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

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

Abstract: Commentators have suggested that there is a link between agricultural productivity and elections in Papua New Guinea. On its face this seems a plausible hypothesis, however I find little supporting evidence for a link between agricultural output in export cash crops and PNG elections. What does appear true is that recent El Nino-Southern Oscillation (ENSO) events in PNG have occurred around election years. It is these ENSO events and the droughts and floods that follow that have impacted PNG agricultural productivity. The unfortunate coincidence of elections and agricultural stress may explain some of the civil unrest in PNG elections.

Should We Be Worried About PNG Agriculture?

Will 2007 be a bad year for PNG cash crops? In the election year 2002, coffee production in PNG fell by 8 per cent[1], copra oil fell by 41 per cent and palm oil fell by 6 per cent from their respective 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 there may 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 PNG, election money will be spent immediately, reducing the incentive to pick crops for cash.
- Election parties and gatherings- Election times are a time for community and clan meetings and discussions. These events will take away from time spent picking crops.
- Election violence- Violence and the threat of violence associated with the election will reduce the willingness of people to travel. Without the ability to travel to the district market to sell the crops, the crops will not be picked in the first place.

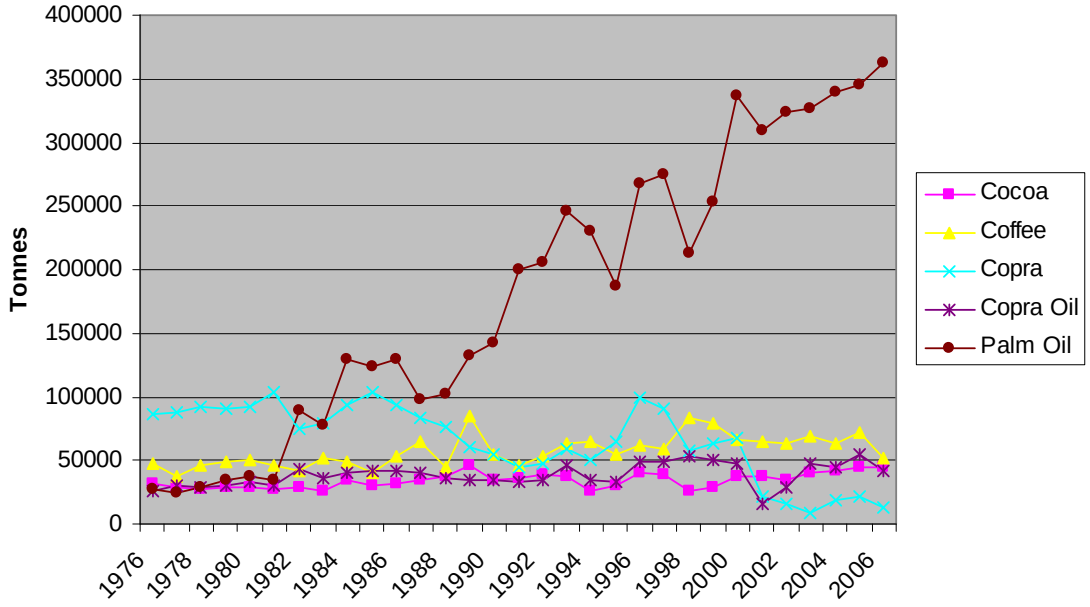
Whatever the mechanism that might or might not cause electoral politics to affect agricultural productivity, development of the PNG agricultural sector is a vital component of overall development. Duncan (2007) has emphasized the important role that agriculture has played in the development of land-rich 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 also saw a large improvement in agricultural productivity in the latter half of the last century.

In this paper I will focus on the four big export or "cash" crops for PNG agriculture: coffee, cocoa, oil palm and copra. The value of cash crops is only a minor part of total exports- agriculture only accounted for 12% 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 over 1 billion kina. A large portion of this money flows into the rural sector of PNG which contains many of the poorest households in PNG. Increasing our understanding of changes in cash crop productivity can help improve poverty policy in PNG (Mosley and Suleiman (2007)).

Figure 1 graphs the export 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 PNG has expanded at approximately 3 per cent per year since Independence then these export volumes for all cash crops have been declining per head of population for PNG except for palm oil.

[1] Production figures are sourced from the Bank of Papua New Guinea's *Quarterly Economic Bulletin* (various years). All figures in the paper are sourced from the *QEB* unless otherwise noted.
[2] This paper grew out of a conversation with Paul Barker of the Institute of National Affairs.

Figure 1: Cash Crop Exports, 1976-2006.



Source: BPNG (various years) *Quarterly Economic Bulletin*.

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

While an inflation target is a good idea for the BPNG, I doubt that the real blame for the failure of cash crops lies with the BPNG. In Figure 2 I graph an imputed real export price index[3] for the major cash crops against the overall CPI from 1976-2006. As shown in Figure 2 the NZIER is certainly correct that the price index for cash crops has fallen relative to the CPI since 1976. Unless there has 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.

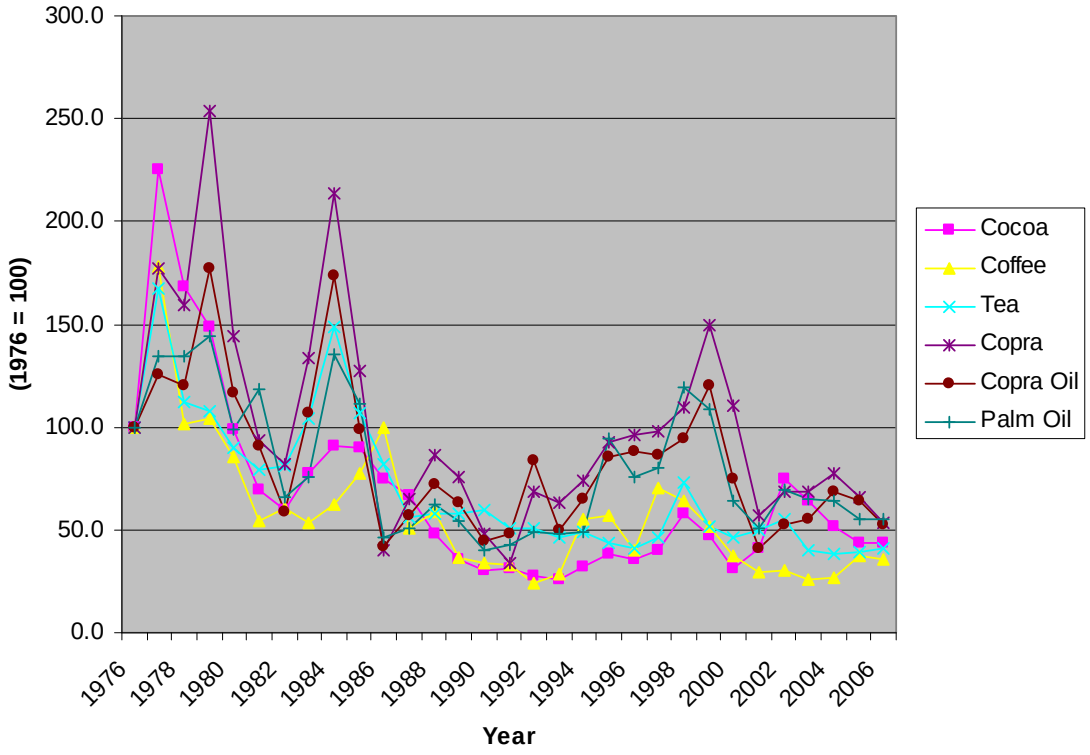
However the data collected by the Food and Agricultural Organization set out in NZIER (2006) shows no evidence of any compensating agricultural productivity increases in PNG. The yield per hectare graphs for the various cash crops for PNG in the NZIER report are flat over time. Similarly Fleming (2007) found no statistical evidence of economically significant total factor productivity growth for PNG for the period 1970 to

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

2002. These findings suggest that the lack of growth of many of the cash crop sectors may simply be due to falling profitability in those sectors. This fact was also suggested by Kinnapiran (2000).

But is the BPNG to blame for poor profitability in the cash crop sector? Not in the sense that there is anything the BPNG could have done to avoid this result. What we are observing in the cash crop prices relative to simply the usual "Dutch disease" result for the non-boom sectors in an economy. The success of minerals exports in PNG in recent years means that the kina 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.

Figure 2: Export Price Indices 1976-2006



Source: BPNG (various years) *Quarterly Economic Bulletin*.

While the BPNG 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 BPNG. The poor performance is 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 policies which will improve cash crop and overall agricultural productivity.

A better set of recommendations, and ones that the NZIER place second, would be to focus on factors that would improve agricultural productivity. These recommendations,

which include many of the ones in Anderson and Parker (2004) such as more 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 PNG? Unfortunately we do not have data on the usual measures of productivity that are collected in developed 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 is quantity and price export data, I will use a variant of the Nerlove (1958) and Nerlove and Addison (1958) supply equations. The framework was further developed in Hartley, Nerlove and Peters (1987). Jolly, Beck and Bodman (1990) was a previous attempt to fit Nerlove supply equations to cash crop production in PNG.

Output in each year depends both on the amount of area under the crop and on the effort expended on picking. The area under cultivation will depend on past estimates of future profitability, so output will depend on past prices. Effort expended on picking however will only depend on the current price- 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}:

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

where z_t includes other factors that affect productivity in that year and may 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 of time. The Nerlove model assumes that the short-run or current level of output, q_t, only slowly adjusts 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:

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

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

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

This is the equation I will be estimating using the PNG agricultural data.

A more complicated lag structure could be used as in Jolly, Beck and Bodman (1990). In that paper price expectations were also modelled 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. However when these equations were estimated, the results were not qualitatively different from the simpler static expectations Nerlove model. As a result I have only presented the results of the simpler model.

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

Droughts affect agricultural productivity. In the case of PNG rainfall is partially determined by the long-run El Nino-Southern Oscillation (ENSO) system[4]. This name comes about because of the two measurable features of the system- ocean surface temperatures and atmospheric air pressures. When equatorial Pacific Ocean surface temperatures are above normal for an extended period of time, this is called an El Nino 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.

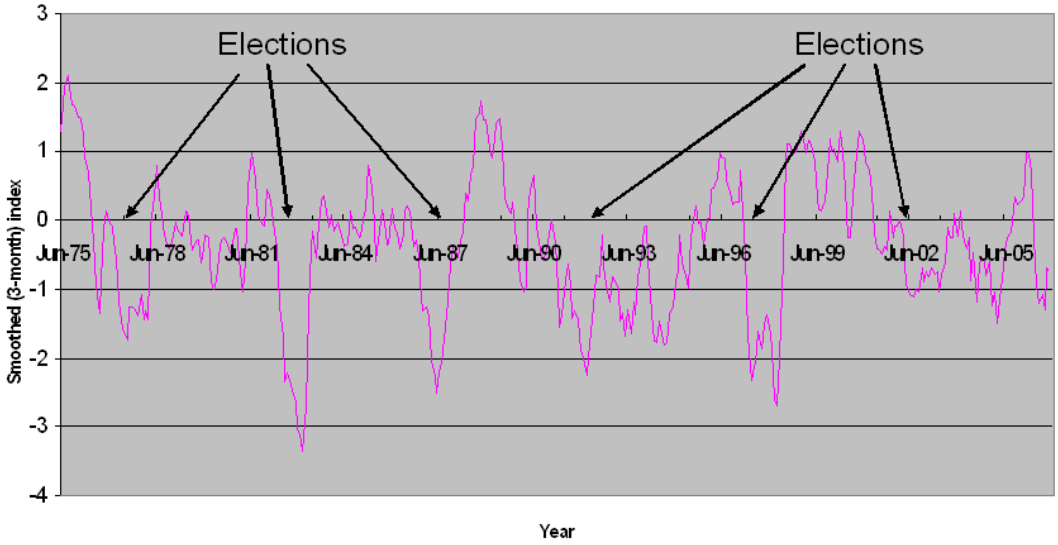
The periods of high water surface temperatures and low air pressure differentials are called ENSO events. Typically these are associated with droughts in western Pacific countries, including PNG. The two largest ENSO events in the period 1976-2006 occurred in 1982-83 and in 1997-98, as measured by the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

A series for the SOI produced by the Climatic Research Unit at the East Anglia University is reported in Figure 3. The data presented here is a smoothed 3-month index. From Figure 3 the coincidence of low SOI values and elections becomes apparent. The large drops in the SOI correspond with times of low rainfall and agricultural stress- especially in the 1982-83 and 1997-98 periods. However every PNG election has occurred at a time of low SOI, as low SOI is also reported during the 1977, 1987, 1992 and 2002 elections.

[4] The following information is drawn from the ENSO webpages on the National Oceanographic and Atmospheric Administration on ENSO at http://www.pmel.noaa.gov/tao/elnino/faq.html.

[5] Rainfall data would have been a preferred variable, but accurate rainfall data is problematic for PNG, particularly after 1996.

Figure 3: SOI and PNG Elections 1975-2006



Source: Climatic Research Unit-http://www.cru.uea.ac.uk/cru/data/soi.htm

The unfortunate timing of elections and periods of agricultural stress may have contributed to some of 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. But the coincidence of elections and low rainfall may explain why some observers have blamed elections for poor agricultural performance in some years.

Using Papua New Guinea Data

To estimate the Nerlove supply equations, we need to have quantity and price data for PNG agriculture. The four big cash crops in PNG 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 is 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 (as well as Table 1 for convenience, as I could not readily find this data in an existing source).

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 fertilizers, if used. As data is not available on inputs, I proxy for input prices by using the consumer price index. The ratio of the unit export price to the CPI is a measure of the profitability of

each crop. These unit real export prices are presented earlier in Figure 2. In the regression equation I estimate the coefficients on unit export price and on CPI.

The effect of election was tested with a dummy variable, $Election_t$, that takes on the value of 1 in an election year and a value of 0 in a non-election year. National elections in PNG took place in the years 1977, 1982, 1987, 1992, 1997, and 2002 for the period under study here.

The ENSO events are assumed to have an impact on agricultural productivity in the years during or following 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 in period 1976-2006 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:

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

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, I report only the coefficients which have the highest statistical significance.

Our primary interest in the results is in the impact of elections on cash crop output, however we will explore some of the other variables and their impact on productivity. For each equation I present the estimated coefficients with the t-statistics beneath them.

Coffee
For coffee the estimated equation was:

$$q_t = \underset{}{52{,}950.52} - \underset{(-0.89)}{52.85\, p_t} + \underset{(1.59)}{102.02\, p_{t-1}} - \underset{(-1.88)}{106.67\, CPI_t} - \underset{(-1.62)}{0.32\, q_{t-1}} + \underset{(3.74)}{2000.58\, T}$$

$$- \underset{(-0.79)}{3{,}353.8\, Election_t} + \underset{(2.00)}{10{,}723.06\, ENSO_{t-1}} + \underset{(1.66)}{383.87\, SOI_{t-1}}$$

$R^2 = 0.65$; 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 percent of average production over the period.

Cocoa
For cocoa the estimated equation was:

$$q_t = 22{,}140.21 - 34.97\ p_t + 15.15\ p_{t-1} + 64.92\ CPI_t + 0.28\ q_{t-1} - 71.1\ T$$
$$\qquad\qquad\quad (-2.37) \quad (0.95) \quad (1.07) \quad (1.61) \quad (-0.17)$$

$$+ 3698.65\ Election_t - 4915.99\ ENSO_t$$
$$\quad (1.62) \qquad\qquad (-2.01)$$

$R^2 = 0.61$; 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 percent of the average level of production over the period.

Copra
For copra the estimated equation was:

$$q_t = 45{,}792.98 + 110.28\ p_t + 35.88\ p_{t-1} - 261.59\ CPI_t + 0.51\ q_{t-1} - 128.07\ T$$
$$\qquad\qquad\quad (2.18) \quad (0.47) \quad (-2.05) \quad (2.28) \quad (-0.18)$$

$$- 138.98\ Election_t - 8{,}459.61\ ENSO_t$$
$$\quad (-0.02) \qquad\qquad (-0.98)$$

$R^2 = 0.85$; n = 30

For copra there was no significant impact of an election.

Copra Oil
For copra oil the estimated equation was:

$$q_t = 28{,}379.16 + 68.09\ p_t + 43.63\ p_{t-1} - 106.57\ CPI_t - 0.06\ q_{t-1} + 594.27\ T$$
$$\qquad\qquad\quad (2.12) \quad (1.11) \quad (-1.88) \quad (-0.27) \quad (1.34)$$

$$- 378.59.14\ Election_t + 6646.78\ ENSO_t$$
$$\quad (-0.1) \qquad\qquad (1.51)$$

$R^2 = 0.49$; 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:

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

$$+ 12{,}727.46\ Election_t - 6{,}553.76\ ENSO_t$$

(1.05) (-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 price would be expected to be positive and statistically significant if these equations are supply equations. However only for copra and copra oil were current price positive and statistically significant. For lagged price the coefficients for palm oil and coffee showed up as positive and significant, but only statistically significant at the 15 per cent level for coffee. The estimated coefficient for the CPI should have been negative and statistically significant, which it was for copra, copra oil and coffee, although only at 10 percent for the latter two.

The poor performance of the price response estimates mirrors the problems that Jolly, Beck and Bodman (1990) encountered when they estimated Nerlove equations for cash crops in order to do supply forecasting for PNG. However this poor performance is not 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) laid 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, where 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 accurately study. In addition the price stabilization schemes of the various commodity boards in PNG over the last 30 years means 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 the national elections, could be to blame for some poor harvests in PNG. By estimating the supply functions of PNG cash crop producers what was discovered was that it was more likely to be the major El Nino-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 Southern Oscillation Index, which correspond with low levels of rainfall. It is this coincidence that may have led some observers to believe that harvest and elections are linked.

The major ENSO episodes in the western Pacific, which will be drought years in many areas in PNG, have had a significant impact on some of the PNG cash crop outputs, although the impact differs across the crops. There is some evidence that coffee harvests rise significantly following droughts, while cocoa harvests are negatively

impacted in the years of the drought. Future information on ENSO episodes may be useful in predicting output for some of the 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 may have been due to the agricultural stress that occurred with the ENSO and SOI episodes. The five year timing of PNG elections has unfortunately coincided with large swings in the SOI, and this may have contributed to the political difficulties that have plagued PNG.

Table 1: PNG Cash Crop Exports 1976-2006 (Tonnes)

Year	Cocoa	Coffee	Copra	Copra Oil	Palm Oil
1976	31321	48151	85741	25482	27262
1977	29392	36965	87733	29743	24532
1978	27129	45801	92164	29088	28413
1979	28085	49486	90880	30822	34527
1980	28700	51000	91700	33600	37300
1981	27800	46400	102900	30100	34100
1982	28600	41200	74800	42700	88900
1983	26400	52500	78700	36000	77900
1984	34100	49400	93500	40700	129900
1985	30900	40600	103500	41500	123800
1986	31900	53100	93000	41100	129000
1987	34400	64800	84100	40200	97300
1988	37100	44800	76800	36300	102600
1989	46600	85000	60700	34600	131700
1990	33900	54600	55000	34800	142700
1991	35800	46600	44000	33200	199600
1992	38600	53000	47500	34800	206100
1993	37800	62800	59000	45500	245700
1994	26000	64700	50300	34700	230800
1995	30600	55100	64200	33100	186600
1996	41000	62300	99200	49600	267000
1997	38600	59200	90300	48600	274900
1998	26100	83500	58100	53200	213000
1999	29000	79200	63500	50300	253800
2000	38000	66600	67200	48000	336300
2001	36500	51600	46400	27100	327600
2001*	38000	65400	22300	15800	309100
2002	34900	63100	15800	28200	323900
2003	40300	68800	8400	47700	326900
2004	41500	63000	19200	45100	339000
2005	44200	72100	22300	54400	345800
2006	44000	52300	12700	41500	362300

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

Note: There is a break in the data at 2001, as the Bank of Papua New Guinea changed its methodology for gathering commodity export data. Prior to 2002 the BPNG 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.

Table 2: PNG Cash Crop Exports Unit Price Indices 1976-2006

Year	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

Source: Commodity volumes and values are from the Bank of Papua New Guinea, *Quarterly Economic Bulletin*, various years. Consumer price index is from the International Monetary Fund *International Financial Statistics* CD-ROM database.

Note: There is a break in the data at 2001, as the Bank of Papua New Guinea changed its methodology for gathering commodity export data. Prior to 2002 the BPNG 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.

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