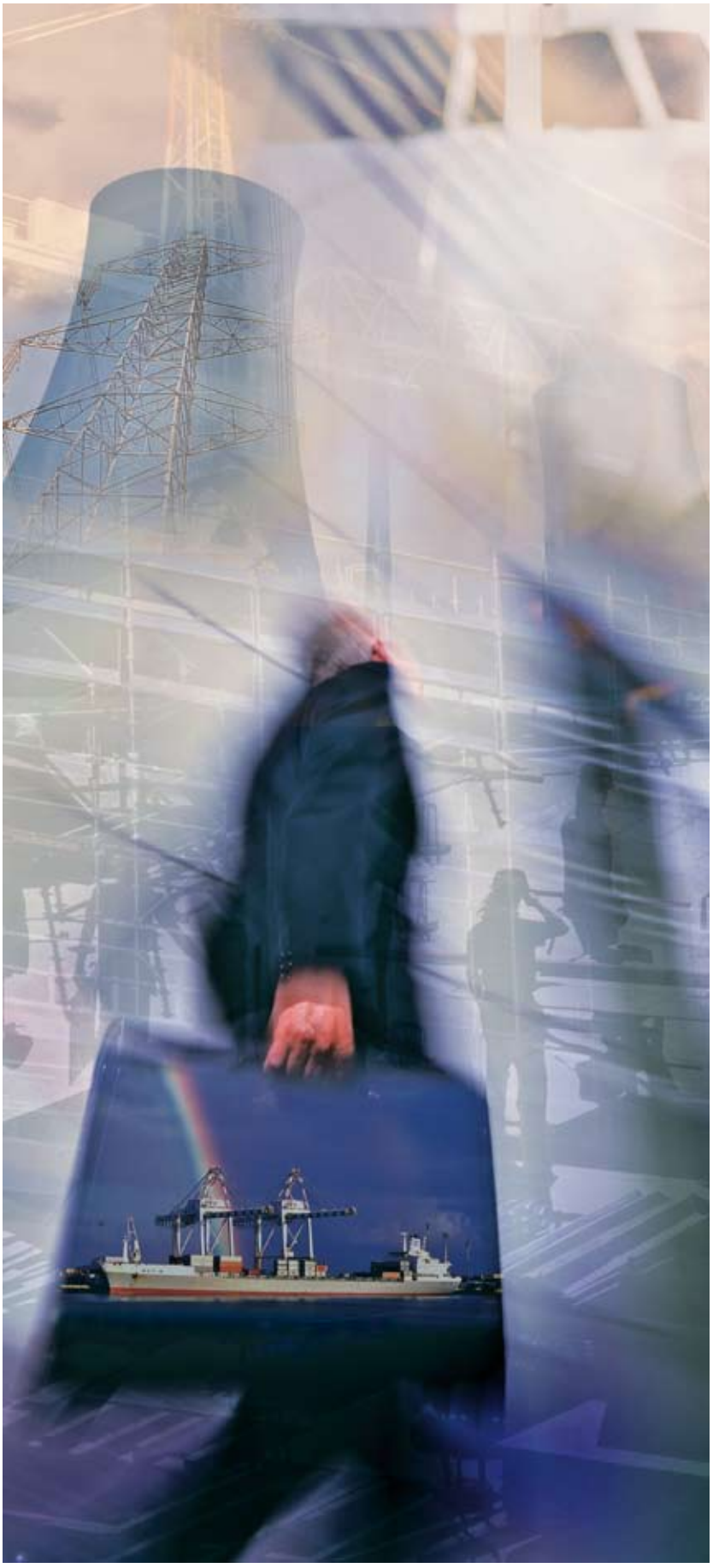

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Is the kina a commodity currency?

Gae Kauzi
Thomas Sampson

DRAFT

Since the kina was floated in 1994 its US dollar value has undergone substantial fluctuations. This paper estimates a model of the determinants of the kina/US dollar exchange rate using quarterly data from 1995-2005. The international price of Papua New Guinea's commodity exports is found to have a strong effect on the exchange rate. A 10 percent increase in commodity prices is estimated to cause the kina to appreciate by 4 percent immediately and by a further 6 percent in two quarters time. No other variable included in the model has a robust effect on the value of the kina. These results support the view that Papua New Guinea is highly vulnerable to external commodity price shocks. This is important for politicians and policy makers to know so that macroeconomic policies, including monetary policy, can take into account changes in commodity prices and the implications of effective spending where it matters for tomorrow, and that government policies and fiscal management should not be over-emphasized/over-credited for the stability the economy has enjoyed over the last 5 years.

In Papua New Guinea's ongoing quest for macroeconomic stability the foreign currency value of the kina has played a central role. The "hard kina" policy that provided the framework within which macroeconomic policy operated from 1976 until the kina was floated in 1994 had at its heart the belief that a stable exchange rate was necessary to maintain price stability in Papua New Guinea (PNG). Judged in terms of price stability the policy was successful with inflation remaining under control throughout the fixed exchange rate period. However, the high value of the kina that resulted from the hard kina policy has been blamed for suppressing agricultural export growth and, thereby, reducing economic growth (NZIER 2006). Following the float, depreciation of the kina was widely perceived as contributing to the series of economic crises that PNG faced between 1994 and 2002, although the extent to which the depreciation was a cause rather than a symptom of macroeconomic problems is uncertain.[1]

Although the kina has been at the heart of macroeconomic policy debates, there has been surprisingly little empirical work on the determinants of the exchange rate. Conventional wisdom holds that the value of the kina is primarily influenced by real, rather than financial sector, developments and that commodity prices, the volume of exports and government expenditure are more important influences on the kina than the interest rate or other monetary variables.[2] This paper attempts to shed some light on the validity of these views by analysing the determinants of the kina exchange rate, focusing particularly on its relationship to commodity prices.

There are two reasons for the focus on commodity prices. Firstly, research on other small, open, primary commodity dependent economies has found that the terms of trade has a significant effect on the exchange rate.[3] Secondly, the prior belief that commodity prices have a strong influence on the kina exchange rate makes them a natural starting point for trying to understand the determinants

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1 Chand and Stewart (1997) analyse the 1994 exchange rate crisis. Manning (1998) discusses the kina depreciation of 1997-98.

2 See, for instance, ANZ (2005) and Bank of Papua New Guinea (2005).

3 See, for instance, Chen and Rogoff (2003).

of the value of the kina.

The effect of changes in commodity prices on the nominal kina/US dollar exchange rate, under the floating exchange rate regime, is estimated using quarterly data from 1995-2005. Commodity prices are measured as an export-weighted average of the real international price of PNG's commodity exports. The paper finds that commodity prices have a significant effect on the value of the kina. A 10 percent increase in commodity prices is estimated to cause the kina to appreciate by approximately 4 percent in the present quarter and by a further 6 percent with two quarters' lag. This effect is robust across all specifications estimated and to estimation using data starting in 1998. When commodity prices are decomposed into mineral and non-mineral prices it is found that an increase in non-mineral prices causes the kina to appreciate in the present quarter, while an increase in mineral prices causes an appreciation with two quarters' lag.

No variable other than commodity prices is found to have a robust effect on the exchange rate. There is some evidence that borrowing by the government of PNG from the domestic banking system, or a decrease in interest rates in PNG relative to the US, causes the exchange rate to depreciate, but these findings are sensitive to whether or not these variables are assumed to be stationary. Specifically, the effects are observed if the variables are assumed to be stationary, but not otherwise. The paper finds that the value of the kina is not directly affected by the level of the money supply in PNG relative to the US, the PNG fiscal deficit or the volume of commodities exported by PNG.

The findings highlight the vulnerability of PNG's economy to external shocks; a vulnerability that raises the question of what are the relative roles of external developments and domestic economic policies in shaping PNG's macroeconomic outcomes. Understanding the balance and interplay between these two influences should be a central objective of policymakers in PNG.

The paper is organised as follows. The next section offers some background on the kina and reviews previous literature. The model that will be estimated is then outlined, followed by a discussion of the data and the estimation methodology. The penultimate two sections present the empirical findings; firstly, using an aggregate commodity price variable and, secondly, decomposing commodity prices into mineral and non-mineral prices. The final section concludes and offers suggestions for future research.

The floating kina

The fixed exchange rate or "hard kina" policy, adopted when the kina became an independent currency on 1st January 1976, came to an end when the Bank of Papua New Guinea floated the kina on 10th October 1994. Since then the kina/US dollar exchange rate has been determined by trading between banks (including at times the Bank of Papua New Guinea) in the inter-bank foreign exchange market. The exchange rate of the kina with currencies other than the US dollar is then calculated by crossing the kina/US dollar exchange rate with the US dollar exchange rate of those currencies.

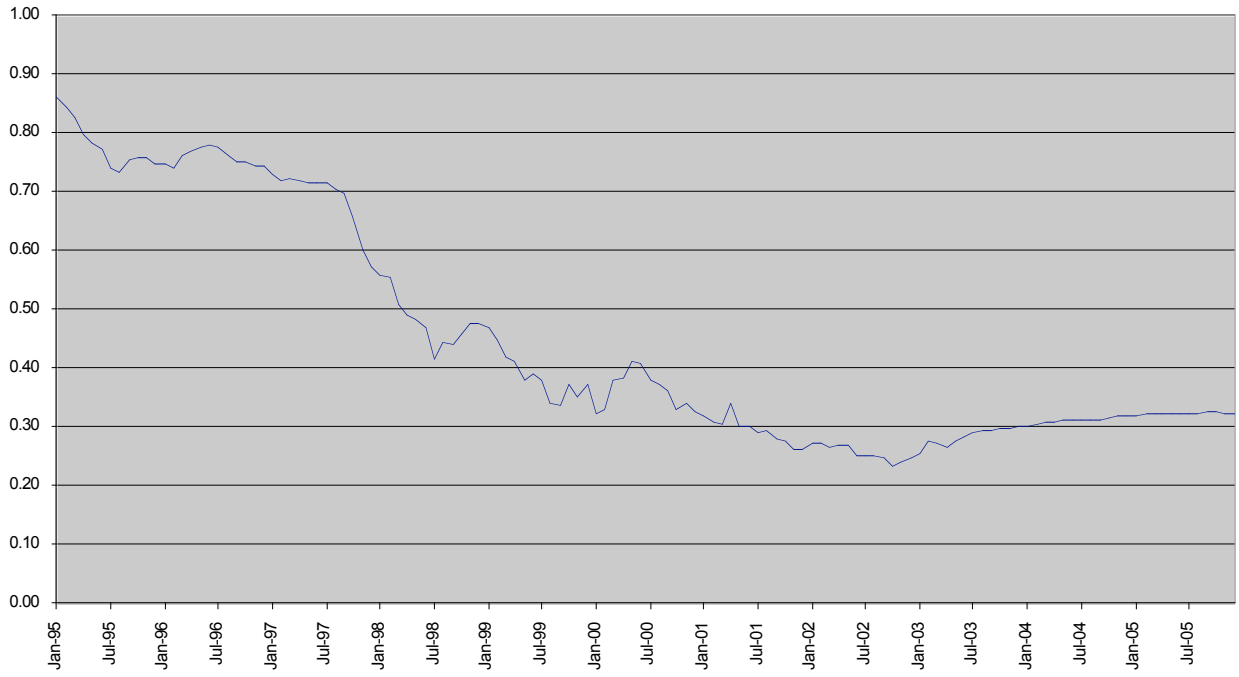
Much has been written about the merits, or otherwise, of the hard kina policy and the reasons why it had to be abandoned. The prescient analysis of Garnaut and Baxter (1984) remains the standard reference for understanding the conditions necessary for the policy to succeed. Garnaut (1995) and Chand and Stewart (1997) discuss the causes of its demise, focusing on the fiscal deficits of the early 1990s.

There is also a substantial literature devoted to discussing whether the kina should remain a floating currency. King and Sugden (1997) favour a freely floating kina on the grounds that a fixed

exchange rate could damage the competitiveness of PNG's exports by preventing any depreciation of the kina. However, Duncan and Xu (2000) argue that PNG should adopt the Australian dollar to reduce the scope for monetary policy mismanagement by the Government of PNG. They further argue that Australia and PNG constitute an optimal currency area, based on evidence in Xu (1999) that the two countries suffer from common shocks. Arguments for and against the Pacific island countries, including PNG, adopting the Australian dollar are reviewed by de Brouwer (2000) who endorses the idea. By contrast, Bowman (2004) suggests that Pacific island countries should consider replacing their national currencies with the US dollar because their exchange rates are more strongly correlated with the value of the US dollar than with the Australian dollar and the importance of Australia as a trading partner for Pacific island countries is declining.

This paper departs from the existing literature by taking the floating exchange rate as given and investigating empirically the causes of changes in the value of the kina. Figure 1 shows the kina/US dollar exchange rate from 1995-2005. The most striking features of the graph are the downward trend in the kina up until late 2002 and the appreciation of the kina thereafter. Between the end of 1994 and October 2002 the kina depreciated by 72 percent from 85 US cents to 23 US cents, but by the end of 2005 the kina had appreciated back to 32 US cents.

Figure 1 - Kina/US dollar exchange rate



However, even during the period when the kina was trending downwards its behaviour varied greatly over time. Following a sharp decline in the first six months of 1995, the kina remained broadly stable until the second half of 1997 when it began a rapid depreciation that took it from 70 US cents in September 1997 to 41 US cents in July 1998. The kina then appreciated slightly to end 1998 at 48 US cents, before beginning the gradual depreciation that, although punctuated by occasional periods of appreciation, continued until late 2002. It would be a mistake, therefore, to view Figure 1 as simply showing a depreciation followed by an appreciation. The actual dynamics of the changes in the value of the kina are much richer than this simple characterisation would suggest. What is the explanation for these changes?

Previous work on exchange rate determinants in PNG has focused on the real exchange rate; perhaps because it may vary even if the nominal exchange rate is fixed and, until recently,

insufficient time had passed since the float to permit a detailed analysis of the determinants of the post-float kina. Chowdhury (1998) estimates a real exchange rate model using annual data from 1970-94, but his findings lack robustness across the alternative definitions of the real exchange rate used and the small size of the dataset (25 observations) means his results should be interpreted with caution. Duncan et al. (1998) argue, based on 1983-1996 data, that "market forces consistent with purchasing power parity (PPP) operate in Papua New Guinea." (p.65) The authors also claim that there is a link between fiscal policy and the exchange rate in PNG, but they fail to provide rigorous empirical evidence in support of this assertion.

In contrast to those studies this paper considers the nominal kina exchange rate. It estimates the causes of movements in the nominal kina/US dollar exchange rate from 1995-2005. Only the US dollar exchange rate is considered because, as explained above, the exchange rate of the kina with currencies other than the US dollar is partially determined by developments in international currency markets. For instance, a depreciation of the kina against the Australian dollar could be caused by either a depreciation of the kina against the US dollar or an appreciation of the Australian dollar against the US dollar (or a combination of the two). Working only with the US dollar exchange rate avoids the need to model behaviour in foreign exchange markets outside of PNG.[4]

Exchange rate models

Two factors complicate choosing a model of the determinants of the kina/US dollar exchange rate to estimate. Firstly, the lack of previous work on the kina. Consequently, there is neither an established consensus, nor an acknowledged puzzle, which can be used as a starting point for selecting a model to estimate, or can provide the reference point against which alternative findings are evaluated. Secondly, the multitude of competing models that fill the exchange rate literature. Despite the vast amount of work that has been undertaken on the economics of exchange rates during the last 30 years no consensus has emerged on the best model to explain the behaviour of nominal exchange rates. Instead, the success of different models has varied greatly across time periods and currency pairs, and in-sample fit has not been matched by forecasting success (Meese and Rogoff 1983; Cheung, Chinn and Pascual 2005).

Against this backdrop the paper estimates variants of the following equation:

$$s_t = \beta_0 + \beta_1 (i_t - i_t^*) + \beta_2 g_t + B(L)z_t + \varepsilon_t \qquad (1)$$

where s is the logarithm of the nominal kina/US dollar exchange rate, i is the nominal interest rate in PNG, i* is the nominal interest rate in the US, g is a measure of the fiscal position of the PNG government, z is the logarithm of the real US dollar price of PNG's commodity exports, B(L) is a polynomial in the lag operator, ε is an error term and t indexes the period.

The equation is not based on any specific structural exchange rate model, but is an ad hoc combination of variables selected because they are often cited as important influences on the value of the kina. The primary interest of the paper is in the relationship between commodity prices and the exchange rate. As mentioned in the introduction, this focus is motivated both by findings that the terms of trade affect the exchange rate in other small, open, primary commodity dependent economies and by a desire to test the conventional wisdom that commodity prices influence the value of the kina.

Gruen and Wilkinson (1994) and Gruen and Kortian (1996) both find a link between the terms of trade and the real Australian dollar/US dollar exchange rate. Chen and Rogoff (2003) present

[4] To date there has been no reported offshore trading in the kina.

evidence that in Australia, Canada and New Zealand the price of commodity exports has a significant influence on the real US dollar exchange rate. Such findings have led to the term "commodity currency" being applied to currencies whose value is influenced by commodity prices. This paper seeks to ascertain whether there is empirical justification for labeling the kina a commodity currency. Following Chen and Rogoff the international price of commodity exports is used as an explanatory variable in preference to the terms of trade. This has two advantages. Firstly, the terms of trade are likely to be endogenous to the exchange rate so that its inclusion may result in inconsistent parameter estimates and, secondly, there is no import price index available to calculate the terms of trade for PNG.

In addition to commodity prices, the baseline model also includes as explanatory variables the inter-country interest rate differential and a fiscal variable. The interest rate differential is at the heart of models, such as the Dornbusch (1976) and Frankel (1979) sticky price monetary model, which take an asset pricing approach to the value of the exchange rate. If there is capital mobility between countries, a rise in the domestic interest rate is expected to lead to an inflow of capital and cause the domestic currency to appreciate. The extent to which this effect is present in PNG is an important factor the Bank of Papua New Guinea should consider when assessing the impact of changes in monetary policy.

On the fiscal side, Garnaut (1995) and Chand and Stewart (1997) both argue that a loss of fiscal control in the early 1990s was the principal reason why the hard kina policy had to be abandoned. Subsequent depreciations of the kina have also been informally linked to fiscal deficits.

Data and estimation methodology

The model is estimated using quarterly data from 1995 Q1 to 2005 Q4. Full details of the definition and source of each of the variables used are given in the Appendix.

Commodity prices are measured using an index of the real international price of PNG's commodity exports. To construct the commodity price variable the international US dollar price of each of PNG's eleven largest commodity exports is deflated using the US Consumer Price Index (CPI) to obtain real prices. The geometric weighted average of the real international prices is then calculated. The weight given to each commodity is the average of its annual shares from 1995-2004 of the value of PNG's combined exports of the eleven commodities.[5] Table 1 shows the weight given to each of the commodities.

Table 1 – Commodity price index weights.

Commodity	Weight (percent)
Cocoa	2.4
Coffee	6.7
Tea	0.3
Copra	0.8
Copra Oil	1.2
Palm Oil	5.9
Rubber	0.1
Forest products	8.3
Crude Oil	27.1
Gold	32.3
Copper	14.8
Non-mineral (aggregate)	**25.8**

[5] Exports of these eleven commodities made up over 90 percent of PNG's total exports during each year from 1995-2004.

Mineral (aggregate)	**74.2**

Each commodity's weight is given by the average of its annual shares from 1995-2004 of PNG's exports of the eleven commodities shown. Export volume index constructed using the same weights.

The fiscal position is measured in two different ways. Firstly, by the net credit to government from the banking system as a percentage of Gross Domestic Product (GDP). Net credit to government measures the stock of government borrowing from commercial banks and the Bank of Papua New Guinea. It is a determinant of broad money, M3, and changes in net credit to government measure the extent to which financing of the fiscal deficit leads to money creation. Secondly, by the fiscal deficit as a percentage of GDP. The fiscal deficit differs from changes to net credit to government because of government borrowing from the non-bank private sector and from foreign sources.

Interest rates are measured as the nominal interest rate per annum on six month government securities. The exchange rate is the kina/US dollar exchange rate. An increase in the exchange rate corresponds to an appreciation of the kina. Net credit to government, exchange rate and interest rate data is end of quarter.

Estimating equation (1) in the form given above will lead to spurious regression results if any of the included variables are non-stationary. It is possible to test for stationarity using unit root tests. The Augmented Dickey-Fuller test indicates that the exchange rate, commodity prices, the interest rate differential and net credit to government are I(1) processes, while the fiscal deficit is I(0). However, as Chen and Rogoff (2003) argue, the low power of existing unit root tests means that testing for stationarity using fewer than 100 observations is not meaningful. The dataset used in this paper contains only 44 observations. Therefore, to avoid any risk of spurious inference the first difference of all variables will be used. The baseline specification is:

$$\Delta s_t = \beta_0 + \beta_1 \Delta(i_t - i_t^*) + \beta_2 \Delta g_t + B(L)\Delta z_t + \varepsilon_t \qquad (2)$$

However, to test the robustness of the results to the alternative hypothesis that the interest rate differential and the fiscal variables are I(0) the model will also be estimated with these variables expressed in level form.

The model will be estimated both by OLS and by Two Stage Least Squares (2SLS). In the 2SLS estimations the interest rate differential and the fiscal variables will be treated as endogenous and their lagged values will be used as instruments.

Empirical results

Visual inspection of movements in commodity prices and the kina exchange rate during the 1995-2005 sample period suggest a correlation between the two (Figure 2). Does this relationship survive more rigorous empirical scrutiny? When equation (2) is estimated by OLS with the price of PNG's commodity exports as the only independent variable commodity prices have a highly significant effect on the exchange rate (Table 2, column a). If four lags of commodity prices are included a one percent increase in commodity prices in a given quarter is estimated to cause a 0.47 percent appreciation of the exchange rate in that quarter and a further 0.58 percent appreciation in two quarters time. The other lags of the commodity price variable are insignificant. The finding that changes in commodity prices affect the exchange rate in the current quarter and with two quarters' lag, but not at other lags, is robust to varying the number of lags included. From this point on, only the results obtained from estimating the model including just the first two lags will be reported.

The link between commodity prices and the exchange rate could result from omitted variable bias if commodity prices are correlated with other variables that affect the value of the kina. Including the first difference of the interest rate differential and net credit to government in the estimation does

not substantially affect the estimated effect of changes in commodity prices and neither the interest rate differential nor net credit to government is significant (column b). Similar results are obtained if the fiscal deficit is used instead of net credit to government (column c).

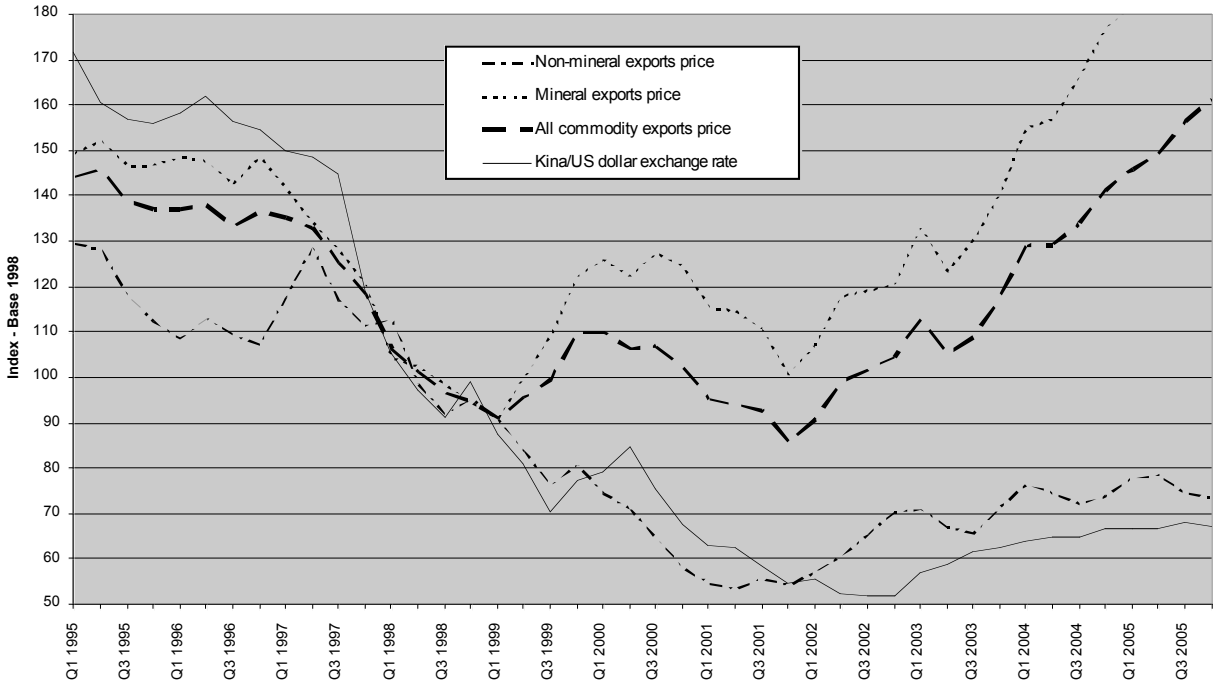
Table 2: OLS estimation results using first difference of interest rate differential and net credit to government.

	(a)		(b)	(c)	(d)	(e)	(f)
Commodity price	0.47*** (0.11)	Commodity price	0.43*** (0.10)	0.43*** (0.10)	0.41*** (0.12)	0.34*** (0.12)	0.41*** (0.11)
Commodity price (lag 1)	0.016 (0.17)	Commodity price (lag 1)	-0.049 (0.16)	0.022 (0.16)	-0.017 (0.15)	-0.039 (0.14)	-0.030 (0.17)
Commodity price (lag 2)	0.58** (0.21)	Commodity price (lag 2)	0.53** (0.20)	0.50** (0.19)	0.56*** (0.19)	0.52** (0.20)	0.63** (0.23)
Commodity price (lag 3)	-0.11 (0.22)	Interest rate differential	-0.20 (0.38)	-0.11 (0.36)	-0.098 (0.39)	-0.073 (0.35)	0.41 (0.25)
Commodity price (lag 4)	0.065 (0.20)	Net credit to government	-0.51 (0.62)		-0.38 (0.61)	-0.32 (0.55)	0.26 (0.41)
		Fiscal deficit		-0.051 (0.092)			
		Southern Oscillation Index			0.00097 (0.00087)		
		Ok Tedi closed				-0.050* (0.027)	
Constant	-0.025*** (0.0063)	Constant	-0.024*** (0.0072)	-0.023*** (0.0067)	-0.022*** (0.0079)	-0.019** (0.0078)	-0.022 (0.00980
R^2	0.39		0.38	0.37	0.39	0.41	0.36
N	39		41	41	41	41	29
Sample	1995 Q1 – 2005 Q4		1995 Q1 - 2005 Q4	1995 Q1 - 2005 Q4	1995 Q1 - 2005 Q4	1995 Q1 - 2005 Q4	1998 Q1 – 2005 Q4

Dependent variable is first difference of kina/US dollar exchange rate. Newey-West heteroscedasticity and autocorrelation consistent standard errors in parentheses. * denotes significance at the 10 percent level, ** at the 5 percent level and *** at the one percent level.

The evidence presented above indicates that commodity prices are a significant determinant of the kina/US dollar exchange rate. Do exogenous shocks to the supply of export commodities also affect the exchange rate? The most substantial supply shock during the sample period was the El Nino induced drought of 1997-98. The drought led to low water levels in the Fly river, which forced the temporary closure of the Ok Tedi mine, PNG's largest source of export revenue. In column (d) equation (2) is estimated including the Southern Oscillation Index[6] as an independent variable. The Southern Oscillation Index is insignificant and its inclusion has negligible impact on the estimated coefficients of the other variables. Column (e) includes a dummy variable for those quarters when Ok Tedi was closed at the start of the quarter due to the drought.[7] The Ok Tedi closed dummy has a negative coefficient with a p-value of 0.07, while the effects of other variables are similar to before. The results suggest that during each quarter in which Ok Tedi was closed the kina/US dollar exchange rate depreciated by 5.0 percent more than it otherwise would have done.

Figure 2 - Commodity prices and the exchange rate



Estimating equation (2) with a sample starting in 1998 Q1 makes little difference to the results (column f). Net credit to government and the interest rate differential remain insignificant and the estimated commodity price effects are similar to before. This confirms that the results are not driven by events immediately following the float in 1995-97 during which the kina suffered a substantial depreciation (see Figure 1).

Table 3 reports the results obtained from estimating the model under the plausible alternative assumption that the interest rate differential and fiscal variables are stationary. The commodity price effects are broadly unchanged, but both the interest rate differential and net credit to government are now significant and have the expected signs (column a). A one percentage point increase in the interest rate differential is linked to a 0.31 percent appreciation of the kina, while a one percentage point increase in the ratio of net credit to government to GDP is associated with a 1.1 percent depreciation of the kina.

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[6] The Southern Oscillation Index measures differences in the air pressure between Tahiti and Darwin. Sustained negative values of the Southern Oscillation Index often indicate El Nino episodes.

[7] Namely: 1997 Q3, 1997 Q4 and 1998 Q1.

As net credit to government is one of the determinants of broad money, M3, this finding is suggestive of a possible link between the money supply and the exchange rate. However, when the broad money supply differential is included instead of net credit to government it is insignificant, while the coefficients of other variables are unaffected (column b). The money supply differential remains insignificant if its first difference is used, if net credit to government is not included in the estimation or if it is defined using M1 instead of M3. When the Ok Tedi closed dummy is included it is no longer significant, but the other results are similar (column c). If the fiscal deficit is included in place of net credit to government, not only is it insignificant, but the interest rate differential also ceases to be significant (column d).

Table 3: OLS estimation results using level of interest rate differential and net credit to government.

	(a)	(b)	(c)	(d)
Commodity price	0.44***	0.46***	0.37***	0.43***
	(0.11)	(0.12)	(0.13)	(0.11)
Commodity price	-0.023	-0.012	-0.036	0.073
(lag 1)	(0.15)	(0.17)	(0.15)	(0.17)
Commodity price	0.55***	0.58***	0.54***	0.52***
(lag 2)	(0.17)	(0.19)	(0.18)	(0.16)
Interest rate	0.31**	0.35*	0.27**	0.19
differential	(0.14)	(0.18)	(0.13)	(0.12)
Net credit to	-1.1*	-1.3*	-1.0*	
Government	(0.56)	(0.72)	(0.59)	
Broad money supply		0.044		
differential		(0.075)		
Ok Tedi closed			-0.038	
			(0.024)	
Fiscal deficit				-0.17
				(0.16)
Constant	0.054	0.10	0.051	-0.040***
	(0.048)	(0.11)	(0.052)	(0.012)
R^2	0.45	0.46	0.47	0.40
N	41	41	41	41

Dependent variable is first difference of kina/US dollar exchange rate. Newey-West heteroscedasticity and autocorrelation consistent standard errors in parentheses. Sample: 1995 Q1 – 2005 Q4. * denotes significance at the 10 percent level, ** at the 5 percent level and *** at the one percent level.

The results in Table 3 show that the estimated effect of commodity prices on the exchange rate is robust to alternative assumptions regarding the data generating processes for the interest rate differential and the fiscal variables. They also provide some evidence of a correlation between the interest rate differential and net credit to government and the exchange rate conditional on the assumption that the two explanatory variables are stationary. If this assumption is valid these findings support the view that net credit to government, and not the fiscal deficit, is the variable to focus on when analysing the effect of fiscal behaviour on the exchange rate in PNG.

The next scenario considered is whether the estimation results are biased because of endogeneity of the independent variables. Although international commodity prices are exogenous to PNG, both the interest rate differential and the fiscal variables may be affected by changes in the exchange rate.[8] To investigate this possibility the model is estimated by 2SLS using the first lag of the interest

[8] For instance, a depreciation of the kina may lead to a rise in interest rates to support the kina and to an increase in the kina value of the Government's foreign currency denominated debt, which could necessitate an increase in domestic Government borrowing.

rate differential and net credit to government, which are assumed not to affect the current period exchange rate directly, as instruments. A necessary condition for the lagged variables to be valid instruments is that the error terms are serially uncorrelated. When the heteroscedasticity robust version of Durbin's alternative test is used on the residuals from the equations estimated above evidence of negative third order serial correlation is found. However, the null hypothesis of no serial correlation is accepted if the first three lag differences of the exchange rate are included as regressors and consequently they are used as independent variables in the 2SLS regressions.[9]

Table 4 shows the results from 2SLS estimation with the interest rate differential and net credit to government in levels. Panel B shows the first stage regression results, which indicate that the lagged values are strong instruments for the endogenous variables.

In the 2SLS results (panel A) commodity prices are significant in the current quarter and with two quarters' lag and the estimated elasticities of 0.48 and 0.67, respectively, are slightly higher than the elasticities estimated using OLS. The estimated effects of the interest rate differential and net credit to government are now approximately twice as large as in the OLS results, however, their estimated standard errors have increased by similar proportions and, consequently, the interest rate differential is not significant and net credit to government is only marginally significant. When a test for endogeneity of the interest rate differential and net credit to government is performed the null hypothesis that they are exogenous is accepted (panel A).

Estimating alternative specifications of equation (2) using 2SLS gives results that are broadly similar to those shown in Tables 2 and 3, but with larger standard errors. There is strong evidence of an effect of current and twice lagged commodity prices on the exchange rate and some evidence that net credit to government affects the exchange rate when in level form. The interest rate differential, fiscal deficit and money supply differential variables are never significant. Overall, the 2SLS results are consistent with the OLS results.

Mineral and non-mineral prices

An unexpected implication of the results discussed above is that commodity prices affect the value of the kina in the current quarter and with two quarters' lag, but not with a one quarter lag. This section attempts to explain this phenomenon by analysing the differing impacts of mineral and non-mineral commodity prices on the exchange rate.

The commodity price index is a weighted average of mineral and non-mineral price indices where the mineral price index has a weight of 0.74 and the non-mineral price index has a weight of 0.26 (Table 1). The use of a single composite commodity price index therefore assumes that changes in mineral prices have a 2.9 times (2.9 = 0.742/0.258) larger effect on the kina/US dollar exchange rate than changes in non-mineral prices and that changes in mineral and non-mineral prices affect the exchange rate at the same lags.

However, the share of minerals in PNG's commodity exports may overstate the importance of mineral relative to non-mineral commodity exports in the PNG foreign exchange market. Bank of PNG data on the foreign exchange market shows that from 2003-05 on average 74 percent of foreign exchange inflows were from the commodity export sector. Of these, 56 percent were from the mineral export sector and 44 percent from the non-mineral commodity export sector. Thus,

[9] When the model is estimated including lags of the dependent variable only the third lag is found to be significant. Including the third lag of the differenced exchange rate in the specifications estimated in Tables 2 and 3 only causes minor changes to the results. The Interest rate differential ceases to be significant in any of the equations estimated in Table 3, as does the Ok Tedi closed dummy in column (e) of Table 2. Most importantly, the estimated commodity price effects are essentially unchanged.

Table 4: Two Stage Least Squares estimation results.

Panel A: 2SLS results	
Commodity price	0.48**
	(0.19)
Commodity price (lag 1)	-0.11
	(0.20)
Commodity price (lag 2)	0.67***
	(0.20)
Interest rate differential	0.52
	(0.32)
Net credit to Government	-2.4*
	(1.3)
Exchange rate (lag 1)	0.037
	(0.13)
Exchange rate (lag 2)	-0.12
	(0.11)
Exchange rate (lag 3)	-0.25**
	(0.12)
Constant	0.16
	(0.099)
Endogenous regressors	No
(p-value)	(0.27)
N	40

Panel B: First stage regressions		
Dependent variable	Interest rate differential	Net credit to Government
Commodity price	-0.048	-0.020
	(0.10)	(0.046)
Commodity price (lag 1)	-0.061	-0.084
	(0.10)	(0.063)
Commodity price (lag 2)	-0.060	0.032
	(0.094)	(0.044)
Interest rate differential	0.79***	0.076
(lag 1)	(0.085)	(0.051)
Net credit to government	0.58**	0.55***
(lag 1)	(0.27)	(0.17)
Exchange rate (lag 1)	-0.071	-0.0061
	(0.067)	(0.054)
Exchange rate (lag 2)	0.024	-0.029
	(0.069)	(0.031)
Exchange rate (lag 3)	-0.088	0.030
	(0.071)	(0.032)
Constant	-0.041*	0.036**
	(0.024)	(0.015)
Under identified	No	No
(p-value)	(0.00)	(0.00)
R^2	0.84	0.54
N	40	40

Dependent variable in second stage is first difference of kina/US dollar exchange rate. Heteroscedasticity robust standard errors in parentheses. Sample: 1995 Q1 – 2005 Q4. "Endogenous regressors" reports the results of a robust test, based on Sargan-Hansen statistics, of the null hypothesis that Interest rate differential and Net credit to government are exogenous. "Under identified" reports the results of a robust F-test of the joint significance of the two instrumental variables: lagged Interest rate differential and lagged Net credit to government. * denotes significance at the 10 percent level, ** at the 5 percent level and *** at the one percent level.

Table 5: Estimation results including separate mineral and non-mineral export prices and volume of commodity exports.

	(a)	(b)		(c)	(d)
Estimation method	OLS	2SLS		OLS	2SLS
Non-mineral price	0.33*	0.28*	Commodity price	0.35***	0.30
	(0.18)	(0.14)		(0.12)	(0.36)
Non-mineral price (lag 1)	-0.00064	-0.037	Commodity price (lag	0.032	-0.043
	(0.16)	(0.19)	1)	(0.16)	(0.26)
Non-mineral price (lag 2)	0.043	0.074	Commodity price (lag	0.58***	0.70***
	(0.15)	(0.19)	2)	(0.17)	(0.25)
Mineral price	0.24	0.30*	Interest rate differential	0.31**	0.58
	(0.15)	(0.16)		(0.13)	(0.41)
Mineral price (lag 1)	-0.053	-0.093	Net credit to	-1.2**	-3.0*
	(0.12)	(0.14)	government	(0.52)	(1.8)
Mineral price (lag 2)	0.49***	0.53***	Commodity volume	0.12*	0.23
	(0.14)	(0.16)		(0.061)	(0.34)
Interest rate differential	0.31*	0.43			
	(0.16)	(0.26)			
Net credit to government	-0.91	-1.8*			
	(0.56)	(1.1)			
Constant	0.036	0.11	Constant	0.063	0.20
	(0.047)	(0.086)		(0.046)	(0.14)
R^2	0.52		R^2	0.49	
N	41	40	N	41	40
Endogenous regressors		No	Endogenous regressors		No
(p-value)		(0.31)	(p-value)		(0.29)

Dependent variable is first difference of kina/US dollar exchange rate. OLS estimates have Newey-West heteroscedasticity and autocorrelation consistent standard errors in parentheses. 2SLS estimates have heteroscedasticity robust standard errors in parentheses. The 2SLS regressions in columns (b) and (d) include the first three lags of the dependent variable as additional regressors. In columns (b) and (d) Interest rate differential and Net credit to government are treated as endogenous and their lagged values are used as instruments. In column (d) Commodity volume is also treated as endogenous and its lagged value is used as an instrument. Sample: 1995 Q1 – 2005 Q4. "Endogenous regressors" reports the results of a robust test, based on Sargan-Hansen statistics, of the null hypothesis that the instrumented variables are exogenous. * denotes significance at the 10 percent level, ** at the 5 percent level and *** at the one percent level.

foreign exchange inflows from the mineral sector were only 1.3 times larger than those from the non-mineral commodity export sector. The discrepancy between this number and the 2.9 times difference in export shares probably results from the widespread use by mineral sector companies of
offshore foreign currency accounts to store export receipts. In both 2003 and 2004 the kina value of mineral exports was over twice as large as the kina value of foreign exchange inflows from the mineral sector. By comparison, the difference between the kina value of non-mineral commodity exports and foreign exchange inflows from the non-mineral commodity export sector was less than 10 percent.

In addition, if the form of export contracts differs across sectors there may be a corresponding difference in the responsiveness of the exchange rate to price movements. For instance, widespread use of forward contracts might be expected to both dampen and slow the effect of price changes on the exchange rate.

To test whether these effects are present equation (3) is estimated:

$$\Delta s_t = \beta_0 + \beta_1 (i_t - i_t^*) + \beta_2 g_t + C(L)\Delta x_t + D(L)\Delta v_t + \varepsilon_t \quad (3)$$

where x is the logarithm of the real US dollar denominated price of PNG's non-mineral commodity exports, v is the logarithm of the real US dollar denominated price of PNG's mineral exports and C(L) and D(L) are lag polynomials.

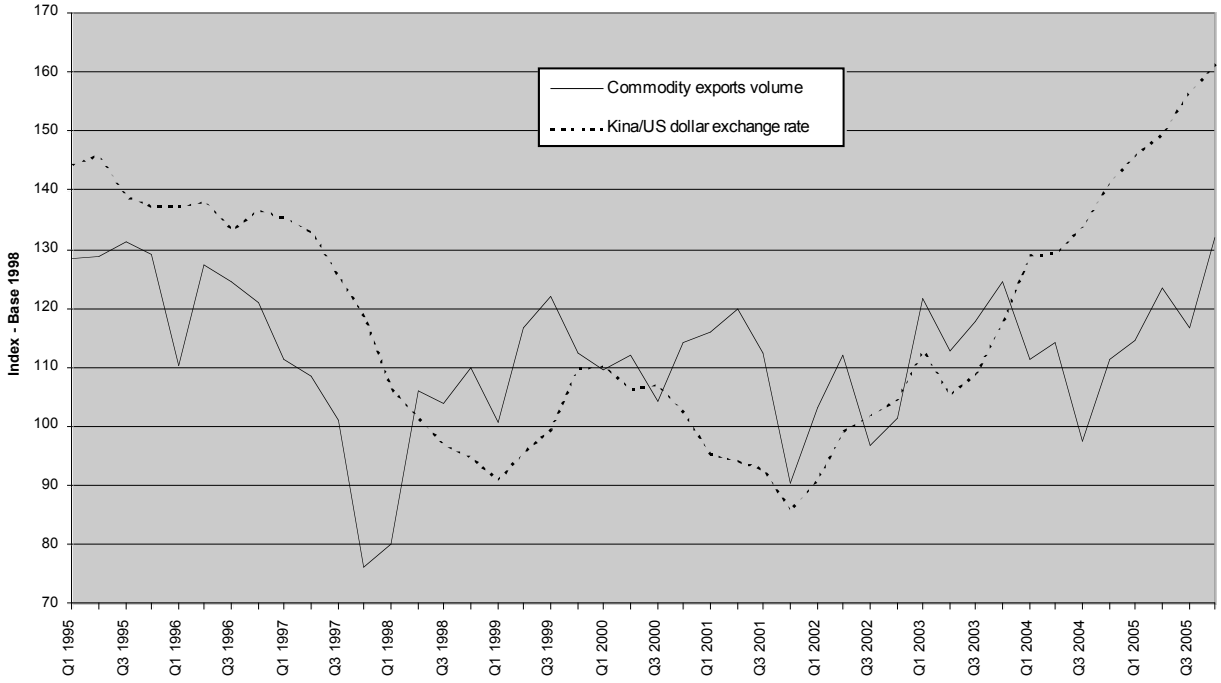
Table 5 shows the results from estimating equation (3) including two lags of both commodity price variables. Non-mineral prices only have a significant impact on the exchange rate for the current quarter, while mineral prices are marginally significant for the current quarter, but are highly significant when lagged twice. Otherwise the results are consistent with those in Tables 2-4 above and are similar for both OLS (column a) and 2SLS (column b) estimation. Including higher lags of the commodity price variables, or using the interest rate and net credit to government in first difference form, does not change these findings. Therefore, the puzzling timing of the effect of commodity price changes on the exchange rate is a consequence of non-mineral prices affecting the exchange rate immediately, while mineral prices affect the exchange rate most strongly at two quarters' lag.

The elasticity of the exchange rate with respect to mineral prices is estimated to be greater than the elasticity with respect to non-mineral prices. However, the standard errors are sufficiently large that neither the hypothesis that current period non-mineral prices and twice lagged mineral prices have the same size effect on the exchange rate, nor the hypothesis that the mineral prices effect is 2.9 times larger can be rejected. The question of whether the relative export shares are an accurate indicator of the relative impact of mineral and non-mineral prices on the exchange rate therefore remains unresolved.

The strong effect of commodity prices on the exchange rate raises the question of whether a change in the volume of commodity exports has a similar effect. To test this possibility a commodity exports volume variable was constructed using the same weights and methodology used to compute the commodity price variable (Figure 3). When the model is estimated by OLS with the first difference of the logarithm of commodity volume as an explanatory variable the estimated effects of other variables are unchanged and commodity volume is positive and significant (Table 5, column c). However, the volume of exports is likely to be endogenous to the exchange rate. For example, a depreciation of the exchange rate will, ceterus paribus, raise the kina price of exports, which could lead to higher export volumes if producers supply more at the higher price, or lower export volumes if producers expect the depreciation to continue and consequently hold back

supplies. When the equation is re-estimated by 2SLS - using lagged values as instruments for commodity volume, the interest rate differential and net credit to government - commodity volume is no longer significant (column d) and the first stage results show that an increase in commodity prices causes higher commodity export volumes. Therefore, there is little empirical support for the idea that the volume of exports affects the exchange rate.

Figure 3 - Commodity exports volume and the exchange rate



Conclusion

This paper provides strong evidence that the kina should be considered a commodity currency – a finding with important implications for both how macroeconomic developments in PNG should be understood and for policy making in PNG.

The dependence of the exchange rate on commodity prices highlights the vulnerability of the PNG economy to external shocks. A vulnerability that is heightened by the positive impact of commodity prices on government tax revenues and on export earnings. However, the importance of commodity prices in determining the overall path of the PNG economy remains an open question. The Somare government and the Bank of Papua New Guinea have frequently been credited with restoring macroeconomic stability since 2002. An alternative hypothesis would be that they have simply been the beneficiaries of a fortuitous rise in commodity prices. Between the end of 1999 and the end of 2001 the price of PNG's commodity exports fell 22 percent and the kina depreciated by 29 percent against the US dollar. In the next four years commodity prices rose by 88 percent and the kina appreciated by 23 percent. Understanding the relative roles of macroeconomic policy and external shocks in shaping PNG's macroeconomic behaviour is an important area for future work.

Setting aside broader macroeconomic questions, understanding the behaviour of the exchange rate is an essential part of the Bank of Papua New Guinea's quest for price stability. For instance, the January 2005 Monetary Policy Statement states, “Maintaining price stability in a small open economy like Papua New Guinea requires amongst other things, relative stability in the exchange rate” (Bank of Papua New Guinea 2005, p.2). The findings of Sampson et al. (2006) documenting the close relationship between the exchange rate and inflation in PNG suggest this view is well-

founded. It therefore follows from the results above that movements in commodity prices have the potential to disrupt price stability and that commodity prices should be an important factor influencing the Bank of Papua New Guinea's monetary policy decisions. If movements in commodity prices are judged to pose a threat to price stability an offsetting monetary policy response may be required.

Unfortunately, this paper does not offer a clear conclusion as to what that policy response should be. Further work on the determinants of the kina is clearly required. The relationships between the interest rate differential and net credit to government and the exchange rate need to be clarified. This is likely to require research on whether or not these variables are stationary – something that will become possible when longer time series are available. Alternative estimation methodologies, particularly those based on cointegration techniques, should also be considered. Work on the real exchange rate and the applicability of models of purchasing power parity in PNG would be interesting. In addition, note that this paper has not considered the effect on the kina of the Bank of Papua New Guinea's foreign exchange market interventions. Research on the effectiveness and importance of these interventions would be very valuable. Finally, it is important to remember that perhaps the most notable features of empirical exchange rate models of other currencies have been their lack of robustness over time and their forecasting failures. Once more data is available it will be necessary to evaluate whether the link between commodity prices and the kina suffers these difficulties.

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Appendix – Data definitions and sources

Exchange rate – End of quarter nominal kina/US dollar exchange rate. Source: Bank of Papua New Guinea.

Commodity prices – Quarterly average international US dollar prices. Source: International Monetary Fund's International Financial Statistics (IMF IFS). Series: Cocoa 65276R.ZZFM44; Coconut Oil 56674AIZZF; Coffee 38676EBZZF; Copper 11276C.ZZF; Copra 56676AGZZF; Gold 11276KRZZF; Palm Oil 54876DGZZF; Petroleum 00176AAZZF; Rubber 54876L.ZZF; Tea 11276S.ZZF; Timber 54876VXZZF.

Export data – Annual value of exports and volume of exports by commodity. Source: Bank of Papua New Guinea.

Net credit to government – End of quarter net credit to the government of PNG from the domestic

banking system. Source: Bank of Papua New Guinea.

Fiscal deficit – Quarterly PNG Government budget deficit. Source: Bank of Papua New Guinea.

Nominal GDP – Quarterly GDP data is not available for PNG. Therefore, quarterly estimates are interpolated from the annual data. Annual data source: PNG National Statistical Office for years up to and including 2002 and PNG Department of Treasury 2006 National Budget thereafter.

Interest rates – End of quarter nominal interest rate per annum on six month Government security (182 day Treasury Bill for PNG, 6 month Treasury Bill for US). Source: PNG data from the Bank of Papua New Guinea; US data from the US Federal Reserve.

Southern Oscillation Index – Quarterly average Troup Southern Oscillation Index. Source: Australian Bureau of Meteorology.

Money supply – End of quarter M1 or M3. Money supply differential is calculated as the difference between the logarithm of the PNG money supply and the logarithm of the US money supply. Source: PNG data from Bank of Papua New Guinea; US data from IMF IFS.

Foreign exchange market turnover – Annual inflows of foreign exchange to PNG by sector. Source: Bank of Papua New Guinea.