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Abstract

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 value of the kina is found to be highly dependent on the international price of Papua New Guinea's commodity exports. 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 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.

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1. Introduction

In Papua New Guinea's ongoing quest for macroeconomic stability the 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 has been blamed for suppressing agricultural export growth and, thereby, reducing economic growth (NZIER 2006). After 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]

Given the importance of the exchange rate in influencing macroeconomic dynamics in PNG, understanding the factors that determine its movements is an important goal for both researchers and policymakers. Conventional wisdom holds that the kina exchange rate is affected primarily 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] However, there has been little empirical analysis that can be used to test these views. The most notable exception is Cashin, Céspedes and Sahay (2002) who find evidence of a positive

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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).

long run effect of increases in international commodity prices on the real kina exchange rate. This leads the authors to label the kina a commodity currency – a term applied to currencies whose value is influenced by commodity prices. This paper sheds further light on the validity of the conventional wisdom by analysing the determinants of the nominal kina exchange rate.

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 effects are only observed if the 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, Papua New Guinea's fiscal deficit or the volume of commodities exported by PNG.

The findings support the classification of the kina as a commodity currency and highlight the vulnerability of PNG's economy to external shocks; a vulnerability that raises the question of whether external developments or domestic economic policies are more important in shaping PNG's macroeconomic outcomes. Understanding the balance and interplay between these two influences should be a central objective of policymakers in PNG.

A comparison of this paper's results with those of Cashin, Céspedes and Sahay (2002), who study the relationship between commodity prices and the real kina exchange rate, and Sampson et al. (2006), who estimate the effect of nominal exchange rate movements on inflation in PNG, shows that following a commodity price shock nominal exchange rate movements cause the real exchange rate to overshoot its long run response. The nominal exchange rate movements, however, induce variation in inflation which return the real exchange rate to its long run level. This dynamic raises the possibility that the Bank of PNG could reduce volatility in both domestic prices and the nominal exchange rate by intervening in the foreign exchange market to smooth the adjustment of the real exchange rate to commodity price shocks. A full analysis of the costs and benefits such a policy, however, lies behind the scope of the present work.

The remainder of the paper is organised as follows. The next section offers some background on the kina and reviews previous literature on determinants of the exchange rate in both PNG and other small, open, commodity dependent economies. The model to be estimated is then described and motivated, followed by a discussion of the data and the estimation methodology. Next, follow two sections presenting the empirical findings: first, using an aggregate commodity price variable, and, second when commodity prices are decomposed into mineral and non-mineral prices. The final section concludes with a discussion of some policy questions which this paper raises and suggestions for future research.

2. 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 (1983) 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 differs from the literature on the optimal choice of exchange rate regime for PNG by taking the floating exchange rate as given and investigating empirically the causes of changes in the value of the kina. Consider the kina/US dollar exchange rate from 1995-2005 (Figure 1). 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.

Even during the period when the kina was trending downwards, however, its behaviour varied greatly. 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?

There is a substantial body of work showing that positive terms of trade shocks cause exchange rate appreciations in small, open, primary commodity dependent economies. 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 evidence that in Australia, Canada and New Zealand the price of commodity exports has a significant influence on the real US dollar exchange rate, while Chen (2004) finds a strong effect of commodity prices on the nominal exchange rates of Australia and New Zealand, but not of Canada. Cashin, Céspedes and Sahay (2002) consider a sample

of 58 primary commodity dependent countries including PNG and, for each country, test whether there is a long run relationship between the real international price of its commodity exports and its real effective exchange rate. Using monthly data from 1980-2002 they find evidence of a cointegrating relationship for 22 of the countries. For PNG they not only find evidence of cointegration between commodity prices and the real exchange rate, but also that causality runs from commodity prices to the exchange rate. Their estimates imply that a 10 percent increase in commodity prices leads to a 4 percent long run appreciation of the real kina exchange rate.

Figure 1: Kina/US Dollar Exchange Rate

Source: Bank of PNG

Other previous work on exchange rate determinants in PNG has also 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 alternative definitions of the real exchange rate 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 these studies, this paper considers the nominal 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 predominantly 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.[3]

3. Exchange Rate Models

Despite the vast amount of work that has been undertaken on the economics of exchange rates during the last 30 years, and the multitude of competing models that have been postulated, no consensus has emerged on how to explain the behaviour of 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 will not attempt structural estimation of a specific theoretical exchange rate model, preferring instead to estimate a

[3] As of 31st December 2005 no offshore trading in the kina had been reported.

reduced form equation formed as a combination of variables selected either for their prominence in the exchange rate literature, or because they are often cited as important influences on the value of the kina.[4]

Motivated by the empirical success of the terms of trade in explaining the exchange rate in other small, open, primary commodity dependent economies, and by the findings of Cashin, Céspedes and Sahay (2002) discussed above, the primary focus of the paper will be on the relationship between commodity prices and the exchange rate. Following Chen and Rogoff (2003), Chen (2004) and Cashin, Céspedes and Sahay (2002) 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 is likely to be endogenous to the exchange rate so that its inclusion may result in inconsistent parameter estimates, whereas, being a price taker on world markets is the defining characteristic of a small economy. Secondly, there is no import price index available to calculate the terms of trade for PNG.

To fix ideas concerning the theoretical relationship between the terms of trade and the nominal exchange rate consider the following sticky price variant of the exchange rate model presented in Cashin, Céspedes and Sahay (2002). The world consists of two economies – home and foreign. Home is a small, open economy that produces two goods: a primary commodity and a non-tradable good. The primary commodity can be costlessly traded across countries. Both goods are produced under perfect competition using constant returns to scale technologies with labour as the only factor of production. Let y_C be home production of the primary commodity. Then:

$$y_C = a_C L_C \qquad (1)$$

where L_C is labour used in commodity production and a_C measures labour productivity in the commodity sector. Similarly, if y_N is home non-tradable production, then:

$$y_N = a_N L_N \qquad (2)$$

[4] Chen (2004) takes a similar approach to estimating whether commodity prices affect the nominal exchange rates of Australia, Canada and New Zealand. He takes four cannonical exchange rate models and augments each of them with a commodity price variable.

Labour is assumed to be perfectly mobile across sectors within a country, but immobile across countries. Using (1) and (2) producer profit maximisation together with equalisation of wages across sectors requires:

$$p_N = \frac{a_C}{a_N} p_C \tag{3}$$

where p_N and p_C are the prices of the non-tradable and the primary commodity, respectively. Now let S denote the exchange rate, written as the foreign currency price of home currency so that an increase in S denotes an appreciation of the home currency. Free trade in the primary commodity ensures:

$$p_C^* = p_C S \tag{4}$$

Combining (3) and (4) then gives:

$$S = \frac{a_C}{a_N} \frac{p_C^*}{p_N} \tag{5}$$

Under the assumption that the price of the non-tradable good is sticky, meaning that it does not respond to changes in the foreign price of the primary commodity, it immediately follows that a rise in international commodity prices must lead to an appreciation of the home nominal exchange rate to ensure that the law of one price given in (4) always holds. Note that no assumptions about the structure of the foreign economy or the nature of consumer demand are required to obtain this result. Moreover, even if non-tradable goods prices are not sticky an analogous relation between the foreign price of the primary commodity and the real exchange rate can still be derived.[5]

In addition to commodity prices, the baseline equation estimated below will also include as explanatory variables the inter-country interest rate differential and a fiscal variable. The interest rate differential is at the heart of asset pricing based exchange rate models that make use of

[5] See Cashin, Céspedes and Sahay (2002) for details.

the uncovered interest parity condition[6]. With 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. If foreign and domestic assets are perfect substitutes, the domestic currency will appreciate to the point where the difference between foreign and domestic interest rates is exactly offset by expected future exchange rate movements. The sensitivity of the kina exchange rate to interest rates 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.

Therefore, the baseline equation used in this paper is:

$$s_t = \alpha + \beta_0 t + \beta_1 (i_t - i_t^*) + \beta_2 g_t + B(L) z_t + \varepsilon_t \qquad (6)$$

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.

4. 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.

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[6] For instance, the Dornbusch (1976) and Frankel (1979) sticky price monetary model.

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 exports of the 11 commodities (Table 1). [7]

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
Mineral (aggregate)	74.2
Note: Each commodity's weight is given by the average of its annual shares from 1995 to 2004 of PNG's exports of the eleven commodities shown. The Export volume index is also constructed using the same weights.	

Source: Authors' calculations

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

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, the exchange rate and the interest rates data are end of quarter values.

Estimating equation (6) 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:

$$\Delta s_t = \beta_0 + \beta_1 \Delta(i_t - i_t^*) + \beta_2 \Delta g_t + B(L)\Delta z_t + u_t \qquad (7)$$

where $u_t = \varepsilon_t - \varepsilon_{t-1}$. 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 is also be estimated with these variables expressed in levels.

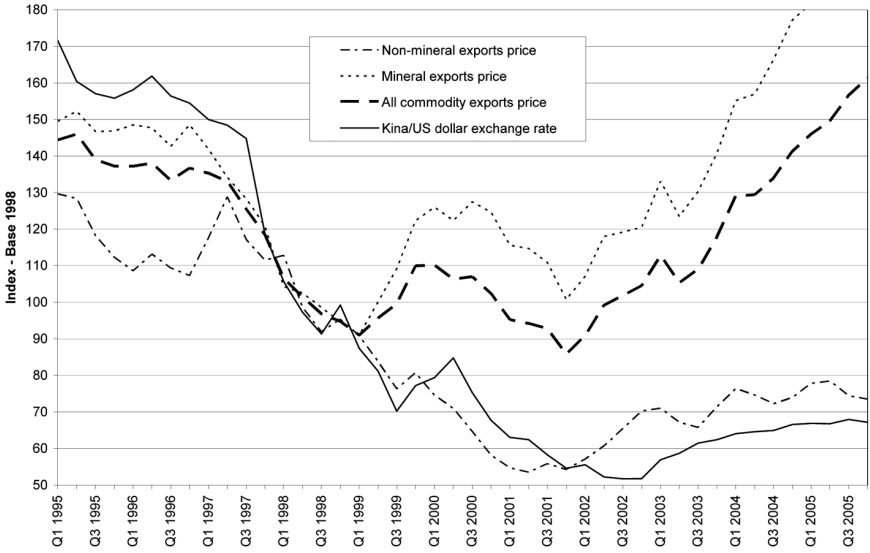
The model will be estimated both by OLS and by Two Stage Least Squares (2SLS). In the 2SLS estimations the interest rate differential and the fiscal variables will be treated as endogenous and their lagged values will be used as instruments.

5. Empirical Results

5.1 Composite Commodity Price

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 (7) 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 both to varying the number of lags included and to controlling for a range of additional independent variables. From this point on, only the results obtained from estimating the model including just the first two lags will be reported.

Figure 2: Commodity prices and the exchange rate



Source: Authors' calculations

Table 2: OLS Estimation Results with the Interest Rate Differential and Net Credit to Government in First Differences							
	(a)		(b)	(c)	(d)	(e)	(f)
ΔCommodity price	0.47*** (0.11)	ΔCommodity price	0.43*** (0.10)	0.43*** (0.10)	0.41*** (0.12)	0.34*** (0.12)	0.41*** (0.11)
ΔCommodity price (lag 1)	0.016 (0.17)	ΔCommodity price (lag 1)	-0.049 (0.16)	0.022 (0.16)	-0.017 (0.15)	-0.039 (0.14)	-0.030 (0.17)
ΔCommodity price (lag 2)	0.58** (0.21)	ΔCommodity price (lag 2)	0.53** (0.20)	0.50** (0.19)	0.56*** (0.19)	0.52** (0.20)	0.63** (0.23)
ΔCommodity price (lag 3)	-0.11 (0.22)	ΔInterest rate differential	-0.20 (0.38)	-0.11 (0.36)	-0.098 (0.39)	-0.073 (0.35)	0.41 (0.25)
ΔCommodity price (lag 4)	0.065 (0.20)	ΔNet credit to government	-0.51 (0.62)		-0.38 (0.61)	-0.32 (0.55)	0.26 (0.41)
		Δ 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.							
Source: Authors' calculations							

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).

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 (7) is estimated including the Southern Oscillation Index[8] 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) (Table 2) includes a dummy variable for those quarters when Ok Tedi was closed at the start of the quarter due to the drought.[9] 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.

Estimating equation (2) with a sample starting in 1998 Q1 makes little difference to the results (table 2). 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

[8] 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.

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

driven by events immediately following the float in 1995-97 during which the kina suffered a substantial depreciation (see Figure 1).

Next, the model is estimated under the plausible alternative assumption that the interest rate differential and fiscal variables are stationary (Table 3). The commodity price effects are broadly unchanged, but both the interest rate differential and net credit to government are now significant (Table: 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.

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. When the broad money supply differential is included instead of net credit to government, however, it is insignificant, while the coefficients of other variables are unaffected (Table 3: 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 not significant, but the other results are similar (Table 3: 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 (Table 3: column d).

Table 3: OLS Estimation Results with Interest Rate Differential and Net Credit to Government in Levels				
	(a)	(b)	(c)	(d)
ΔCommodity price	0.44*** (0.11)	0.46*** (0.12)	0.37*** (0.13)	0.43*** (0.11)
ΔCommodity price (lag 1)	-0.023 (0.15)	-0.012 (0.17)	-0.036 (0.15)	0.073 (0.17)
ΔCommodity price (lag 2)	0.55*** (0.17)	0.58*** (0.19)	0.54*** (0.18)	0.52*** (0.16)
Interest rate differential	0.31** (0.14)	0.35* (0.18)	0.27** (0.13)	0.19 (0.12)
Net credit to Government	-1.1* (0.56)	-1.3* (0.72)	-1.0* (0.59)	
Broad money supply differential		0.044 (0.075)		
Ok Tedi closed			-0.038 (0.024)	
Fiscal deficit				-0.17 (0.16)
Constant	0.054 (0.048)	0.10 (0.11)	0.051 (0.052)	-0.040*** (0.012)
R^2	0.45	0.46	0.47	0.40
N	41	41	41	41
Note: Dependent variable is first difference of kina/US dollar exchange rate. Newey West heteroscedasticity and autocorrelation consistent standard errors in parentheses. Sample: 1995 Q1 to 2005 Q4. * denotes significance at the 10 percent level, ** at the 5 percent level and *** at the one percent level.				
Source: Authors' calculations				

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.[10] To investigate this possibility the model is estimated by 2SLS using the first lag of the interest 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 applied to the residuals from the equations estimated above evidence of negative third order serial correlation is found. The null hypothesis of no serial correlation is accepted, however, if the first three lag differences of the exchange rate are included as regressors and, consequently, they are included as independent variables in the 2SLS regressions.[11]

[10] 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.

[11] When the model is estimated including lags of the dependent variable only the third lag is 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		
ΔCommodity price	0.48**	
	(0.19)	
ΔCommodity price (lag 1)	-0.11	
	(0.20)	
ΔCommodity price (lag 2)	0.67***	
	(0.20)	
Interest rate differential	0.52	
	(0.32)	
Net credit to government	-2.4*	
	(1.3)	
ΔExchange rate (lag 1)	0.037	
	(0.13)	
ΔExchange rate (lag 2)	-0.12	
	(0.11)	
ΔExchange rate (lag 3)	-0.25**	
	(0.12)	
Constant	0.16	
	(0.099)	
Endogenous regressors (p-value)	No (0.27)	
N	40	
Panel B: First stage regressions		
Dependent variable	Interest rate differential	Net credit to government
Δ Commodity price	-0.048	-0.020
	(0.10)	(0.046)
Δ Commodity price (lag 1)	-0.061	-0.084
	(0.10)	(0.063)
Δ Commodity price (lag 2)	-0.060	0.032
	(0.094)	(0.044)
Interest rate differential (lag 1)	0.79***	0.076
	(0.085)	(0.051)
Net credit to government (lag 1)	0.58**	0.55***
	(0.27)	(0.17)
ΔExchange rate (lag 1)	-0.071	-0.0061
	(0.067)	(0.054)
ΔExchange rate (lag 2)	0.024	-0.029
	(0.069)	(0.031)
ΔExchange rate (lag 3)	-0.088	0.030
	(0.071)	(0.032)
Constant	-0.041*	0.036**
	(0.024)	(0.015)
Under identified (p-value)	No (0.00)	No (0.00)
R^2	0.84	0.54
N	40	40

Note: Dependent variable in second stage is first difference of kina/US dollar exchange rate. Heteroscedasticity robust standard errors in parentheses. Sample: 1995 Q1 to 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.

Source: Authors' calculations

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 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 (7) 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.

5.2 Mineral and Non-mineral Prices

An unexpected implication of the results 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 0.742 and the non-mineral price index has a weight of 0.258 (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 Papua New Guinea's 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, 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.

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
ΔNon-mineral price	0.33* (0.18)	0.28* (0.14)	Δ Commodity price	0.35*** (0.12)	0.30 (0.36)
ΔNon-mineral price (lag 1)	-0.00064 (0.16)	-0.037 (0.19)	ΔCommodity price (lag 1)	0.032 (0.16)	-0.043 (0.26)
ΔNon-mineral price (lag 2)	0.043 (0.15)	0.074 (0.19)	ΔCommodity price (lag 2)	0.58*** (0.17)	0.70*** (0.25)
ΔMineral price	0.24 (0.15)	0.30* (0.16)	Interest rate differential	0.31** (0.13)	0.58 (0.41)
ΔMineral price (lag 1)	-0.053 (0.12)	-0.093 (0.14)	Net credit to government	-1.2** (0.52)	-3.0* (1.8)
ΔMineral price (lag 2)	0.49*** (0.14)	0.53*** (0.16)	ΔCommodity volume	0.12* (0.061)	0.23 (0.34)
Interest rate differential	0.31* (0.16)	0.43 (0.26)			
Net credit to government	-0.91 (0.56)	-1.8* (1.1)			
Constant	0.036 (0.047)	0.11 (0.086)	Constant	0.063 (0.046)	0.20 (0.14)
R^2	0.52		R^2	0.49	
N	41	40	N	41	40
Endogenous regressors (p-value)		No (0.31)	Endogenous regressors (p-value)		No (0.29)
Note: 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) ΔCommodity 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.					
Source: Authors' calculations					

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 the relative sensitivity of the exchange rate to mineral and non-mineral price movements equation (8) is estimated:

$$\Delta s_t = \beta_0 + \beta_1 (i_t - i_t^*) + \beta_2 g_t + C(L)\Delta x_t + D(L)\Delta v_t + \varepsilon_t \qquad (8)$$

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.

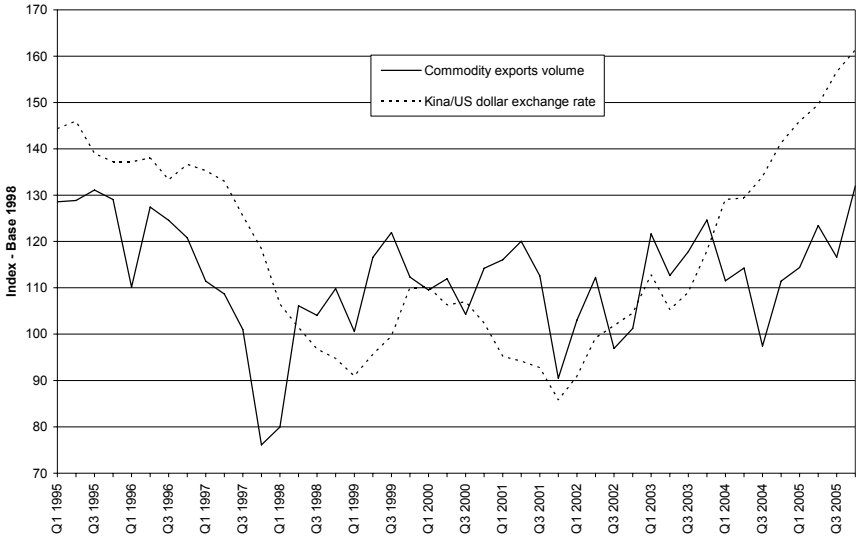
When equation 8 is estimated including two lags of both commodity price variables the non-mineral price only has a significant impact on the exchange for the current quarter, while the mineral price variable is marginally significant for the current quarter, but highly significant when lagged twice (Table 5). Otherwise the results are consistent with those in Tables 2-4 above and are similar for both OLS (Table 5: column a) and 2SLS (Table 5: 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 coefficients are not estimated with sufficient precision to reject either the hypothesis that current period non-mineral prices and twice lagged mineral prices have the same size effect on the exchange rate, or the hypothesis that the mineral prices effect is 2.9 times larger. 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, ceteris 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 exports volume, the interest rate differential and net credit to government - commodity volume is no longer significant (Table 5: 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 volumes and the exchange rate



Source: Authors' calculations

Conclusion

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

The dependence of the exchange rate on commodity prices highlights the vulnerability of the PNG economy to external shocks. A vulnerability which is heightened by the positive impact of commodity prices on both government tax revenues and export earnings. This shock exposure raises a number of issues worthy of further consideration. Firstly, the Somare government and the Bank of Papua New Guinea have frequently been credited with restoring macroeconomic stability following the 2002 election. 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.

Secondly, is the current level of commodity price vulnerability desirable and, if not, what steps could be taken to reduce it? Answering this question will require an assessment of the optimal trade-off between exploiting PNG's comparative advantage by promoting primary commodity exports and reducing exposure to external shocks by seeking a more diversified economic base. It is also likely that there is heterogeneity in costs and benefits across commodities. Desirable characteristics include: low price volatility; facilitating technology diffusion into PNG and the establishment of domestic upstream and downstream industries, and; high levels of job creation.

Understanding the behaviour of the exchange rate is also 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). Sampson et al. (2006) document the close relationship between the exchange rate and inflation in PNG, suggesting that this view is well-founded. Therefore, the results above imply that movements in commodity prices, through their effect on the exchange rate, 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.

In this regard, it is interesting to compare this paper's finding that a 10 percent increase in commodity prices leads to a cumulative 10 percent appreciation of the nominal exchange rate with the estimate of Cashin, Céspedes and Sahay (2002) that a 10 percent increase in commodity prices leads to a 4 percent appreciation of the real kina exchange rate in the long run.[12] These two results can be reconciled by noting that Sampson et al. (2006) conclude that long run pass-through from the exchange rate to inflation in PNG is 50-60 percent. Based on this estimate, a 10 percent exchange rate appreciation will cause a 5-6 percent drop in inflation meaning that the real exchange rate will appreciate by 4-5 percent in the long run. The consistency of these three sets of results is reassuring. Moreover, taken together they suggest that the Bank of PNG may be able to reduce both domestic price and nominal exchange rate volatility by intervening in the foreign exchange market to dampen the response of the nominal exchange rate to commodity price shocks.[13] Such a policy

[12] It should also be pointed out that while this paper works with the kina/US dollar exchange rate, both Cashin, Céspedes and Sahay (2002) and Sampson et al. (2006) use trade-weighted effective kina exchange rates.

[13] Although, PNG has had a floating exchange rate since 1994 the Bank of PNG has a policy of intervening in the foreign exchange market to "smoothen volatility in the exchange rate where necessary" (Bank of Papua New Guinea 2005, p.16). However, it does not explicitly aim to ensure a smooth adjustment of the real exchange rate to commodity price movements.

has potential drawbacks: not all exchange rate movements are caused by changes in commodity prices; identifying when the real exchange rate is overshooting is easier ex-post than in real time, and; not all foreign exchange market interventions have the desired outcome.[14] It is, however, far from clear that these costs outweigh the possible benefits of lower price and exchange rate volatility; a full analysis of the trade-offs involved would be useful.

This paper advances our understanding of the determinants of the value of the kina, but further work 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 also be of interest. 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 results from empirical studies 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.

[14] In addition, such a policy can be effective only if there is some endogeneity of the estimates reported above to the Bank of PNG's exchange rate policy. For instance, if pass-through from the exchange rate to inflation is always 60 percent, then a 4 percent real exchange rate appreciation will necessarily require a 10 percent nominal exchange rate appreciation. However, if the degree of pass-through is endogenous to the policy regime it may be possible to obtain a 4 percent real exchange rate appreciation despite having a nominal exchange rate movement below 10 percent. Consideration of the likely effect of a change in policy on the extent of pass through from commodity price shocks to the real exchange rate and from the nominal exchange rate to inflation should be central to any analysis of the desirability of smoothing real exchange rate adjustment to commodity price shocks. See Choudhri and Hakura (2001) for cross-country evidence that low average inflation is associated with low pass-through from the exchange rate to inflation and Sampson et al. (2006) for evidence that pass-through from the exchange rate to inflation in PNG rose after the floating of the kina.

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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.

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