Agricultural productivity, the electoral cycle and ENSO effects in Papua New Guinea

Roderick Duncan

Commentators have suggested that there is a link between agricultural productivity and elections in Papua New Guinea. On the face of it, this seems a plausible hypothesis; however, on closer examination, there is little supporting evidence for a link between agricultural output in export cash crops and PNG elections. What does appear to be true is that recent El Niño–Southern Oscillation (ENSO) events in Papua New Guinea have occurred around election years. It is these ENSO events and the droughts and floods that follow that have impacted on Papua New Guinea's agricultural productivity. The unfortunate coincidence of elections and agricultural stress could explain some of the civil unrest that occurs during PNG elections.

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Was 2007 a bad year for PNG cash crops? In the election year 2002, production of coffee in Papua New Guinea fell by 8 per cent,[1] production of copra oil fell by 41 per cent and production of palm oil fell by 6 per cent from their 2001 levels. In the previous election year of 1997, coffee production fell by 5 per cent, copra production fell by 9 per cent and cocoa production fell by 6 per cent from the previous year. There is some reason to believe that there could be a relationship between poor harvests and PNG national elections.

Some commentators[2] have suggested that there are good reasons for a relationship between agricultural output and PNG elections. Such explanations could include

- election bribes. With few vehicles for saving in rural Papua New Guinea, election money will be spent immediately, reducing the incentive to pick crops for cash.
- election parties and gatherings. Elections are a time for community and clan meetings and discussions; these events take away from time spent picking crops.
- election violence. Violence and the threat of violence associated with the election

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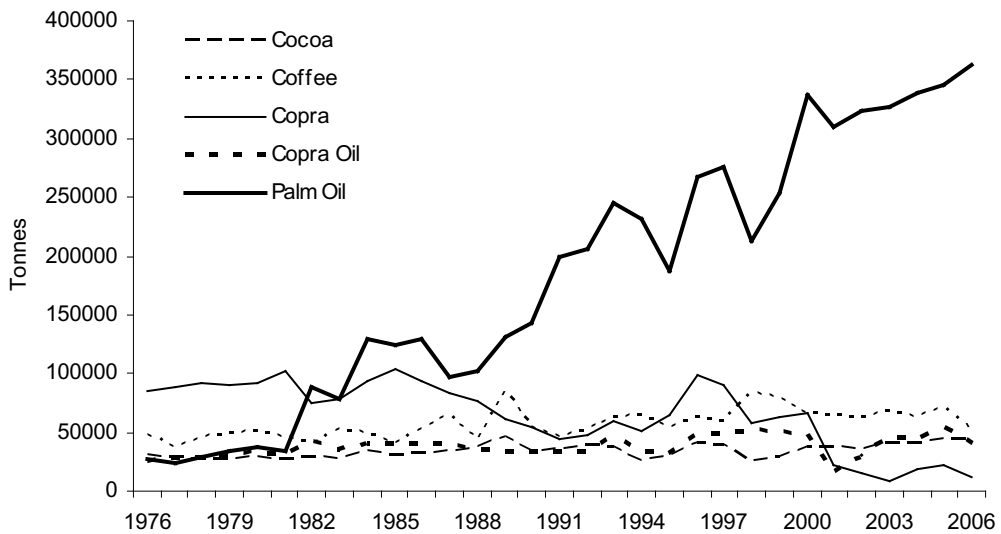
will reduce the willingness of people to travel. Without the ability to travel to the district markets to sell the crops, the crops will not be picked in the first place.

Whatever the mechanism that might or might not cause electoral politics to affect agricultural productivity, development of the PNG agricultural sector is a vital component of overall development. Duncan (2007) has previously emphasised the important role that agriculture has played in the development of land-rich developing countries such as Indonesia, Malaysia and Thailand. Duncan also argued that despite the international focus on the rapid industrialisation of these economies, all three economies saw a large improvement in agricultural productivity in the latter half of the last century.

This article focuses on the four big export or 'cash' crops in PNG agriculture: coffee, cocoa, oil-palm and copra. The value of cash crops is only a minor part of total exports (agriculture accounted for only 12 per cent of the total value of exports in 2006) but it is an important source of cash for poor and rural households, with the value of coffee, cocoa, copra and palm oil exports in 2006 totalling more than 1 billion kina. A large portion of this flows into Papua New Guinea's rural sector, which contains many of the country's poorest households. Increasing our understanding of changes in cash-crop productivity can help improve poverty policy in Papua New Guinea (Mosley and Suleiman 2007).

Figure 1 graphs the exports of the four major cash crops from 1976 until 2006. As is readily apparent, of these four crops, only palm oil has grown in importance since 1976. If we consider that the population of Papua New Guinea has expanded at approximately 3 per cent per annum since independence, the export volumes for all cash crops have been declining per head of population, except for palm oil.

Figure 1 **Papua New Guinea: cash-crop exports, 1976–2006** (tonnes)



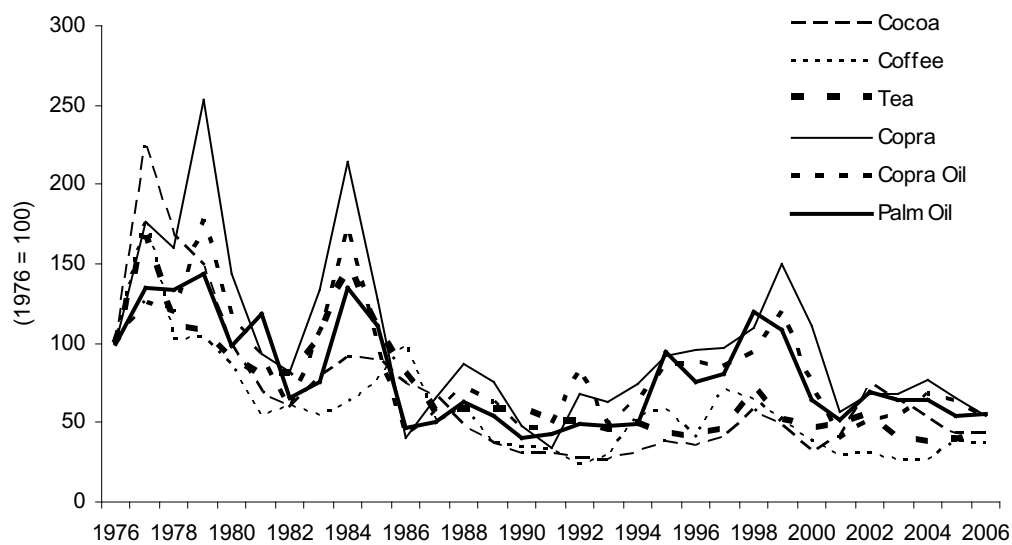
Source: Bank of Papua New Guinea, various years. *Quarterly Economic Bulletin*, Bank of Papua New Guinea, Port Moresby.

Given Papua New Guinea's climatic advantages, why are the cash crops not developing as we would wish? A report by the New Zealand Institute of Economic Research (NZIER 2006) placed the blame for the poor performance of cash crops on high inflation rates, which were a result of macroeconomic instability in the 1990s. According to the NZIER, high inflation meant that the profitability of cash crops fell over time. The appropriate response, the NZIER report argued, was better management by the Bank of Papua New Guinea—in particular, the adoption of an inflation target.

While an inflation target is a good idea for the Bank of Papua New Guinea, I doubt that the real blame for the failure of cash crops lies with the bank. Figure 2 shows an imputed real export price index[3] for the major cash crops against the overall consumer price index (CPI) from 1976 to 2006. The NZIER is certainly correct that the price index for cash crops has fallen relative to the CPI since 1976 (Figure 2). Unless there have been productivity increases in PNG agriculture since 1976, this fall in relative export values means that these cash crops are a less profitable activity for farmers than they were in 1976.

The data collected by the Food and Agricultural Organization set out in NZIER (2006), however, show no evidence of any compensating agricultural productivity increases in Papua New Guinea. The yield per hectare graphs for the various cash crops for Papua New Guinea in the NZIER report are flat over time. Similarly, Fleming (2007) found no statistical evidence of economically significant total factor productivity growth for Papua New Guinea for the period 1970–2002. These findings suggest that the lack of growth of many of the cash-crop sectors could be due simply to falling profitability in those sectors. Kannapiran (2000) also suggested this fact.

Figure 2 **Papua New Guinea: export price indices, 1976–2006**



Source: Bank of Papua New Guinea, various years. *Quarterly Economic Bulletin*, Bank of Papua New Guinea, Port Moresby.

Is the Bank of Papua New Guinea to blame for poor profitability in the cash-crop sector? Not in the sense that there is anything the bank could have done to avoid this result. What we are observing in the cash crop sector is simply the usual 'Dutch disease' result for the non-boom sectors in an economy. The success of minerals exports in Papua New Guinea in recent years means that the kina's nominal exchange rate is not depreciating relative to other currencies as fast as inflation differentials would warrant. The real exchange rate rises and exporters outside the minerals sector are hurt.

While the Bank of Papua New Guinea could change policies to reduce the average level and the standard deviation of inflation, the level of the real exchange rate is not something that most economists would argue should be managed by the bank. The poor performance in the cash-crop sector is simply the result of a booming minerals sector and no productivity growth in the cash-crop sector. Faced with a rising real exchange rate, appropriate policies to boost cash-crop exports are those that will improve cash crop and overall agricultural productivity.

A better set of recommendations—ones that the NZIER places second—would be to focus on factors that will improve agricultural productivity. These recommendations, including many of those in Anderson and Parker (2004) such as increased targeted agricultural research, improved rural infrastructure and public services and easier finance, would do much to improve overall agricultural productivity.

Explaining agricultural output

What is it that determines cash-crop production in Papua New Guinea? Unfortunately, we do not have data on the usual measures of productivity that are collected in industrialised countries, such as labour, capital and materials inputs into agriculture—as, for example, in Hayami and Ruttan (1970). Since the only data on PNG agriculture are quantity and price export data, I will use a variant of the Nerlove (1958) and Nerlove and Addison (1958) supply equations. The framework was developed further in Hartley et al. (1987). Jolly et al. (1990) was a previous attempt to fit Nerlove supply equations to cash-crop production in Papua New Guinea.

Output in each year depends on the amount of area planted and on the effort expended on picking the crop. The area under cultivation will depend on past estimates of future profitability, so output will depend on past prices. Effort expended on picking will, however, depend only on the current price—that is, the return to picking. These facts imply that there will be a lag structure in the data.

In the adjusted Nerlove model, the long-run output of a cash crop in year t, Q_t, depends on the current price, p_t, and on last year's price, p_{t-1}.

$$Q_t = a + b\, p_t + c\, p_{t-1} + d\, z_t \qquad (1)$$

where z_t includes other factors that affect productivity in that year and could include a time trend. This long-run level of output is the level that would be true if prices and output were to remain constant for a sufficiently long period. The Nerlove model assumes that the short-run or current level of output, q_t, adjusts only slowly to the long-run level of output, Q_t, as time is required to change crops, production methods, supply chains and other supply considerations.

The speed of adjustment in the Nerlove model depends on the parameter γ. Current output is assumed to follow the partial adjustment equation.

$$q_t - q_{t-1} = \gamma\,(Q_t - q_{t-1}) \qquad (2)$$

Substituting this equation into the previous equation, we get the regression equation.

$$q_t = a\gamma + b\gamma p_t + c\gamma p_{t-1} + (1 - \gamma) q_{t-1} + d\gamma z_t + u_t \quad (3)$$

Equation 3 will be used with the PNG agricultural data.

A more complicated lag structure could be used, as in Jolly et al. (1990). In that paper, price expectations were modelled also as a partial adjustment process instead of the static expectations of the Nerlove model. This model produces a regression equation with p_t, q_{t-1} and q_{t-2} as explanatory variables. When these equations were estimated, however, the results were not qualitatively different from the simpler static expectations of the Nerlove model. Only the results of the simpler model are included here.

Elections are suggested to be a factor that affects agricultural output. I assume that the national elections affect agricultural productivity only in the year of the election itself. The national election years for the period 1976–2006 were 1977, 1982, 1987, 1992, 1997 and 2002.

Droughts affect agricultural productivity. In the case of Papua New Guinea, rainfall is determined partially by the long-run El Niño–Southern Oscillation (ENSO) system.[4] This name comes about because of the two measurable features of the system: ocean surface temperatures and atmospheric air pressure. When equatorial Pacific Ocean surface temperatures are above normal for an extended period, this is called an El Niño episode. The Southern Oscillation Index (SOI) refers to the air pressure differential between Darwin and Tahiti, which drives trade winds. When this index is particularly low, this is called an SO event, and trade winds will be low.

The periods of high water-surface temperatures and low air pressure differentials are called ENSO events. Typically, these are associated with droughts in western Pacific countries, including Papua New Guinea. The two largest ENSO events in the period 1976–2006 occurred in 1982–83 and 1997–98, as measured by the SOI. These were also periods of extreme drought in Papua New Guinea. I will use ENSO events as a proxy for extreme drought.[5]

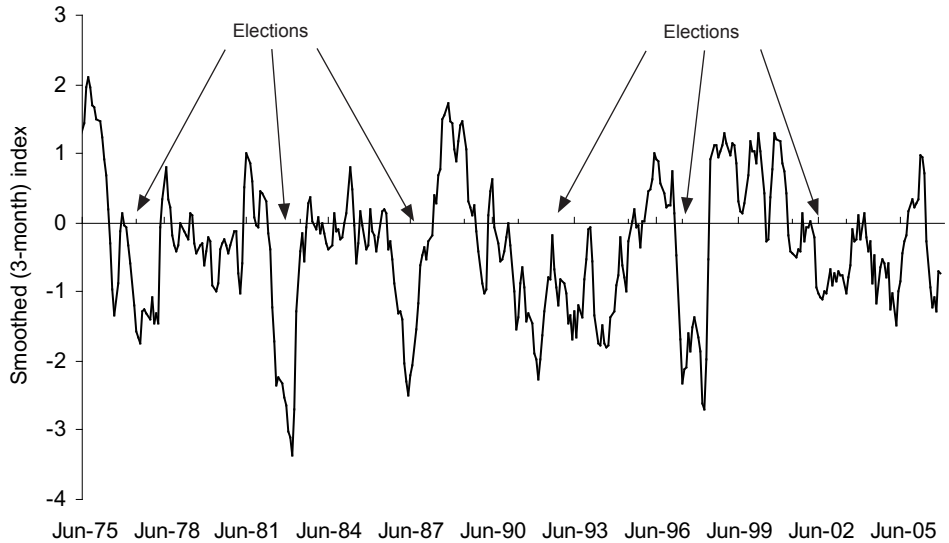
An SOI series produced by the Climatic Research Unit at the East Anglia University is reported in Figure 3. The data presented here are a smoothed three-month index. The coincidence of low SOI values and elections becomes apparent (Figure 3). The large drops in the SOI correspond with times of low rainfall and agricultural stress, especially in 1982–83 and 1997–98. Every PNG election has, however, occurred at a time of a low SOI; a low SOI was reported also during the 1977, 1987, 1992 and 2002 elections.

The unfortunate timing of elections during periods of agricultural stress could have contributed to the electoral unrest and conflict that have occurred in PNG elections in the past. The high correlation between elections and ENSO/SOI events means that untangling the impact of elections alone, as opposed to elections and low rainfall, will be difficult. The coincidence of elections and low rainfall could, however, explain why some observers have blamed elections for poor agricultural performance in some years.

Using PNG data

To estimate the Nerlove supply equations, we need to have quantity and price data for PNG agriculture. The four big cash crops in Papua New Guinea are coffee, cocoa, copra and copra oil, and oil-palm and kernels. The Bank of Papua New Guinea publishes export data in the *Quarterly Economic Bulletin*, which are used as a proxy for total cash-crop output. The export volume figures for coffee, cocoa, copra, copra oil and palm oil are presented in Figure 1 and Table 1.

Figure 3 **The SOI and PNG elections, 1975–2006**



Source: Climatic Research Unit. Southern Oscillation Index (SOI) data, Climatic Research Unit, East Anglia University. Available from http://www.cru.uea.ac.uk/cru/data/soi.htm

The unit price for PNG farmers is calculated from the export volume and value figures in the *Quarterly Economic Bulletin*. The unit export prices for coffee, cocoa, copra, copra oil and palm oil are presented in Table 2.

To estimate per unit profit for each cash crop, we would need to take account of the change in the price of inputs such as labour, machinery, energy and fertilisers—if used. Because data are not available for inputs, I proxy for input prices by using the CPI. The ratio of the unit export price to the CPI is a measure of the profitability of each crop. This ratio is referred to here as the 'real price' (see Figure 2). In the regression I estimate separately the coefficients on unit export prices and on CPI.

The effect of an election was tested with a dummy variable, Election_t, which took on the value of 1 in an election year and a value of 0 in a non-election year. Within the period under study here, national elections took place in Papua New Guinea in 1977, 1982, 1987, 1992, 1997 and 2002.

The ENSO events are assumed to have an impact on agricultural productivity in the years during or after the events. The dummy variable, ENSO_t, takes on the value of 1 during a year of a major ENSO event and a value of 0 in all other years. The major ENSO events between 1976 and 2006 were the drought years of 1982–83 and 1997–98.

What did we find out?

Nerlove supply equations were estimated for each of the major export cash crops: coffee, cocoa, copra, copra oil and palm oil. The regression equation that was used was

$$q_t = \alpha_0 + \alpha_1 p_t + \alpha_2 p_{t-1} + \alpha_3 \text{CPI} + \alpha_4 q_{t-1} + d\gamma z_t + u_t$$

Table 1 **PNG cash-crop exports, 1976–2006** (tonnes)

	Cocoa	Coffee	Copra	Copra oil	Palm oil
1976	31,321	48,151	85,741	25,482	27,262
1977	29,392	36,965	87,733	29,743	24,532
1978	27,129	45,801	92,164	29,088	28,413
1979	28,085	49,486	90,880	30,822	34,527
1980	28,700	51,000	91,700	33,600	37,300
1981	27,800	46,400	102,900	30,100	34,100
1982	28,600	41,200	74,800	42,700	88,900
1983	26,400	52,500	78,700	36,000	77,900
1984	34,100	49,400	93,500	40,700	129,900
1985	30,900	40,600	103,500	41,500	123,800
1986	31,900	53,100	93,000	41,100	129,000
1987	34,400	64,800	84,100	40,200	97,300
1988	37,100	44,800	76,800	36,300	102,600
1989	46,600	85,000	60,700	34,600	131,700
1990	33,900	54,600	55,000	34,800	142,700
1991	35,800	46,600	44,000	33,200	199,600
1992	38,600	53,000	47,500	34,800	206,100
1993	37,800	62,800	59,000	45,500	245,700
1994	26,000	64,700	50,300	34,700	230,800
1995	30,600	55,100	64,200	33,100	186,600
1996	41,000	62,300	99,200	49,600	267,000
1997	38,600	59,200	90,300	48,600	274,900
1998	26,100	83,500	58,100	53,200	213,000
1999	29,000	79,200	63,500	50,300	253,800
2000	38,000	66,600	67,200	48,000	336,300
2001	36,500	51,600	46,400	27,100	327,600
2001*	38,000	65,400	22,300	15,800	309,100
2002	34,900	63,100	15,800	28,200	323,900
2003	40,300	68,800	8,400	47,700	326,900
2004	41,500	63,000	19,200	45,100	339,000
2005	44,200	72,100	22,300	54,400	345,800
2006	44,000	52,300	12,700	41,500	362,300

Note: There is a break in the data in 2001 as the Bank of Papua New Guinea changed its methodology for gathering commodity export data. Before 2002, the bank had not reconciled its commodity export data with the respective commodity boards. The revised 2001 figures for volume and value are used to estimate the supply equations.
Source: Bank of Papua New Guinea, various years. *Quarterly Economic Bulletin*, Bank of Papua New Guinea, Port Moresby.

Table 2 **PNG cash-crop export unit price indices, 1976–2006**

	Cocoa	Coffee	Copra	Copra oil	Palm oil	CPI
1976	112.0	65.7	48.4	55.6	74.0	36.0
1977	263.4	122.6	89.5	73.0	104.2	37.6
1978	208.1	74.0	85.5	73.9	109.9	39.8
1979	194.3	79.8	143.7	115.4	124.6	42.1
1980	145.3	73.5	91.4	85.3	95.8	47.2
1981	110.0	50.5	64.2	71.7	124.0	51.0
1982	99.7	59.7	59.0	48.9	72.7	53.8
1983	140.6	57.0	104.3	95.9	90.6	58.1
1984	176.2	70.8	179.7	167.1	173.5	62.4
1985	181.3	91.4	110.4	98.6	148.2	64.7
1986	158.5	124.0	36.8	43.7	65.3	68.2
1987	146.5	65.7	61.8	62.3	73.2	70.5
1988	111.2	80.0	86.4	82.8	95.5	74.3
1989	87.0	52.2	78.9	76.3	86.6	77.6
1990	79.1	51.3	54.1	57.5	68.2	83.0
1991	85.1	53.9	40.4	66.6	78.3	88.8
1992	79.2	40.6	85.0	120.1	92.8	92.6
1993	78.5	50.6	82.4	74.4	96.0	97.2
1994	100.0	100.0	100.0	100.0	100.0	100.0
1995	139.8	123.0	146.0	154.9	226.9	117.3
1996	144.8	96.5	169.0	178.9	203.4	130.9
1997	170.3	173.9	178.9	181.5	224.4	136.1
1998	280.6	180.2	228.5	226.2	380.2	154.6
1999	261.5	166.4	358.3	328.8	396.5	177.7
2000	199.6	139.8	305.0	236.7	271.5	205.4
2001	270.9	115.5	114.3	173.9	264.1	224.5
2001*	284.3	119.1	171.9	141.0	235.9	224.5
2002	581.3	138.5	231.7	203.9	358.5	251.0
2003	573.3	137.1	264.8	243.9	383.8	287.8
2004	471.0	142.3	306.5	310.1	385.4	293.9
2005	403.0	206.4	265.5	297.4	337.1	298.9
2006	416.5	203.6	223.6	251.3	351.7	309.3

Note: There is a break in the data for 2001 as the Bank of Papua New Guinea changed its methodology for gathering commodity export data. Before 2002, the bank had not reconciled its commodity export data with the respective commodity boards. The revised 2001 figures for volume and value are used to estimate the supply equations.

Source: Commodity volumes and values are from Bank of Papua New Guinea, various years. *Quarterly Economic Bulletin*, Bank of Papua New Guinea, Port Moresby. The CPI is from International Monetary Fund, *International Financial Statistics*, CD-ROM database, International Monetary Fund, Washington, DC.

The prices used were the real prices are described above. The other explanatory variables, the z_t, possibly included the election dummy, $Election_t$, the ENSO dummy, $ENSO_t$, the prior year dummy, $ENSO_{t-1}$, the average Southern Oscillation Index, SOI_t, the prior year's average, SOI_{t-1}, and a linear time trend, T. For the ENSO and SOI variables, only the coefficients which have the highest statistical significance are reported.

Our primary interest is in the impact of elections on cash crop output, however some of the other variables and their impact on productivity are also explored. For each equation the estimated coefficients are presented with t-statistics in parentheses.

Coffee

For coffee the estimated equation was

$$q_t = 52{,}950.52 - 52.85\ p_t + 102.02\ p_{t-1}$$
$$(-0.89) \quad (1.59)$$
$$- 106.67\ CPI_t - 0.32\ q_{t-1} + 2000.58\ T$$
$$(-1.88) \quad (-1.62) \quad (3.74)$$
$$- 3{,}353.8\ Election_t + 10{,}723.06\ ENSO_{t-1}$$
$$(-0.79) \quad (2.00)$$
$$+ 383.87\ SOI_{t-1}$$
$$(1.66)$$
$$R^2 = 0.65;\ n = 30$$

For coffee there was no significant impact of an election. There is a positive linear time trend, and there is strong evidence that coffee production improves the year following an ENSO event by an amount equal to 19 per cent of average production over the period.

Cocoa

For cocoa the estimated equation was

$$q_t = 22{,}140.21 - 34.97\ p_t + 15.15\ p_{t-1}$$
$$(-2.37) \quad (0.95)$$
$$+ 64.92\ CPI_t + 0.28\ q_{t-1} - 71.1\ T$$
$$(1.07) \quad (1.61) \quad (-0.17)$$
$$+ 3698.65\ Election_t - 4915.99\ ENSO_t$$
$$(1.62) \quad (-2.01)$$
$$R^2 = 0.61;\ n = 30$$

For cocoa there was some support for a positive impact of an election, perhaps due to the coincidence with low rainfall. There is strong evidence that an ENSO event has a significant impact on output—the estimated coefficient for an ENSO event is 14 per cent of the average level of production over the period.

Copra

For copra the estimated equation was

$$q_t = 45{,}792.98 + 110.28\ p_t + 35.88\ p_{t-1}$$
$$(2.18) \quad (0.47)$$
$$- 261.59\ CPI_t + 0.51\ q_{t-1} - 128.07\ T$$
$$(-2.05) \quad (2.28) \quad (-0.18)$$
$$- 138.98\ Election_t - 8{,}459.61\ ENSO_t$$
$$(-0.02) \quad (-0.98)$$
$$R^2 = 0.85;\ n = 30$$

For copra there was no significant impact of an election.

Copra oil

For copra oil the estimated equation was

$$q_t = 28{,}379.16 + 68.09\ p_t + 43.63\ p_{t-1}$$
$$(2.12) \quad (1.11)$$
$$- 106.57\ CPI_t - 0.06\ q_{t-1} + 594.27\ T$$
$$(-1.88) \quad (-0.27) \quad (1.34)$$
$$- 378.59.14\ Election_t + 6646.78\ ENSO_t$$
$$(-0.1) \quad (1.51)$$
$$R^2 = 0.49;\ n = 30$$

For copra oil as with copra there was no evidence of an impact of an election, and only weak evidence of a positive impact of an ENSO event.

Palm oil

For palm oil the estimated equation was

$$q_t = -13{,}404.77 - 198.98\ p_t + 236.43\ p_{t-1}$$
$$(-2.17) \quad (2.31)$$
$$- 64.02\ CPI_t + 0.22\ q_{t-1} + 9{,}846.48.6\ T$$
$$(-0.32) \quad (1.18) \quad (3.98)$$

$$+ 12{,}727.46\ \text{Election}_t - 6{,}553.76\ \text{ENSO}_t$$
$$(1.05) \qquad (-0.45)$$
$$R^2 = 0.96;\ n = 30$$

For palm oil there was no evidence of an impact of elections or ENSO events. There was a strong positive time trend.

Overall

The overall performance of the Nerlove supply equations was relatively weak. The estimated coefficients on current and lagged prices would be expected to be positive and statistically significant if these equations were supply equations. Only for copra, however, was the current price positive and statistically significant—even then, only at the 10 per cent level. For the lagged price, the coefficients for palm oil and coffee showed up as positive and significant, but statistically significant only at the 10 per cent level.

The poor performance of the price response estimates mirrors the problems that Jolly et al. (1990) encountered when they estimated Nerlove equations for cash crops in order to do supply forecasting for Papua New Guinea. This poor performance is not, however, surprising when you consider the results found by Askari and Cummings (1977) when they surveyed 600 Nerlove supply response estimates for different countries and commodities. Diebold and Lamb (1996) placed the blame for this failure on the sampling properties of the estimator.

In this particular case, the cash crops studied are from long-lived tree crops, and we might expect that the lag between planting and production will produce longer lag structures than the 30 years of data would allow us to study accurately. In addition, the price stabilisation schemes of the various commodity boards in Papua New Guinea in the past 30 years mean that farmers have not faced the export price while making their on-farm decisions.

Conclusions

This paper was prompted by the idea that politics—and in particular national elections—could be to blame for some poor harvests in Papua New Guinea. By estimating the supply functions of PNG cash-crop producers, what was discovered was that blame more likely lay with the major El Niño–Southern Oscillation (ENSO) episodes that occurred recently and coincided with the elections of 1982 and 1997. PNG elections since independence have coincided with low values for the SOI, which correspond with low levels of rainfall. It is this coincidence that could have led some observers to believe that harvests and elections were linked.

The major ENSO episodes in the western Pacific—which will be drought years in many areas of Papua New Guinea—have had a significant impact on some PNG cash-crop outputs, although the impact differs between crops. There is some evidence that coffee harvests rise significantly after droughts, while cocoa harvests are impacted negatively in the years of drought. Future information on ENSO episodes could be useful in predicting output for some PNG cash crops.

The coincidence of elections and extreme ENSO episodes suggests the possibility that some of the unrest and violence associated with PNG elections could be due to the agricultural stress that occurs with ENSO and low SOI episodes. The five-year timing of PNG elections has unfortunately coincided with large swings in the SOI—and this could have contributed to the political difficulties that have plagued Papua New Guinea.

Notes

1 Production figures are sourced from the Bank of Papua New Guinea's *Quarterly Economic Bulletin*. All figures in the paper are sourced from the *Quarterly Economic Bulletin* unless otherwise noted.

2 This paper grew out of a conversation with Paul Barker of the Institute of National Affairs.

3 This imputed real price index is discussed later in the data section of the paper.

4 The following information is drawn from the ENSO web pages of the National Oceanographic and Atmospheric Administration at http://www.pmel.noaa.gov/tao/elnino/faq.html

5 Rainfall data would have been a preferred variable, but accurate rainfall data are problematic for Papua New Guinea, particularly after 1996.

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