Exchange rate pass-through in Papua New Guinea

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This article examines the relationship between the value of the kina and the price level in Papua New Guinea. The pass-through from the exchange rate to inflation is estimated using data from 1989–2004. Pass-through is found to be higher than previously estimated and evidence is presented that pass-through has increased since the kina was floated. Although results display sensitivity to how inflation and the exchange rate are measured, the article concludes that pass-through to underlying inflation is approximately 50–60 per cent and is complete after between four and six quarters. The article also shows that exchange rate movements have been the main source of variation in inflation during the sample period.

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How does the value of the kina affect prices in Papua New Guinea ? Economic theory and descriptive empirics both provide support for thinking that the exchange rate is likely to be one of the principal determinants of inflation.

Papua New Guinea is a small, open economy with a high marginal propensity to import (Blyth 1991). A depreciation of the exchange rate can be expected to lead directly to higher prices for imports of both intermediate inputs and final goods. If firms choose to pass the import price increases on to consumers, domestic inflation will result. This inflation may in turn stimulate further price changes through 'second round' effects such as increases in inflation-indexed wages or demand shifts resulting from the initial price rises. One of the primary purposes of the 'hard kina' policy Papua New Guinea pursued from the time of independence until the kina was floated in 1994 was to avoid imported inflation by maintaining the value of the kina (Garnaut and Baxter 1983).

A comparison of exchange rate movements and inflation rates before and after the floating of the kina in October 1994

Pacific Economic Bulletin Volume 21 Number 1 2006 © Asia Pacific Press

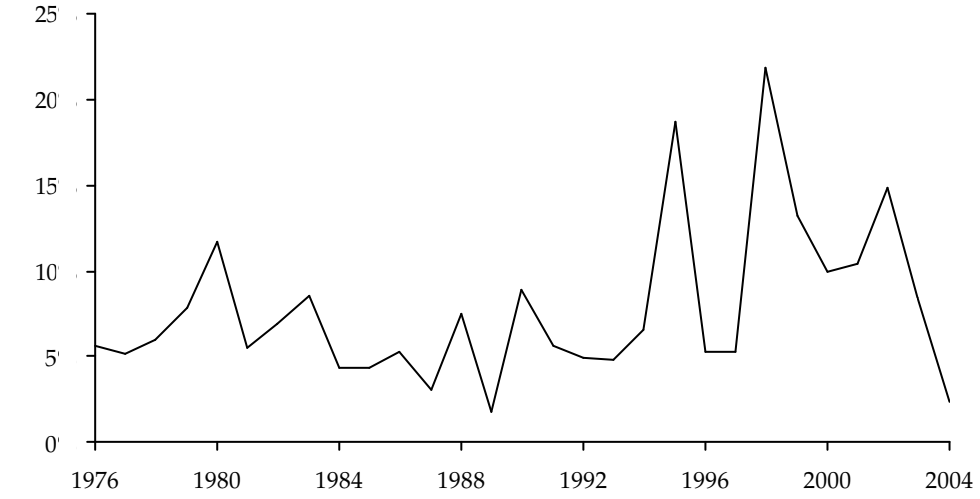
illustrates the perceived link. Between the start of 1989 and the end of 1993 the kina depreciated by 16 per cent against the US dollar. Average annual Consumer Price Index (CPI) inflation for this five year period was 5.2 per cent. During the next five years, from 1994–98, the kina depreciated by 53 per cent against the US dollar. Average annual inflation for this period was 11.5 per cent—double its level before the kina was floated.

Despite the theoretical link between exchange rate movements and inflation outcomes, and the circumstantial evidence supporting this hypothesis, little empirical work has been conducted to quantify the dynamics of the exchange rate–inflation relationship in Papua New Guinea.

Asafu-Adjaye (1998) and Choudhri and Hakura (2001) both estimate the pass-through[1] of exchange rate movements to inflation to be around 30–40 per cent. Choudhri and Hakura, who undertake a cross-country analysis, also find that countries with lower average inflation have lower pass-through. Both papers, however, use datasets primarily covering the period prior to the floating of the kina. Figure 1 shows annual CPI inflation in Papua New Guinea from 1976–2004. It shows an increase in the average level of inflation after the floating of the kina in 1994. Has exchange rate pass-through increased since the kina was floated?

This paper uses 1989–2004 data to investigate the dynamics of pass-through in Papua New Guinea under a floating exchange rate. A simple pass-through model is estimated in which inflation is postulated to be a function of exchange rate movements, past inflation outcomes, foreign inflation and the output gap. Estimated pass-through dynamics are sensitive to how inflation and

Figure 1 **Papua New Guinea: annual inflation, 1976–2004** (per cent)



Source: Bank of Papua New Guinea.

the exchange rate are measured, but pass-through is generally found to be in the 50–60 per cent range and to take between four and six quarters. The results also confirm that exchange rate movements have been the principal determinant of inflation during the sample period. When the model is estimated using data from before the kina was floated, pass-through is only 25 per cent and is complete after three quarters.

Modeling exchange rate pass-through is an integral part of developing an understanding of macroeconomic behaviour in Papua New Guinea. It establishes a relationship between two of the main macroeconomic variables. The magnitude and timing of exchange rate pass-through also has important policy implications for the Bank of Papua New Guinea, which is mandated to maintain price stability. The findings presented here could form the basis for an inflation forecasting model to be used in monetary policy formulation.

In addition, the relatively high level of estimated pass-through, combined with the dominance of exchange rate movements in causing inflation, raises an issue that would become important were Papua New Guinea to consider adopting an explicit inflation targeting framework for monetary policy. Is the impact of monetary policy-induced interest rate changes on the determinants of inflation sufficient for the Bank of Papua New Guinea to be able to combat the inflationary effects of shocks to a freely floating exchange rate and maintain a credible inflation targeting regime? Attempts to answer this question should bear in mind that the results suggest that if a low inflation environment can be achieved, pass-through may decline from its current levels.

Measuring inflation in Papua New Guinea

Measurement of inflation in Papua New Guinea faces three principal difficulties. Two of these are country specific, while the other is of more general concern.

First, there is the lack of alternative measures of inflation. The only domestic inflation measure in Papua New Guinea is the CPI,[2] published quarterly by the National Statistics Office since December 1975. There is no measure of producer prices, import prices, retail prices or non-tradable prices and no measure of consumer prices to compare with the figures published by the National Statistics Office.

Second, there are the limitations of the CPI. The basket of goods whose prices are included in the CPI is based on a survey of the consumption patterns of wage-earning urban households in 1975–76. The limited coverage of this survey, and, more importantly, the failure to update the consumption basket in the last 30 years, means that the CPI basket is not an accurate reflection of current expenditure patterns. Both the items included[3] and the weights given to different areas of expenditure are out of date and even in 1975–76 did not represent the consumption of the urban poor and rural households.[4]

The first two difficulties result from the failure of successive governments to devote sufficient resources to the collection of the data necessary to make informed policy decisions. The third is a problem faced by statisticians in all countries: how can the underlying rate of inflation be inferred from published inflation figures? No consensus exists on the theoretical definition of underlying inflation (Roberts 2005). Heuristically, it is generally taken to be the medium-term trend in inflation, but this understanding admits multiple modeling

frameworks. Roberts presents a model in which the underlying rate of inflation is the systematic component of aggregate inflation

$$\Pi_{it} = \Pi^{u}_{t} + \varepsilon_{it} \quad (1)$$

where Π_{it} is the inflation rate of item i in period t, Π^{u}_{t} is underlying inflation and ε_{it} is a stochastic shock specific to item i. Alternatively, underlying inflation may be viewed as the residual when seasonal effects, temporary economic shocks and stochastic variations are removed from observed headline inflation

$$\Pi^{u}_{t} = P_{t} - S_{t} - N_{t} - U_{t} \quad (2)$$

where P_t denotes headline inflation in period t, S_t is a seasonal factor, N_t denotes the inflationary effect of temporary shocks to the economy and U_t is a stochastic error term.

Despite the absence of agreement on a theoretical framework to model underlying inflation, most empirical measures are based on a common approach. Each period the components of the price index are re-weighted—the aim being to give greater weight to items whose price changes are indicative of underlying inflation. Roberts outlines different techniques used to achieve this goal and discusses their relative merits.

The Bank of Papua New Guinea publishes two underlying inflation measures: exclusion-based inflation and trimmed mean inflation. Both these measures are calculated by re-weighting the cross-section of price changes in the CPI. The CPI can be disaggregated into 23 sub-groups. The exclusion-based measure zero weights the nine sub-groups that are considered the most volatile.[5] To calculate trimmed mean inflation, the sub-groups are ranked each quarter by inflation rate and the bottom 33 per cent and top 27 per cent of the distribution are zero-weighted. Therefore, whereas the exclusion-based measure excludes the same sub-groups every quarter, the trimmed mean measure excludes each quarter those sub-groups that lie in the tails of the distribution of price changes in that specific quarter.[6]

Table 1 shows descriptive statistics for headline, exclusion-based and trimmed mean inflation. Headline and exclusion-based inflation display similar volatility, but the volatility of trimmed mean inflation is noticeably lower. This paper estimates exchange rate pass-through using both measures of underlying inflation, in addition to headline inflation, as the dependent variable. If the underlying measures are successful in capturing the medium-term

Table 1 **Descriptive statistics for the three inflation measures** (mean standard deviation)

Period	Headline	Trimmed mean	Exclusion-based
1976Q1–1989Q1	1.54 (1.26)	-	-
1989Q2–1994Q3	1.08 (1.03)	1.04 (0.81)	1.18 (1.01)
1994Q4–2004Q4	2.56 (2.42)	2.26 (1.69)	2.74 (2.36)
1989Q2–2004Q4	2.04 (2.15)	1.83 (1.55)	2.19 (2.11)
1976Q1–2004Q4	1.94 (2.06)	-	-

Notes: Inflation rates are quarterly. Underlying inflation measures not available prior to 1989Q2. 1999Q3 excluded from all calculations due to introduction of value-added tax.
Source: Authors' calculations.

inflation trend, then the model should explain a greater proportion of underlying inflation than of headline inflation.

Inflation model

Several alternative modeling frameworks have been used to estimate exchange rate pass-through. The long-run relationship between the exchange rate and the price level has been analysed using cointegration analysis. This is the approach taken by Hampton (2001) to examine the link between import prices and consumer prices in New Zealand. McCarthy (1999) introduces a 'distribution chain' model in which pass-through is estimated in a recursive VAR framework that analyses how exchange rate movements affect prices at different stages of the production chain. Gueorguiev (2003) applies this method to estimate pass-through in Romania.

Asafu-Adjaye (1998) uses cointegration analysis on a quarterly dataset covering 1981–96 to estimate the long-run relationship between domestic prices and excess money supply, foreign prices, price expectations and the exchange rate in Papua New Guinea. Surprisingly, the estimated exchange rate coefficient is not significant in the cointegrated model. However, Granger-causality tests with the variables in first-difference form show that, while the exchange rate Granger-causes domestic prices, the converse is not true. The author also estimates an error-correction model and finds a significant short-run effect of exchange rate movements on inflation. The estimated pass-through of exchange rate movements to inflation is 12 per cent after one quarter and 32 per cent after two quarters.

As part of a cross-country analysis of the relationship between inflation regimes and exchange rate pass-through, Choudhri and Hakura (2001) estimate pass-through for Papua New Guinea using a quarterly dataset from 1979 to 2000. They find pass-through of 11 per cent after one quarter, 23 per cent after two quarters, 36 per cent after four quarters and 38 per cent in the long-run.

Both Asafu-Adjaye and Choudhri and Hakura use data sets primarily covering the period prior to the floating of the kina. In their work, however, Choudhri and Hakura (2001:1) find 'strong evidence of a positive and significant association between the pass-through and the average inflation rate across countries and periods'. In other words, pass-through is lower in countries with low inflation regimes. Average inflation in Papua New Guinea has increased since the kina was floated in 1994. One question this paper addresses is whether exchange rate pass-through has also increased.

This paper estimates variants of

$$\tilde{\Pi}_t = \sum_{i=1}^{4} g_i d_{i,t} + g_5 l_t + C_1(L)\tilde{\Pi}_{t-1} + C_2(L)\Delta E_t + C_3(L)\Pi_t^F + C_4(L)D_t + e_t \quad (3)$$

where $\tilde{\Pi}_t$ is an inflation measure, $\delta_{i,t}$ for i=1,…,4 are quarterly dummy variables, λ_t is a dummy for the introduction of a value-added tax in 1999 Q3, DE_t is the percentage change in the exchange rate, P_t^F is a foreign inflation measure, D_t is a measure of excess domestic demand, ε_t is a stochastic error term, L is the lag operator and C_1,…, C_4 are polynomials.

This simple model is similar to those used in Choudhri and Hakura (2001) and Debelle and Wilkinson (2002). Domestic inflation is postulated to be a function of inflationary expectations, which are proxied by past inflation outcomes, exchange rate movements, foreign inflation, domestic demand characteristics and seasonal effects. The model allows both for direct effects of exchange rate movements on inflation and for 'feedback' effects caused by changes in inflation expectations. Exchange rate pass-through will

be a combination of the two effects. Unit root tests[7] on headline CPI, the two underlying price indices, the exchange rate and foreign prices indicate that these variables are integrated of order one. They are therefore expressed in percentage change form in Equation 3 to ensure stationarity and estimated using ordinary least squares.

The underlying inflation measures are intended to eliminate the seasonality and reduce the noise in headline inflation. Therefore, it is expected that when the model is estimated with either exclusion-based or trimmed-mean inflation as the dependent variable the estimated seasonal coefficients will be equal and the standard deviation of the residuals will be lower than when headline inflation is used.

The exchange rate is measured as the weighted average of the exchange rates of the kina with the US dollar, Australian dollar, Japanese yen, Singaporean dollar and New Zealand dollar. Two alternative weightings are used to calculate the effective exchange rate. One based on the average share of Papua New Guinea's imports purchased from each country during 1989–2004 and the other based on the average share of Papua New Guinea's imports purchased in each currency during 1996–2004 (Table 2). The effective exchange rates calculated using these weightings are labelled the country-based exchange rate and the currency-based exchange rate respectively. Domestic inflation, exchange rate and import data is from the Bank of Papua New Guinea. Exchange rates are expressed such that an increase denotes an appreciation of the kina. Foreign inflation is measured as the percentage change in a weighted average of the CPI of Australia, the United States, Japan, Singapore and New Zealand. The weights used are the same as the country-based weights used for the exchange rate. Foreign CPI data is from the International Monetary Fund's *International Financial Statistics*. The dataset covers 1989Q2–2004Q4. The disaggregated CPI data required to calculate the two underlying inflation measures are not available prior to 1989.

Estimation results

The previous section was intentionally vague concerning the definition of the domestic demand measure, D_t, included in Equation 3. The variable most commonly used to capture

Table 2 **Weights used to calculate weighted exchange rates and weighted foreign CPI**

Weights based on	Average share of Papua New Guinea's imports coming from country		Average share of Papua New Guinea's imports purchased in currency
	1989–2004	1977–93	1996–2004
Australia	62.1	53.1	35.1
United States	16.7	11.3	52.6
Japan	8.7	18.2	4.9
Singapore	8.3	12.5	4.1
New Zealand	4.3	4.9	3.3

Notes: Weights normalised to sum to 100. All excluded countries had shares of less than 3 per cent for the 1989–2004 and 1996–2004 data and less than 4 per cent for the 1977–93 data.
Source: Bank of Papua New Guinea.

inflationary pressures resulting from excess demand is the output gap. Calculation of an output gap for Papua New Guinea is complicated by the fact that GDP data is only published annually. Therefore, to obtain a quarterly output gap series the following steps are taken. First, a quarterly GDP series is calculated by interpolating the annual data. Second, trend GDP is estimated by applying a Hodrick-Prescott filter to the quarterly GDP series and, third, the output gap is computed as the difference between the log of actual GDP and the log of trend GDP. The annual GDP series used consists of National Statistics Office data from 1989–2002 and Department of Treasury estimates for 2003–04.

Unit root tests are inconclusive in determining whether or not the output gap series is stationary. The Augmented Dickey-Fuller test indicates stationarity, while the Phillips-Perron test does not reject the null hypothesis of a unit root. In addition, previous authors (for example, Debelle and Wilkinson 2002; Hampton 2001) have found that inflation may depend on both the level and the first difference of the output gap. Therefore, we decided to include the current period value of both these variables in the model, by assuming

$$C_4(L) = \alpha_0 + \alpha_1 (1 - L) \qquad (4)$$

The number of exchange rate lags to include is determined by a general-to-specific methodology. The model is first estimated with eight lags included and the Schwarz criterion is then used to determine which lags to exclude. It is assumed that expected inflation is a four-quarter moving average of past inflation outcomes. Foreign inflation is also expressed as a four-quarter moving average. That is,

$$C_j(L) = \frac{b_j}{4}\left(1 + L + L^2 + L^3\right) \qquad j = 1,3 \qquad (5)$$

where b_1, b_3 are the coefficients to be estimated. The validity of the restrictions on C_1, C_3 and C_4 will be examined below.

Table 3 shows the results obtained from estimating the model using the country-based exchange rate. In columns (a) and (b) headline inflation is the dependent variable. Exchange rate movements have significant effects at lags one, two and three and the largest impact is at lag one. Applying the Schwarz criterion causes the current period exchange rate to be dropped (column a). In column (b) the current period exchange rate is included; it has the theoretically correct sign, but is insignificant. The output gap has an insignificant effect, but its first difference has a positive effect that is significant at the 10 per cent level. Foreign inflation is also significant at the 10 per cent level and the hypothesis that the coefficient of foreign inflation equals one cannot be rejected. Past inflation outcomes have an insignificant effect. Consequently, exchange rate pass-through is calculated as the cumulative sum of the estimated coefficients of the exchange rate variables. Estimated long-run pass-through is 46 per cent if the current period exchange rate is excluded, and 51 per cent if it is included, and is complete after four quarters.

Columns (c) and (d) report the results obtained when the trimmed mean is used as the dependent variable. Exchange rate movements have a significant effect on inflation in the current period and at each of the first four lags. The effect is strongest at the first lag and declines thereafter. Application of the Schwarz criterion also results in the sixth exchange rate lag being included, even though the fifth lag is excluded (column c). When the sixth lag is dropped the estimated coefficients of the remaining variables are similar (column d), but long-run pass-through drops from 64 to 55 per cent. Past trimmed mean outcomes and the output gap are insignificant, but foreign inflation is significant at the 1 per cent level, and the first difference of the output gap is also significant.

Table 3 **Estimation results using country-based exchange rate**

Dependent variable	(a) Headline	(b) Headline	(c) Trimmed mean	(d) Trimmed mean	(e) Exclusion-based
Exchange rate	-	–0.0613 (0.0631)	–0.0818*** (0.0233)	–0.0881*** (0.0242)	–0.168*** (0.0510)
Exchange rate (–1)	–0.211*** (0.0617)	–0.208*** (0.0613)	–0.182*** (0.0339)	–0.173***(0.0307)	–0.206*** (0.0346)
Exchange rate (–2)	–0.100** (0.0449)	0.0985** (0.0465)	0.144*** (0.0247)	–0.130*** (0.0273)	–0.136*** (0.0327)
Exchange rate (–3)	–0.151*** (0.0508)	–0.142*** (0.0479)	–0.107*** (0.0244)	–0.0936*** (0.0213)	–0.155*** (0.0322)
Exchange rate (–4)	-	-	–0.0809*** (0.0260)	–0.0601** (0.0288)	–0.0884** (0.0420)
Exchange rate (–6)	-	-	–0.0483** (0.0228)	-	-
Output gap	0.859 (5.37)	0.490 (4.79)	–0.586 (2.44)	–0.388 (2.38)	3.48 (5.14)
First difference of output gap	18.5* (10.3)	20.1* (10.2)	16.2** (6.35)	13.7** (6.36)	27.3** (11.4)
Past inflation	–0.110 (0.254)	–0.0544 (0.231)	–0.216 (0.122)	–0.0576 (0.131)	–0.0634 (0.178)
Foreign inflation	1.03* (0.596)	1.08* (0.587)	1.19*** (0.404)	1.12*** (0.396)	1.48**(0.614)
Estimation period	1989Q3–2004Q4	1989Q3–2004Q4	1990Q2–2004Q4	1990Q2–2004Q4	1990Q2–2004Q4
R^2	0.57	0.58	0.83	0.81	0.74
Adjusted R^2	0.47	0.48	0.77	0.76	0.66
Regression standard error	1.72	1.71	0.81	0.83	1.27
Seasonal effects significant	Yes (0.03)	Yes (0.05)	No (0.44)	No (0.43)	No (0.20)
Exchange rate pass-through (long-run) (per cent)	46	51	64	55	75

Notes: Quarterly dummy variables and a dummy for the introduction of value-added tax in 1999Q3 included in all regressions. White heteroskedasticity consistent standard errors in parentheses. * indicates significance at the 10 per cent level, ** indicates significance at the 5 per cent level, *** indicates significance at the 1 per cent level. 'Regression standard error' is an estimate of the standard deviation of the residuals. 'Seasonal effects significant' reports the results of a Wald Chi-squared test at the 10 per cent significance level of the null hypothesis that the coefficients on the quarterly dummy variables are equal (p-value in parentheses). Exchange rate pass-through is calculated using the estimated coefficients of all the included exchange rate variables, regardless of their level of significance.
Source: Authors' calculations.

When exclusion-based inflation is used (column e), the exchange rate and its first four lags are significant, but higher lags are excluded. The estimated effect of the current period exchange rate is substantially larger than was the case for either headline or trimmed mean inflation, with pass-through of 17 per cent after one quarter. Long-run pass-through is 75 per cent and is complete after five quarters. Once again the output gap and past inflation outcomes are insignificant, while the first difference of the output gap and foreign inflation are both significant at the 5 per cent level.

Comparing the estimation results for the two underlying inflation measures with those for headline inflation there is evidence that both underlying measures succeed in reducing the seasonality and noise present in headline inflation. The significant seasonal effects found in the headline inflation regressions are absent when using either underlying measure. The regression standard errors for the trimmed-mean regressions are less than half the values for the headline regressions, with the regression standard error for the exclusion-based model approximately halfway between the two. Similarly, the model R^2 is greater than 0.80 for trimmed-mean inflation, 0.74 for exclusion-based inflation and less than 0.60 for headline inflation. These results also suggest that the trimmed mean is a better indicator of underlying inflation than exclusion-based inflation.

Table 4 shows the results from estimating the model using the currency-based exchange rate. For headline inflation (column a), the results are similar to those obtained using the country-based exchange rate, except that the first difference of the output gap is no longer significant. For the trimmed-mean and exclusion-based measures, however, there are substantial differences from the results obtained using the country-based exchange rate. In both cases, the first difference of the output gap is no longer significant, but past inflation outcomes now have a positive and significant effect (columns b and c). In addition, the fourth lag of the exchange rate is excluded from both models. The estimated coefficients on the included exchange rate variables are similar to those obtained when the country-based exchange rate is used.

The persistence in inflation outcomes reported in columns (b) and (c) of Table 4 must be included when calculating exchange rate pass-through. For instance, a fall in inflation resulting from an appreciation of the exchange rate will, because of persistence, cause further decreases in future inflation outcomes thereby increasing the deflationary impact of the initial exchange rate movement. Long-run exchange rate pass-through is estimated to be 56 per cent for trimmed-mean inflation and 80 per cent for exclusion-based inflation. Nine-tenths of the pass-through is complete after six quarters in both cases.

Are the maintained assumptions on the lag polynomials for past inflation, foreign inflation and the output gap valid? Past inflation outcomes enter the model as a four-quarter moving average. To examine this assumption, an alternative specification is estimated in which

$$C_1(L) = \beta_0 + \beta_1 L + \beta_2 L^2 + \beta_3 L^3 \qquad (6)$$

When the null hypothesis that $b_0 = b_1 = b_2 = b_3$ is tested, it is not rejected at the 10 per cent level when either trimmed-mean or exclusion-based inflation is used and the exchange rate is either country-based or currency-based.[8] It is rejected at the 10 per cent level, however, for both exchange rate weightings when headline inflation is the dependent variable. In each of these cases the second lag of headline inflation has a negative and significant effect and the magnitude of the exchange rate coefficients is larger than previously estimated. The negative persistence counteracts the larger exchange rate coefficients and long-run pass-through is 48

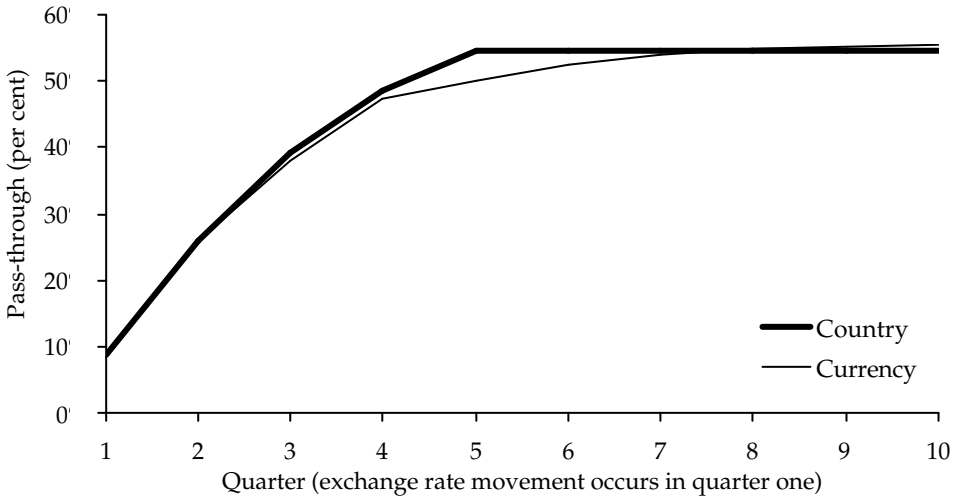
per cent for the country-based exchange rate[9] and 50 per cent for the currency-based exchange rate. These estimates are close to the 46 per cent long-run pass-through estimated for both exchange rate weightings when past inflation was written as a four-quarter moving average.

When the validity of writing foreign inflation as a four-quarter moving average is investigated using the same test, the null hypothesis is accepted in all cases except for when the exclusion-based model is estimated using the country-based exchange rate. Even in this case, however, the estimated coefficients of other variables are not sensitive to including foreign inflation and its first three lags separately. The results also indicate that the impact of foreign inflation is strongest in the current period and at the first lag. Additionally, the findings described above are robust to excluding the output gap from the model and to including lags of the first difference of the output gap.

The results in this section show that pass-through is sensitive to the inflation measure used. Long-run pass-through estimates range from 46 to 80 per cent and are lowest for headline inflation and highest for exclusion-based inflation. In all cases pass-through takes a minimum of four quarters and is at least 90 per cent complete after six quarters. Of the three inflation measures trimmed mean inflation has the lowest volatility and is considered to be the best indicator of underlying inflation. Estimates of pass-through to trimmed-mean inflation range from 55 to 64 per cent.

Estimation output is also sensitive to the exchange rate weighting. When the country-based exchange rate is used the first difference of the output gap is significant. However, this is not the case when the currency-based exchange rate is used. Furthermore, when the trimmed-mean and exclusion-based inflation models are estimated using the currency-based exchange rate fewer exchange rate lags are

Figure 2 **Pass-through to trimmed mean inflation as estimated using country-based and currency-based exchange rates** (per cent)



Source: Authors' calculations.

significant and there is evidence of persistence in the inflation process. Despite these differences the magnitude and timing of pass-through is similar across exchange rate weightings (Figure 2). This is because the significant persistence when the currency-based exchange rate is used is matched by the affect of extra exchange rate lags when the country-based exchange rate is used. Note also that, when past inflation outcomes are significant, pass-through is sensitive to the estimated level of persistence. A one standard deviation decrease in the persistence coefficient for trimmed-mean inflation reduces long-run pass-through to 49 from 56 per cent, while a one standard deviation increase raises it to 65 per cent.

Finally, all the models estimated above indicate that movements in the exchange rate were the main factor driving the substantial variations in inflation outcomes from 1989–2004. Figure 3 shows both trimmed-mean inflation and inflation mandated by exchange rate movements as calculated from the results in column (d) of Table 3. Changes in trimmed-mean inflation closely track changes in exchange rate-mandated inflation.

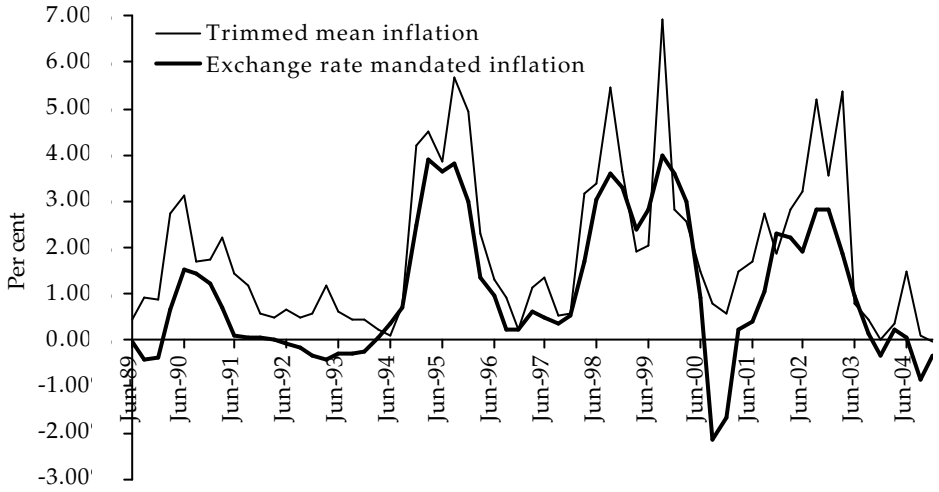
Alternative proxies for domestic demand

To construct the output gap variable included in the regressions estimated in the previous section, quarterly GDP was calculated from annual data by interpolation. If the output gap does not accurately capture excess domestic demand then there is a potential for omitted variable bias in the estimated coefficients. For instance, if an increase in domestic demand leads to an increase in import demand, which causes the exchange rate to depreciate, then the magnitude of the exchange rate coefficients may be biased upwards because they will capture the inflation caused by the increased domestic demand in addition to the exchange rate effect. Conversely, if high export prices were to cause a simultaneous appreciation of the exchange rate and increase in domestic demand, the estimated exchange rate coefficients will be biased towards zero.

This section assesses the impact on estimated exchange rate pass-through of excluding the output gap and its first difference from the model and including instead proxies for domestic demand that are available quarterly. The variables used are the budget deficit and non-mineral exports. The budget deficit is measured as the ratio of government expenditure, excluding foreign interest payments, to government receipts, excluding foreign grants. Unit root tests indicate that the budget deficit series is stationary and the non-mineral exports series is integrated of order one.[10] Consequently, the percentage change in non-mineral exports is included in Equation 3. Fiscal and export data are from the Bank of Papua New Guinea.

The results obtained using trimmed mean inflation and including the domestic demand proxies are shown in Table 5. Both the budget deficit and the percentage change in non-mineral exports are expressed as four-quarter moving averages to smooth seasonal variations in the fiscal and agricultural cycles. When either the country-based or currency-based exchange rate is used, neither the budget deficit (columns a and b) nor non-mineral exports (columns c and d) are significant. All other variables have very similar effects to those recorded in the regressions that included the output gap. The same is true if either the budget deficit or non-mineral exports is included in the models for headline or exclusion-based inflation. These findings are robust to redefining the budget deficit calculation to include foreign interest payments and foreign grants and to including the variables and their lags separately instead of as four-quarter moving averages.

Figure 3 **Quarterly trimmed mean inflation and exchange rate mandated inflation** (per cent)



Note: Exchange rate mandated inflation calculated from the estimation results in Table 3, column d.
Source: Authors' calculations.

There is no link between the domestic demand proxies considered in this section and inflation outcomes. This suggests that they are less successful than the output gap in capturing excess domestic demand.[11] However, in spite of the failure to find an improved measure of excess domestic demand, it is reassuring to note that estimated exchange rate pass-through is not sensitive to the replacement of the output gap by either the budget deficit or non-mineral exports.

Pass-through and the inflation regime

This section considers the sensitivity of the results to varying the sample period, and re-weighting the CPI expenditure groups to reflect 1996 expenditure patterns.

The sample used previously commences in 1989Q2; the first quarter for which trimmed mean and exclusion-based inflation are available. However, there is extensive cross-country evidence that the level of pass-through is linked to the inflation regime, with higher inflation outcomes leading to higher pass-through. Figure 1 suggests the possibility that the inflation regime in Papua New Guinea may have changed following the floating of the kina in 1994. Is there any evidence of a change in pass-through in Papua New Guinea since 1994?

To test this question, the headline inflation regression shown in column (b) of Table 3 is re-estimated using data for 1977–93. The exchange rate and foreign CPI are weighted based on the average share of Papua New Guinea's imports purchased from each country during 1977–93 (Table 2). Exchange rate and foreign CPI data are from the IMF's *International Financial Statistics*.

There is a clear difference between the results obtained using the pre-float sample

(Table 6, column a) and the results for the 1989–2004 sample. For the earlier period the exchange rate is only significant at lags one and two and pass-through is 25 per cent, compared to 51 per cent for the latter period. The results indicate that exchange rate pass-through has doubled since the floating of the kina in 1994 and that the time taken for exchange rate movements to affect domestic prices fully has increased. The estimated effects of other variables are remarkably similar in both samples.

Given these results it is interesting to examine whether excluding data from before the float alters estimated pass-through. Asafu-Adjaye (1998) and Choudhri and Hakura (2001) both estimated pass-through to be in the 30–40 per cent range using samples that included primarily, but not exclusively, pre-float data. Columns (b) and (c) of Table 6 show the results of re-estimating the trimmed-mean models in column (d) of Table 3 and column (b) of Table 4 using data starting from 1995 Q1.

When the country-based exchange rate is used (column b), the only noteworthy differences from the results in column (d) of Table 3 are, first, that the coefficient on foreign inflation increases from 1.12 to 1.88 and is significantly different from one at the 10 per

Table 4 **Estimation results using currency-based exchange rate**

	(a)	(b)	(c)
Dependent variable	Headline	Trimmed mean	Exclusion-based
Exchange rate	-	–0.0851*** (0.0304)	–0.171*** (0.0619)
Exchange rate (–1)	–0.219*** (0.0555)	–0.170*** (0.0248)	–0.185*** (0.0330)
Exchange rate (–2)	–0.0869** (0.0422)	–0.105*** (0.0215)	–0.0963** (0.0294)
Exchange rate (–3)	–0.157*** (0.0468)	–0.0727*** (0.0256)	–0.129*** (0.0316)
Output gap	1.65 (5.38)	0.286 (2.39)	2.83 (5.09)
First difference of output gap	14.2 (9.36)	5.92 (5.46)	16.9 (10.4)
Past inflation	–0.0774 (0.224)	0.225** (0.106)	0.272** (0.118)
Foreign inflation	0.954* (0.553)	0.956** (0.364)	1.15** (0.571)
Estimation period	1989Q3–2004Q4	1990Q2–2004Q4	1990Q2–2004Q4
R^2	0.59	0.80	0.70
Adjusted R^2	0.50	0.75	0.62
Regression standard error	1.67	0.85	1.34
Seasonal effects significant	Yes (0.02)	No (0.36)	No (0.34)
Exchange rate pass-through (long-run) (per cent)	46	56	80

Notes: Quarterly dummy variables and a dummy for the introduction of value-added tax in 1999Q3 included in all regressions. White heteroskedasticity consistent standard errors in parentheses. * indicates significance at the 10 per cent level, ** indicates significance at the 5 per cent level, *** indicates significance at the 1 per cent level. 'Regression standard error' is an estimate of the standard deviation of the residuals. 'Seasonal effects significant' reports the results of a Wald Chi-squared test at the 10 per cent significance level of the null hypothesis that the coefficients on the quarterly dummy variables are equal (p-value in parentheses).
Source: Authors' calculations.

Table 5 **Estimation results including alternative domestic demand proxies**

	(a)	(b)	(c)	(d)
Dependent variable	Trimmed mean	Trimmed mean	Trimmed mean	Trimmed mean
Exchange rate weighting	Country	Currency	Country	Currency
Exchange rate	–0.0860*** (0.0247)	–0.0859*** (0.0298)	–0.0861*** (0.0245)	–0.0849*** (0.0303)
Exchange rate (–1)	–0.162*** (0.0258)	–0.166*** (0.0235)	–0.162*** (0.0261)	–0.165*** (0.0224)
Exchange rate (–2)	–0.123*** (0.0266)	–0.107*** (0.0212)	–0.124*** (0.0264)	–0.105*** (0.0210)
Exchange rate (–3)	–0.0892*** (0.0233)	–0.0736*** (0.0260)	–0.0903*** (0.0224)	–0.0695** (0.0245)
Exchange rate (–4)	–0.0532* (0.0292)	-	–0.0533* (0.0291)	-
Past inflation	–0.0164 (0.138)	0.248** (0.112)	–0.0139 (0.138)	0.240** (0.112)
Foreign inflation	1.02** (0.382)	0.864** (0.338)	0.998** (0.384)	0.957*** (0.337)
Budget deficit	–0.165 (0.795)	0.528 (0.772)	-	-
Non-mineral exports	-	-	–0.00150 (0.0197)	0.00838 (0.0146)
Estimation period	1990Q2–2004Q4	1990 Q2–2004Q4	1990Q2–2004Q4	1990Q2–2004Q4
R^2	0.80	0.80	0.80	0.80
Adjusted R^2	0.75	0.75	0.75	0.75
Regression standard error	0.85	0.84	0.85	0.85
Seasonal effects significant	No (0.46)	No (0.35)	No (0.47)	No (0.37)
Exchange rate pass-through (long-run) (per cent)	51	57	52	56

Notes: Quarterly dummy variables and a dummy for the introduction of value-added tax in 1999Q3 included in all regressions. White heteroskedasticity consistent standard errors in parentheses. * indicates significance at the 10 per cent level, ** indicates significance at the 5 per cent level, *** indicates significance at the 1 per cent level. 'Regression standard error' is an estimate of the standard deviation of the residuals. 'Seasonal effects significant' reports the results of a Wald Chi-squared test at the 10 per cent significance level of the null hypothesis that the coefficients on the quarterly dummy variables are equal (p-value in parentheses).
Source: Authors' calculations.

Table 6 **Estimation results using alternative samples and CPI weightings**

	(a)	(b)	(c)	(d)
Dependent variable	Headline	Trimmed mean	Trimmed mean	Headline (1996 weights)
Exchange rate weighting	Country (1977–93)	Country (1989–2004)	Currency (1996–2004)	Country (1989–2004)
Exchange rate	–0.0292 (0.0549)	–0.0685** (0.0261)	–0.0533 (0.0326)	–0.0696 (0.0450)
Exchange rate (–1)	–0.0964* (0.0544)	–0.176*** (0.0222)	–0.172*** (0.0219)	–0.175*** (0.0431)
Exchange rate (–2)	–0.124*** (0.0460)	–0.132*** (0.0259)	–0.106*** (0.0213)	–0.0879** (0.0355)
Exchange rate (–3)	–0.00134 (0.0529)	–0.0950*** (0.0248)	–0.0723** (0.0266)	–0.154*** (0.0385)
Exchange rate (–4)	-	–0.0547* (0.0325)	-	-
Output gap	–2.11 (3.57)	–15.4** (7.32)	–14.1* (8.16)	2.09 (4.57)
First difference of output gap	21.3* (11.8)	21.5** (8.65)	12.0 (8.91)	12.0 (9.68)
Past Inflation	–0.0658 (0.261)	–0.0710 (0.173)	0.255 (0.172)	–0.0149 (0.164)
Foreign Inflation	1.03*** (0.298)	1.88*** (0.524)	1.33** (0.602)	1.37** (0.571)
Estimation period	1978Q1–1993Q4	1995Q1–2004Q4	1995Q1–2004Q4	1990Q1–2004Q4
R^2	0.52	0.87	0.84	0.65
Adjusted R^2	0.42	0.80	0.77	0.56
Regression standard error	0.93	0.81	0.88	1.39
Seasonal effects significant	Yes	No	No	No
	(0.00)	(0.14)	(0.14)	(0.14)
Exchange rate pass-through (long-run) (per cent)	25	53	40	49

Notes: Quarterly dummy variables included in all regressions. Dummy for the introduction of value-added tax in 1999Q3 included in all regressions except column (a). White heteroskedasticity consistent standard errors in parentheses. * indicates significance at the 10 per cent level, ** indicates significance at the 5 per cent level, *** indicates significance at the 1 per cent level. 'Regression standard error' is an estimate of the standard deviation of the residuals. 'Seasonal effects significant' reports the results of a Wald Chi-squared test at the 10 per cent significance level of the null hypothesis that the coefficients on the quarterly dummy variables are equal (p-value in parentheses). Exchange rate pass-through is calculated using the estimated coefficients of all the included exchange rate variables, regardless of their level of significance.
Source: Authors' calculations.

cent level and, second, that in the 1995–2004 sample the output gap has a negative effect significant at the 5 per cent level. Pass-through is 53 per cent in the 1995–2004 sample, compared to 55 per cent in the 1989–2004 sample.

When the currency-based exchange rate is used (column c), past inflation is not significant and consequently pass-through is only 40 per cent, compared to 56 per cent in the 1989–2004 sample. The current period exchange rate is also insignificant, while the output gap again has a negative and significant effect. Overal, however, the results obtained using the 1995–2004 sample are similar to those from the 1989–2004 sample. This finding also holds when the models for headline and exclusion-based inflation are estimated using the reduced sample.

The problems with measuring inflation using Papua New Guinea's CPI were discussed earlier. One of the difficulties is that the weights given to different items do not reflect current expenditure patterns. The CPI is made up of seven expenditure groups. Table 7 shows the weight given to each of the expenditure groups in the CPI, alongside weights based on the expenditure patterns recorded by the 1996 PNG Household Survey. CPI weights are from the National Statistics Office. 1996 PNG Household Survey weights are shown in World Bank (1999: Box 1.2). The main differences evident in the 1996 data are that substantially more weight is given to the 'rents, council charges, fuel and power' group, while the 'food' and 'drinks, tobacco and betel nut' groups have noticeably lower weights.

To examine whether estimated pass-through is sensitive to the weighting of the expenditure groups, an alternative headline inflation measure is calculated by re-weighting the expenditure groups using the 1996 weights. The model is then estimated using this inflation measure and the country-based exchange rate; the results are shown in column (d) of Table 6. The first difference of the output gap is not significant, but otherwise there are no substantial differences from the results obtained when estimating the model using published headline inflation (Table 3, columns a and b). Most importantly, re-weighting the CPI to reflect 1996 expenditure patterns at the group level does not affect estimated pass-through. However, this re-weighting does not alter the fact that the items included in the CPI groups are based on the 1975–76 survey and themselves require updating to reflect changes in consumption.

Table 7 **Expenditure group weights**

Expenditure group	CPI weight	1996 PNG Household Survey weight
Food	40.9	33.2
Drinks, tobacco and betel nut	20.0	8.8
Clothing and footwear	6.2	2.7
Rents, council charges, fuel and power	7.2	25.1
Household equipment and operation	5.3	5.5
Transport and communication	13.0	12.2
Miscellaneous goods and services	7.5	12.5

Source: World Bank, 1999. *Papua New Guinea: improving governance and performance*, World Bank, Washington, DC; Papua New Guinea National Statistics Office.

Conclusion

The evidence presented in this article is insufficient to justify definitive conclusions on the magnitude and timing of exchange rate pass-through in Papua New Guinea. Findings have displayed sensitivity to both the inflation measure used and the weightings applied to calculate the effective exchange rate. On balance, however, the results support the following four stylised facts about exchange rate pass-through in Papua New Guinea.

- Pass-through to underlying inflation is approximately 50–60 per cent.
- Pass-through is complete after between four and six quarters.
- Pass-through is strongest in the quarter following an exchange rate movement and declines thereafter.
- Since the floating of the kina in 1994 pass-through has doubled and the time taken for pass-through to be complete has increased.

None of these conclusions is indisputable, but they provide a set of benchmarks that policymakers can use to think about the inflationary impact of exchange rate movements and with which future work on pass-through can be compared.

Although the results confirm the hypothesis that exchange rate movements have been the main cause of variations in inflation, the paper also sheds light on other determinants of inflation in Papua New Guinea. Foreign inflation has a significant impact that is robust across all specifications considered. The hypothesis that the pass-through from foreign inflation to domestic inflation is one-to-one is rejected in only one of the models estimated. There is some evidence of persistence in the inflation process and of a role for the first difference of the output gap in causing inflation, but these results are not robust to the exchange rate weighting used. Headline inflation displays seasonality, but the underlying inflation measures do not. The trimmed mean is judged to be the best measure of underlying inflation available.

Future work should focus on achieving a better understanding of the relationship between domestic variables and inflation and on developing a model of the exchange rate. Both researchers and policymakers should also remain alert to the possibility that the dynamics of exchange rate pass-through will vary over time.

Notes

1 Throughout this paper exchange rate pass-through over K periods is defined to be the cumulative sum of the effects of a 100 per cent movement in the exchange rate in period t on estimated inflation in periods t, $t+1$, …, $t+K–1$. When the number of periods is not specified, the pass-through referred to is the long-run value.

2 The Bank of Papua New Guinea publishes a quarterly Export Price Index, but this is not suitable as a measure of domestic inflation.

3 For instance, the price of cinema admission makes up 0.96 per cent of the CPI basket, even though there are currently no cinemas in Papua New Guinea. When calculating the CPI the National Statistics Office assumes the price of cinema admission remains constant.

4 For further details see World Bank (1999:Box 1.2).

5 The sub-groups excluded are fruit and vegetables, betel nut and accompaniments, alcoholic drinks, cigarettes and tobacco, rents and council charges, fuel and power, fares, communication and medical and health care. These sub-groups together account for 36.4 per cent of the CPI.

6 For further details on the construction of underlying inflation measures see 'For the Record' in Bank of Papua New Guinea (2001).

7 Both the Augmented Dickey-Fuller test and the Phillips-Perron test give the same results.

[8] The results do suggest, though, that for both trimmed mean and exclusion-based inflation the significant impact of past outcomes when the currency-based exchange rate is used is driven by the effect of the first lag. The estimated coefficients of other variables are robust enough to include only the first lag of inflation in the model.

[9] Current period exchange rate is not included in the estimation (see also Table 3, column a).

[10] Both the Augmented Dickey-Fuller test and the Phillips-Perron test give the same results.

[11] Note, however, that this conclusion relies on the assumption that a relationship exists between excess domestic demand and inflation and, consequently, that a successful measure of excess domestic demand must have a significant effect on inflation. If it is assumed that no such relationship exists, then the results suggest that the output gap is the less successful measure.

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Acknowledgments

The authors would like to thank Dominic Mellor and Chrisite Smith who laid the foundations for our work, James Holloway who guided us in the right direction, and Gae Kauzi and Ebrima Faal who provided helpful comments on earlier drafts of the article. The views expressed in this article are those of the authors and do not necessarily represent the position of the Bank of Papua New Guinea.