{t-1} + ...\beta_n exchrate_{t-n} + \varepsilon_t \qquad (2)$$

where:

[9] Granger causality test was run between interest rate and inflation but the results were inconclusive.

cpi_t is the percentage change of the CPI_t from CPI_{t-1} or the first difference of $\log CPI_t$ and $\log CPI_{t-1}$;

α_t is the constant term;

$exchrate_t$ is the percentage change in the specific exchange rate or the first difference of the log of the exchange rate in period t;

$exchrate_{t-1}$ to $exchrate_{t-n}$ is the percentage change in the exchange rate lagged by one period to $t-n$ period or the first difference of the log of the lagged exchange rates;

β_1 to β_n are the respective coefficients of the explanatory variables defined above; and

ε_t is the stochastic error or disturbance term.

To estimate the equation, quarterly data for the period 1990(Q2) to 2005(Q2) are used. For the exchange rates, quarterly averages are derived from the daily exchange rates so that the frequency of observations is consistent with the quarterly CPI observations. The exchange rates used are the key ones of US dollar/kina, Australian dollar/kina and a weighted average of the exchange rates of the kina with some key foreign currencies.

The best of the regression results are shown in table 2 for the Australian dollar and inflation and the US dollar and inflation.

The signs of the coefficients for both the US dollar/kina and Australian dollar/kina rates are as expected. That is, an appreciation of the exchange rate would lead to a decline in inflation while an increase in inflation would follow a depreciation of the exchange rate. Most of the coefficients are significant at least at the 10 percent significance level and the magnitude of impact are greater than those of the interest rates shown earlier, ranging from 0.05 to 0.19. A 1.0 percent depreciation in the exchange rate would lead to a 0.05 to 0.19 of a percent increase in inflation in the current period. A 1.0 percent appreciation in the exchange rate would have the opposite effect, that is, a 0.05 to 0.19 of a percent fall in inflation in the current period. We also see that there is a three-quarter lag in the influence of the US dollar/kina and Australian dollar/kina

exchange rates on inflation. In aggregate, the impact is 0.39 to 0.42 of a percent change in inflation over three quarters for every one percent change in the exchange rate.

Most of the diagnostic tests showed no problem of autocorrelation and heteroscedasticity. Autocorrelation was present in one case but it was not that significant to dismiss the results. The models could explain 28 to 31 percent of the changes in inflation. The problem of omitted variables and model misspecification appears in the US dollar/kina model while it does not exist in the Australian dollar/kina model.

Table 2: Results for the Exchange Rate Channel

Variable	Coefficients for		
	US Dollar/kina	Australian Dollar/kina	Weighted Exchange Rate
Constant	1.435*** (0.299)	1.408*** (0.308)	0.906*** (0.147)
Percentage change$_t$	-0.049 (0.046)	-0.071* (0.045)	-0.092*** (0.023)
Percentage change$_{t-1}$	-0.191*** (0.476)	-0.158*** (0.045)	-0.170*** (0.023)
Percentage change$_{t-2}$	-0.060 (0.048)	-0.086** (0.045)	-0.125*** (0.023)
Percentage change$_{t-3}$	-0.099** (0.047)	-0.121*** (0.044)	-0.079*** (0.024)
Percentage change$_{t-4}$			-0.057** (0.023)
Estimation period	1990 Q2 – 2005 Q2	1990 Q2 – 2005 Q2	1989 Q2 – 2004 Q4
Adjusted R^2	0.310	0.280	0.695
Regression standard error	2.006	2.049	0.920
Diagnostic tests			
Serial correlation: Higher order – Breusch-Godfrey LM test	0.063	0.129	0.866
White heteroscedasticity test	0.284	0.118	0.145
Ramsey RESET test	0.2394	0.0003	0.0007

Notes: Standard errors in parentheses. * indicates significance at the 10% level. ** indicates significance at the 5% level. *** indicates significance at the 1% level.

Sources: US dollar and Australian dollar; Authors' calculations. Weighted Exchange Rate; Sampson, Yabom, Nindim and Marambini, 2005.

The results of the inflation as the dependent variable and the weighted exchange rate as the independent variable are quoted from another BPNG research on exchange rate pass-through in PNG.[10] These results are reproduced in table 2.

Results of the diagnostic tests proved the null hypotheses that there were no problems of serial correlation and heteroscedasticity in the error term. The model is also well specified as the Ramsey RESET test coefficient shows. As shown, there is a better fit than the ones we found for the individual kina/Australian dollar and kina/US dollar equations. The R^2 is 0.69, that is 69 percent of the variations in inflation in the PNG economy can be explained by the model. The sign of the coefficients are consistent with theory and the coefficients are significant at the 1 to 10 percent significance levels. Importantly, the transmission to inflation is around 0.5 percent in aggregate over four quarters for every one percent change in the weighted average exchange rate.

4. Conclusion

The transmission mechanism of monetary policy is a complex process. In PNG, as in most developing countries, adequate data on some variables such as output are not readily available. We have therefore focused our analysis on data that are more readily available and tried to consider how these interact and are affected by policy decisions of BPNG. For ease of analysis and consistent with BPNG's mandate of price stability, we have taken inflation as the final variable in the monetary policy transmission process in this paper.

The empirical analysis suggests that the transmission of changes in the kina exchange rates to inflation is more pronounced and direct than the transmission of changes in interest rates to inflation. There is a 3 to 4 quarter lag in the flow-on effect of exchange rate movements on inflation and the influence is significant in magnitude. The interest rate channel is less clear and the direction of change appears to be in contradiction with theory. Both the graphical and regression analysis show the direction of change is perhaps from inflation to

interest rate rather than the other way around. This may be due in part to the practice of accounting for realised inflation outcome in the setting of monetary policy, that is, interest rate changes are in reaction to changes in inflation. It could also imply that the supply and demand mechanism is not really strong in the PNG money market. The price of money, interest rate, may not be strongly related to demand of funds. It may be more determined by the costs, including inflation, and return to the commercial banks. This would be consistent with the view that inflation in the PNG economy is cost-push rather than demand-pull. The results of the exchange rate channel tend to support that.

The relatively simple approach employed in the empirical part of the paper has lent itself to the issue of omitted variables and model misspecification. While current research into the exchange rate pass-through in the economy suggests that exchange rate changes is the dominant factor in influencing inflation in the PNG economy, the role of interest rates and other channels can become important as financial intermediation deepens. Further research could explore this and other issues relating to the transmission process, including an incorporation of domestic demand variables in the empirical investigations.

[10] See BPNG Working Paper 2006/02.

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