Rice Self-Sufficiency in Papua New Guinea

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Policy makers in Papua New Guinea want to increase rice self-sufficiency. Food security has been cited as a reason, because the recent fall in the world price for tree crops causes rice imports to make a larger call on scarce export earnings. Analysis of the long run trend in the terms of trade between rice and tree crops suggests that rice self-sufficiency will not produce a sensible allocation of resources. The falling relative price of rice makes it is more efficient to devote resources to expansion of exports, particularly cocoa and coffee, in order to import rice.

1. Introduction

Australian rice is the most important food purchase made by Papua New Guineans. Imported rice provides almost 40 percent of the dietary energy for urban residents. Although rural consumption levels are lower, they have been increasing at a faster rate as market access improves and village economies become monetized. It is likely that locally produced root crop staples now provide only four-fifths of food energy (FAO 1986).

This reliance on imports of rice and other foods is also apparent at the macro economic level. The entire foreign receipts from agricultural exports, which are mainly coffee, palm oil, cocoa and copra, were required to pay for food imports in 1990. By 1991 agricultural export receipts were insufficient for this task. Currently, Papua New Guinea depends on foreign exchange earnings from the minerals sector to cover the cost of food imports.

It is against this background that the government of Papua New Guinea has signalled a desire to substitute grain and rice imports with domestically produced staples including root crops such as sweet potato and grains such as rice. Ambitious targets have been set, including a total substitution of imported long grain rice by 1995 and at least a 40 percent substitution of short-medium grain rice by the end of the decade (National Executive Council 1992).

If achieved, this self-sufficiency campaign will have major economic effects in both Australia and Papua New Guinea. Rice imports are currently 130,000 tonnes per year, with almost all of this being medium grain rice, supplied by Australia. Losing 40 percent of the Papua New Guinea market would reduce Australian rice exports by over 50,000 tonnes per year. This 10 percent decline implies lost export revenues of over A$20 million.

Current rice production in Papua New Guinea is less than 800 tonnes. To have a 50,000 tonne rice industry by the end of the decade will require substantial government involvement in providing infrastructure, research and extension services. This represents an important resource allocation decision in a country that has few roads and only limited education and health facilities. If 40 percent self-sufficiency requires higher prices to stimulate local production there will also be enormous income and nutritional effects, especially for the urban population.

This present paper questions whether a policy of rice self-sufficiency will lead to a sensible use of Papua New Guinea's resources. It does this by analyzing trends in the terms of trade between rice and the major tree crop exports. The motivation for this is the neoclassical theory of exchange, which notes that command can be gained over rice either by producing it directly or by producing some other

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crop to exchange for rice on world markets. The correct choice depends on the current and expected terms of exchange between rice and the export good.

Despite a recent fall in the rice purchasing power of tree crop exports, the long-run trend is for a given quantity of exports, especially cocoa and coffee, to buy increasing quantities of rice. Having rice as an import has improved Papua New Guinea's terms of trade by about one percent every five years. The cheapest way for Papua New Guinea to obtain rice is by devoting resources to export production.

2. Rice in Papua New Guinea

Rice was first imported into New Guinea in 1885 to feed plantation labour and demand was such that it caused a serious drain on the German plantation colony. Production started at the turn of the century in both New Guinea and in Papua, where the Australian administration occasionally resorted to the use of enforced labour. Despite this, production was sporadic due to crop failures and low world prices. Allied and Japanese wartime administrations enforced rice growing and the post-war period saw several spontaneous outbreaks of frenetic activity associated with cargo cults.[1] Government provided rice mills in some areas and semi-mechanised production persisted in the Mekeo region of Papua but local supply never exceeded three percent of demand. Production fell after 1970 as attention switched to more profitable tree crops.

Technical and economic reasons combined to prevent rice development. Many areas have insufficient solar radiation and where there is sufficient, as in the Mekeo district, the rainfall is unreliable. Rice requires a disciplined labour input due to weeding requirements whereas indigenous root crop farming systems are based on sporadic labour inputs, allowing time for other agricultural and social commitments (FAO 1986). Tree crops have been successfully grafted onto the existing farming systems because they can survive long periods of inattention and they offered high returns to labour input. In most situations rice has the lowest return of all cash crops and it has generally not been considered as a subsistence crop, where it could be integrated into food garden rotations with a lower labour input.

Despite these difficulties, policy makers have never abandoned hope for a local industry. Emotive reasons appear important in this persistent hope. It is considered somehow 'immoral' for an agricultural country to import a major foodstuff, especially from its former governing power. Consequently, rice continues to consume research funds and several overseas donors have responded to aid requests by establishing rice projects or providing technical aid.

Shaw (1985) reported that in 1981 the same time was devoted to research on rice as on tea, and more than that for either coconuts or rubber (these three crops earned A$70 million of foreign exchange that year). The FAO provided a major technical mission in 1986 and concluded that large scale production would not be viable without subsidies. France provided a mission in 1991 and offered to spend A$1m on further agronomic research. Taiwan is funding rice breeding research near Lae and China is reputed to be offering to build a rice and food crop research institute. An A$8m technical cooperation program has been negotiated with IRRI to provide research and extension over the next five years, although donor funding has not been secured. These aid initiatives are generally unaccompanied by sectoral level economic analysis, and most project analysis is carried out within the Department of Agriculture and Livestock, which is the main bureaucratic proponent of rice development.

The major importing company has also agreed to invest A$6m for rice development, directed at both smallholder production and large scale commercial production for the urban market. There is some element of market-preservation in this investment because other incumbent food importers have re-

[1] Cargo cults were based on the following logic: if Papua New Guineans engage in the right rituals of *'bisnis'*, including in some areas rice growing, they would earn the respect of Europeans and gain access to equivalent sources of wealth and power. There is no evidence that people ate the rice that was grown in these symbolic exercises (Allen n.d.).

cently been shut out of the market by new entrants, who come promising to develop local industry in return for an initial period of monopoly import rights.

Meanwhile there is some evidence that rice demand is stabilising and will never reach the level projected in some of the analyses used to justify an intensified self-sufficiency effort. From 1963/64 to 1982/83 rice import volumes grew at an annual rate of seven percent but since 1982/83 this has slowed to only three percent as diets shift towards wheat products (Fereday 1993).

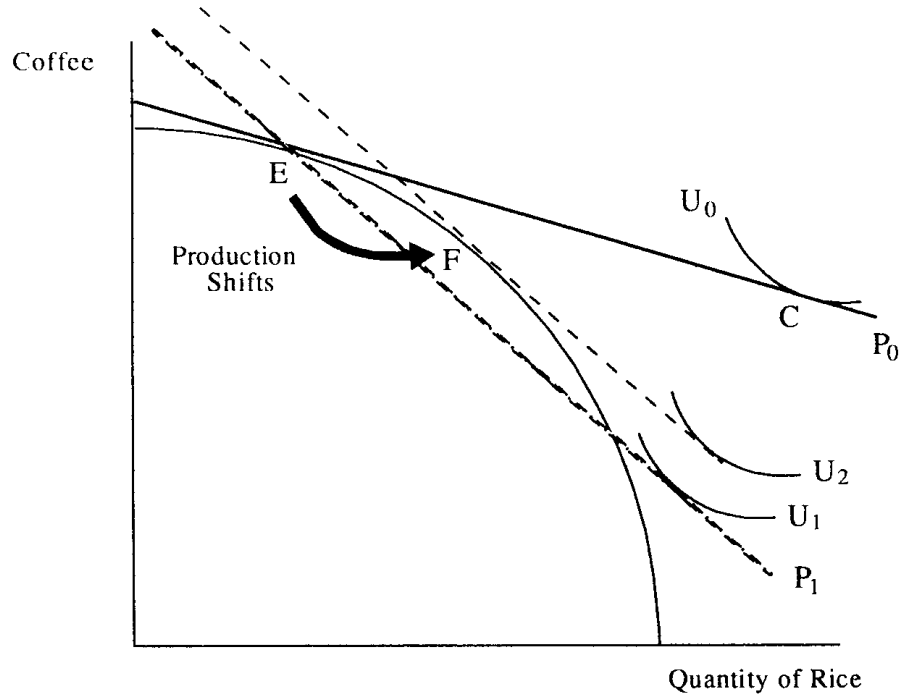
3. The Terms of Trade Approach

The theory of international trade is based on the premise that a country can gain command over desired goods or services either by directly producing them or by producing other goods and exchanging these for the desired ones. An important factor in this resource allocation choice is the ratio at which the produced goods, e.g. coffee, can be exchanged for the desired goods, e.g. rice. This ratio is determined by the relative price of the produced (exported) and desired (imported) goods. If coffee prices rise against rice, a given quantity of coffee can buy more rice so a coffee exporting, rice importing country becomes better off.

Figure 1 illustrates the trade possibilities for a country that can produce coffee and rice. Although no country has such a simple economic structure important insights are gained from this abstraction. Moreover, Figure 1 is a realistic picture of most PNG households: cash is earned from the sale of coffee and used to "import" foods such as rice, which supplement traditional root crops. Production is at *E*, consumption is at *C*, welfare is at level U_0 and the terms of trade are P_0 ($=P_{Rice} / P_{Coffee}$). Suppose the terms of trade fall to P_1 due to a decline in the price of coffee. Coffee now buys less rice so consumption falls and welfare is reduced to U_1.

How should a country respond to this reduced purchasing power for its exports? By redeploying production from *E* to *F* it is possible to make the best of a bad situation and improve welfare to U_2.

Figure 1: Response to a Fall in the Terms of Trade



The same terms of exchange exist at both E and F but given the new prices, F is a more favourable output mix at which to apply these terms. The reaction of the country (or household) is quite sensible: reallocate resources to produce more of the good fetching a higher price and less of the low priced good.

The problem for economic policy, therefore, is to form accurate expectations of future relative prices and then guide production in the desired direction.[2] Unless there has been a shift in the economic forces generating the terms of trade, future prices should obey long-run trends. The first empirical question therefore is to determine whether rice prices have tended to increase faster than tree crop prices, making the move from P_0 to P_1 a general trend. If they do, removing rice from the import bundle and producing it at home can increase welfare by re-directing production to higher valued uses. The terms of trade and the international purchasing power of exports will also increase because an increasingly-expensive good has been removed from the import bundle. The reverse holds if rice prices tend to fall against tree crop prices.

During the late 1980s rice prices undoubtedly rose against tree crop prices. The 1991 nominal world price of rice was 65 percent of its 1980s peak but tree crop prices were only 50 percent of their peak. Is this enough to support rice self-sufficiency? If shifts in production were costless, instantaneous and reversible there would be few problems in obeying short-run price movements. In the real world production shifts only slowly and industries, once set up, do not willingly wither. The PNG sugar industry provides an example of the irreversibility of a self-sufficiency decision. It was set up on the basis of optimistic price forecasts and has higher than expected production costs. Closing the industry and returning to imports would improve economic welfare. This is unlikely to happen because capital was invested on the basis of guaranteed protection, workers migrated and communities were established. A rice industry would prove equally difficult to budge if its establishment is based on government guarantees of support.

The empirical analysis proceeds in two stages. The first measures the trend in the long-run historical terms of trade between rice and tree crops. This will show whether the strengthening of the rice terms of trade in the late 1980s was either a return to, or a deviation from the usual trend. Second, evidence for whether this period marks the beginning of a new trend is assessed.

4. A Method For Estimating Relative Price Trends

Methods for estimating relative price trends have benefitted from the controversy over the Prebisch-Singer hypothesis of declining terms of trade for primary commodities (Singer 1991). A log-linear regression of the relative price on a time trend provides an unbiased estimate of the (usually annual) average percentage rate of change in the relative price. The difficulty arises in determining if the trend is statistically non-zero. The regression residuals are usually autocorrelated and often have a unit root so ordinary least squares (OLS) provides biased estimates of standard errors. The conventional t statistic on the time trend coefficient gives a spurious impression of a significant trend, even if use has been made of a first-order autocorrelation correction (Nelson and Kang 1984).

Consequently, there has been a substantial reappraisal of the statistical evidence on the terms of trade, using advanced techniques such as unit root tests (Cuddington and Urzua 1989) and cointegration analysis (Powell 1991). The unit root tests determine whether the error process is non-stationary: if it is the regression should be on first differenced data. However this is just the first step. Cuddington (1992) then uses Box-Jenkins methods to identify the specific form of error autocorrelation from the set of mixed autoregressive moving-

[2] It could be claimed that the best role for the state would just be to provide information from price forecasting agencies like the World Bank, but not to interfere with the product market choices made by forward-looking firms. However, as the major supplier of infrastructure for agricultural projects, the Papua New Guinea government's view of the relative attractiveness of certain crops will influence firm's choices.

average (ARMA) processes and only then uses the model to make claims about the trend in the terms of trade.

The difficulty with this complex approach is that it introduces many subjective elements. Results from unit root tests are sensitive to the lag lengths used, especially for short data series. Examining partial autocorrelation functions to discern the appropriate length and type of error process is a little like reading tea leaves. Conclusions about trends also depend on specifying occasional 'breaks' in the data series when relative prices make one-off shifts to new circumstances (Powell 1991). Thus it is not surprising that recourse to the statistical heavy artillery has not settled any debates about the terms of trade. More fundamental is the problem of how one explains these methods and their results to practical people interested in policy.

An alternative course is to stick to the tried and true OLS and use a *robust* estimator for standard errors. Such an estimator has become popular in dealing with unspecified forms of heteroscedasticity (White 1980). Less well known is the equivalent estimator for unknown forms of autocorrelation (Newey and West 1987).[3] Instead of worrying about esoteric time series methods the robust method uses a simple estimator that will not be embarrassed by various misspecifications. This is all that is needed for policy purposes where one wishes to make cautious but consistent recommendations. Academic debate between the followers of trend or difference stationary models simply falls into the hands of the 'do-it-yourself-economics' brigade who discredit all attempts at quantitative/rational appraisal of policies. The robust approach is especially useful when dealing with the short data series typically available in developing countries: often there are not enough degrees of freedom to use estimating the model and looking for the right order of the augmented unit root test or the ARMA error.

The Newey-West estimator for unknown forms of autocorrelation should become more well known since it has been incorporated into the latest version of the popular econometric programme, *Shazam* (White 1978). That programme was used to estimate trends, and their standard errors, in the terms of trade between rice and the major tree crop exports of Papua New Guinea. Appendix 2 provides details and also reports the results of tests on the residuals, which suggest that unit roots are not present. The terms of trade results are displayed graphically.

5. Past Trends in the Relative Price of Rice

Annual world prices of rice and relevant tree crops (in nominal U.S. dollars) for the period 1948-91, as established in specific locations, were made available by the World Bank and are described in Appendix 1. While not exactly the prices that Papua New Guinea pays and receives, these prices represent the trading opportunities which should be available for a small country, given an international market in commodities. The greatest difference is likely to be in the rice price because imports are Australian temperate, medium-grain *Japonica* varieties whereas the world price data is for tropical, long-grain *Indica* Thai rice. However, statistical tests carried out by Gibson (1992) showed that the estimated trend using world rice prices was not significantly different from the trend estimated with Australian rice prices (although the comparison was over a shorter period than the 1948-91 data used here).

The terms of trade between rice and each of six major tree crops are considered: cocoa, coffee, tea, coconut oil, copra, and palm oil. These comprise 91 percent of Papua New Guinea's agricultural exports over the 1948-91 period. Two groups form naturally: beverages and oilseeds.

Important differences in demand face the two groups. Oilseeds have had weak prices since World War II because of competition from temperate crops and greater substitution with industrial inputs. In contrast, the major substitutes for the beverages are each other. In econometric models of coffee demand, tea and cocoa often emerge as

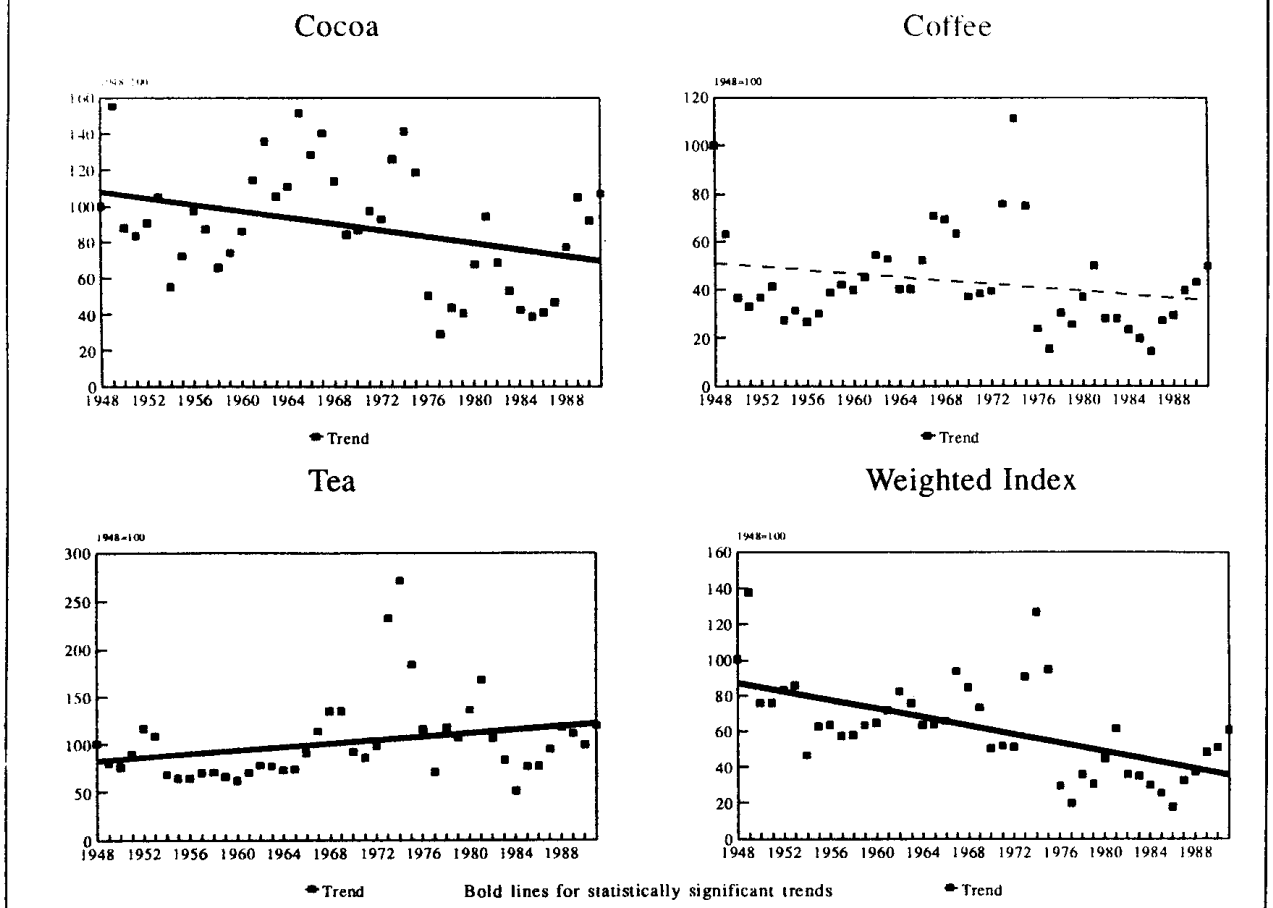
[3] The equivalence is not quite exact. The Newey-West estimator requires information on how long the lag length is before autocorrelations can be safely ignored. The White estimator requires no operator input.

the only significant cross-prices. Income elasticities are also high: for coffee they exceed 1.0 in France, Germany, Japan, Eastern Europe and the former USSR (Yeboah 1991). For cocoa, the aggregate developed country income elasticity is 0.69 (Gibson 1993), suggesting that some markets have income elasticities close to one. The problems for beverages are more on the supply side, creating difficulties for orderly marketing. Their long term demand prospects are much better than for the oilseed crops.

Figure 2 displays the historical terms of trade between rice and the three beverages (defined as $P_{Rice} / P_{Beverage}$). The purchasing power of cocoa and coffee have both improved and that of tea has declined. The terms of trade improvement has been greatest for cocoa, with the (rice/cocoa) price falling at a rate of 1.2 percent each year (standard error 0.57 percent). The (rice/coffee) trend of -0.98 percent is statistically significant using the OLS standard errors (t=1.94) but not using the robust Newey-West estimator (the t-statistic falls to 1.67 with an autocorrelation lag length set at one and even further, to 1.58 with a lag length of eight).

Figure 2 also shows the terms of trade for a weighted beverage index, formed using the value

Figure 2: The Price of Rice Relative to the Price of Beverages, 1948-91

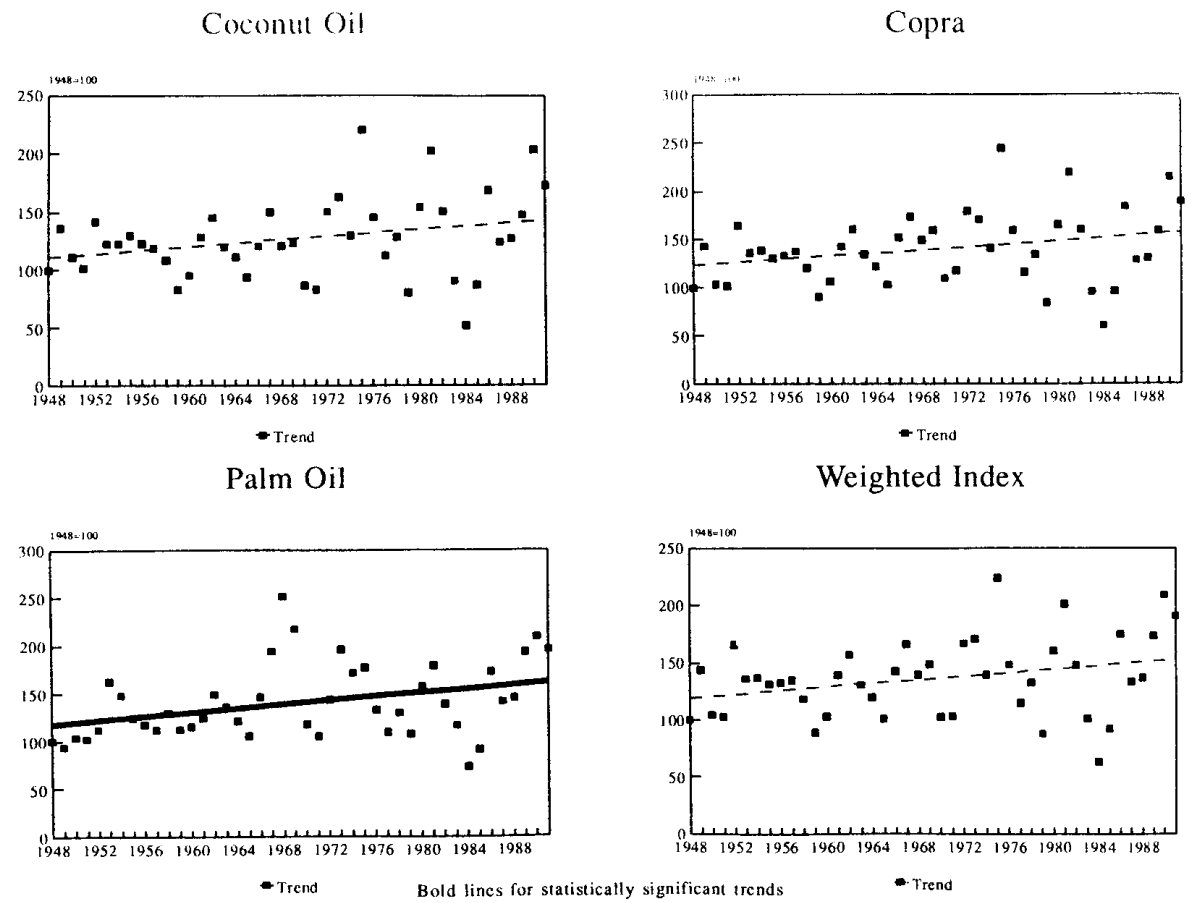


share of each crop in Papua New Guinea's annual exports. The trend is strongly against rice with the relative price falling by 2.3 percent per year (standard error 0.43 percent). The weighted beverage index has a larger trend than any individual crop because supply responses contribute to a larger volume (and therefore value) weight for particular crops in high-price years.

Close inspection of each graph shows that the high relative rice prices in the early 1970s have never been subsequently matched. This was a time of disruption to world grain markets and fears that production could not keep up with demand. In fact the continuing spread of IRRI High Yielding Varieties and production enhancement programmes in net importing countries helped create such supply that real prices fell from the late 1970s. Changing consumption patterns also played a part, with growing incomes leading to substitution away from rice (Ito, Peterson and Grant 1989). Figure 2 also shows short-term deviations from the trend: 1958-62 and 1977-81 for cocoa, and 1956-62 and 1977-81 for coffee. It is argued below that the movement since 1984 (tea), 1985 (cocoa) and 1986 (coffee) is also a short-term deviation and not a new trend.

Figure 3 shows the price of rice relative to oilseeds. Coconut products and palm oil all exhibit declining terms of trade. However only the trend for

Figure 3: The Price of Rice Relative to the Price of Oilseeds, 1948-91



(rice/palm oil) is significant, at 0.69 percent per annum (standard error 0.30 percent). The weighted index shows that the purchasing power of oilseeds declined at an annual rate of 0.44 percent but with a large standard error (0.36 percent) so that the trend is not statistically significant.

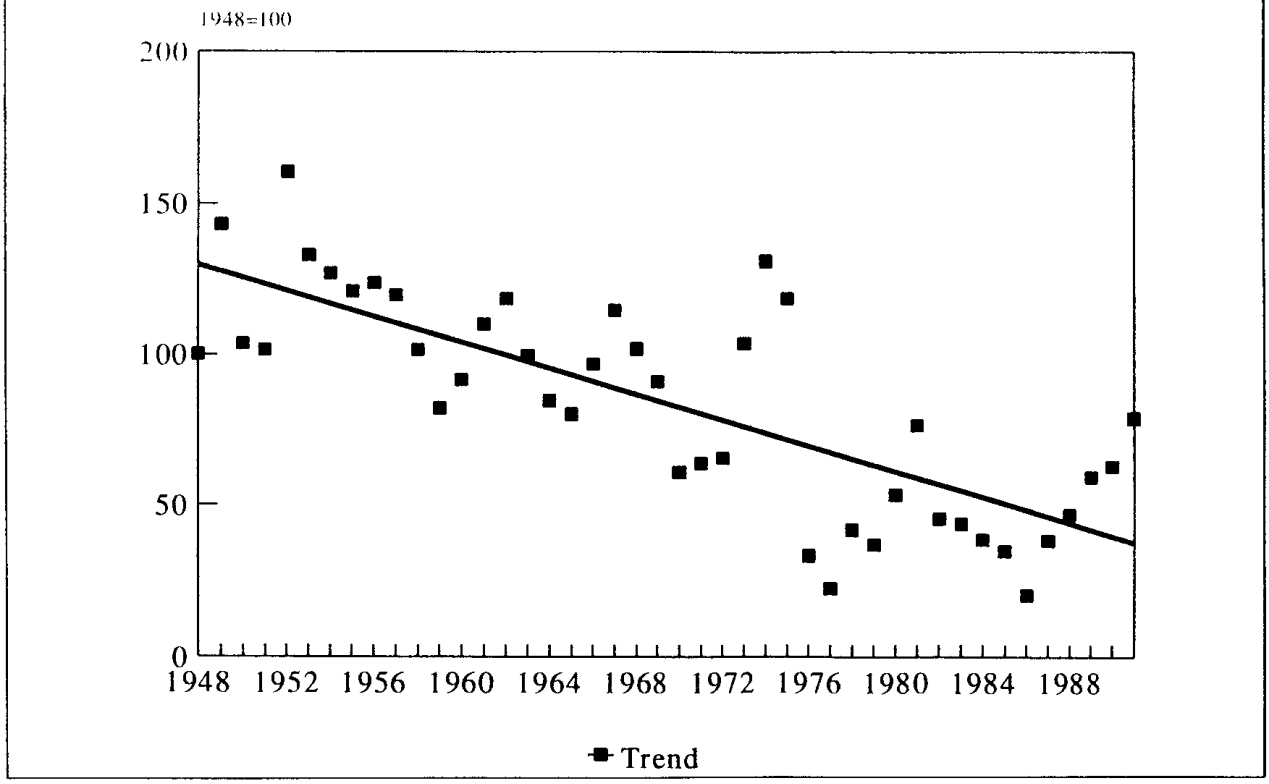
If the economy were dominated by oilseeds production, moving towards rice might be justifiable on this evidence. However oilseed crops are much less important than they once were, precisely because their low prices caused greater emphasis to be placed on developing beverage crops. From 1948 to 1958 oilseeds (and meals) averaged 84 percent of PNG agricultural exports but during 1981-91 they averaged only 31 percent. There are now fewer households producing oilseeds than beverages (110,000 versus 245,000).

Figure 4 plots the terms of trade between rice and an overall tree crop index formed from the six prices weighted by the value share of each crop in Papua New Guinea's annual exports. Rice prices have been falling against the weighted average price of tree crops at an annual rate of 2.9 percent. The trend is statistically significant with a standard error of 0.43 percent and the overall relationship is well defined (R^2=0.54).

It is worth noting that if the 1948 composition of exports held through the period the tree crop terms of trade would mirror the (rice/copra) price, which moves in favour of rice. If the 1991 composition of exports held throughout, the trend would be slightly downward, resulting from the diluting of the favourable cocoa and coffee trends with the unfavourable palm oil trend. It is market-led diversification by Papua New Guinea, toward higher value commodities, that has improved exports' purchasing power. The production of rice would reduce purchasing power.

A total export price index was constructed by adding prices for rubber, logs, copper and gold to the six tree crop prices already studied (using value weights for each year to aggregate). These 10 products comprised 90 percent of total export values over the 1948-91 period, so can be considered

Figure 4: The Price of Rice Relative to Weighted Index of Tree Crop Prices



representative of the international purchasing power of the entire economy. The price of rice declined relative to this overall index at an annual rate of 4.5 percent. The trend was well defined with a standard error of 0.65 percent and an R^2 of 0.79. On average, rice imports comprised slightly over 4 percent of Papua New Guinea's total imports for the 1948-51 period. With this portion of the terms of trade improving by 4.5 percent per year, the overall terms of trade should improve by 0.2 percent each year, *ceteris paribus*. Having rice as an import appears to help the terms of trade.

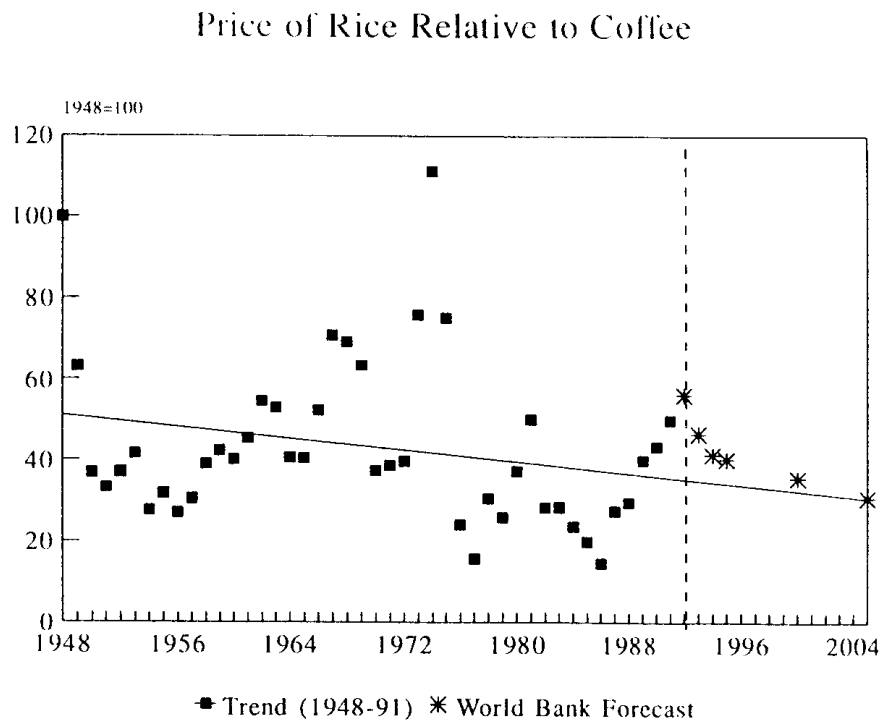
Some additional support for these results is provided by Cuddington (1992), who modelled trends in the world prices of 26 commodities over the period 1900-1983. Deflating each price by the World Bank's index of manufacturing unit value, he found only five commodities with negative price trends. Rice and palm oil were two of them. There was no trend in the real price of cocoa, coffee and tea. Falling relative rice prices do not seem to be a feature of just the post-1948 period.

6. Future Trends in the Relative Price of Rice

The first empirical question has been answered: the historical trend is for the rice terms of trade to fall against the basket of Papua New Guinea's exports, especially against cocoa and coffee. Unless there has been some shift in the economic factors causing relative price movements, future relative prices should return to their long-run trend. There is no evidence in the price forecasts made by the International Economics Department of the World Bank to suggest that the adverse movement in the terms of trade since 1986 is the beginning of a new trend. The forecast (rice/coffee) price was 60 percent above the long-run trend in 1992 but is expected to be only 18 percent above trend in 1995. For the (rice/cocoa) price the deviation from trend falls from 48 percent to 30 percent over the same period (Gibson 1992).

Going even further into the future, the (rice/coffee) price is expected to return to its long-run trend value. Figure 5 reproduces the (rice/coffee) trend

Figure 5: Future Coffee Prices Forecast to Return to Trend



line from Figure 2, extrapolates it forward to 2005 and plots the World Bank forecasts. Rice prices seem most likely to continue falling relative to coffee.

The expectation of falling relative rice prices is strengthened by examining the economic factors that caused the historical rice terms of trade to fall. Rice (and other starchy staples) faces low income elasticity of demand because households purchase higher priced sources of calories and devote less of their budgets to food when incomes grown (Timmer, Falcon and Pearson 1983). On the supply side, a massive investment in rice breeding research and intensified input use allowed global supply to increase by a factor of 2.5 over the last 30 years. Tree crops have not been subjected to the same economic forces. World output of the three beverage crops (in total) did not even double over the last 30 years and there is no downward pattern in the estimates of their income elasticities (Gibson 1993).

These factors affecting rice supply and demand have not been reversed, and if anything, are likely to accelerate, considering changes in rapidly developing Asian economies, which produce and consume 90 percent of the world's rice. Two factors related to the Asian rice economy, plus the structure of rice production and trade lead one to predict that the world rice market will be over-supplied in the future.

1. The tendency for rice to become an inferior good in rapidly growing Asian economies once they reach certain income levels. Ito, Peterson and Grant (1989) found falling income elasticities of demand for rice in most Asian countries. In Japan the elasticity fell from 0.165 in 1961 to -0.708 in 1984, in Thailand from 0.237 to -0.431 and in China from 0.418 to 0.133. If population growth is not sufficient to offset falling individual consumption, aggregate rice demand will decline, leading to either a lower demand for imports or a need to export the newly-found domestic surplus.

2. The tendency for countries to switch from taxing their agricultural sector to subsidising it as they become wealthier and more industrialised (Anderson and Tyers 1989). This means that the burden of falling demand, caused by (1), is not borne just by the farmers facing reduced sales. Instead agricultural policy tries to soften the blow by maintaining high guaranteed prices and seeking additional markets for any domestic surplus. This is most pronounced in East Asian economies where economic growth is fast and comparative advantage in agriculture is low. Hence the countries where rice demand is falling most rapidly are also likely to become subsidised exporters, increasing the supply onto the world market.

3. The "thinness" of the world market for rice. Most rice produced does not enter international trade: only 13 million of the 350 million tonnes produced is traded.[4] Thus, even a one or two percent surplus in a large producing country, which previously did not export, would put intense pressure on world market prices.

The result of these three factors will be more rice on the world market with less demand, so relative prices can be expected to fall. In contrast, tree crops (especially the beverages) are not likely to become inferior goods so quickly and have a world market which is much more adapted to dealing with over-supply.

7. Policy Implications

The empirical question has been answered. Rice prices do not tend to increase faster than tree crop prices. There is no evidence in the historical data to suggest that Papua New Guinea would have been better off by shifting production towards rice. In 1948 one tonne of Papua New Guinean tree crop output (mainly copra) could be traded on world markets for 1.7 tonnes of rice. At the peak of tree

[4] In contrast, the world wheat market commonly exchanges 20 per cent of production and tree crop markets exchange over 80 per cent of production.

crop prices in 1984, one tonne of output could buy 5.5 tonnes of rice. Even in 1991, with tree crop prices down 50 percent, one tonne of output could still buy 23 percent more rice than in 1948. With these exchange ratios the cheapest way of gaining rice is by devoting resources to export expansion.

The historical long-run trend in the terms of trade between rice and tree crops is also likely to hold into the future. The implications of over-supply in the world rice market have been clearly spelled out for an importing country like Papua New Guinea:

> "Low prices would make rice more easily available for importing countries, *rendering costly programs aimed at entirely satisfying internal demand from domestic production less tenable.*"
>
> (Ito, Peterson and Grant 1989, p.40)

The Papua New Guinea rice market is open to any supplier, so even if rice continues to be supplied from Australia, the benefits of low world prices will flow to local consumers because Australian exporters will have to match the falling world prices or lose their market.

The technical problems besetting previous rice-growing attempts in PNG suggest that local production could not match the falling prices of the world market. If consumers are forced to eat locally grown rice in order to satisfy the self-sufficiency desires of policy makers, the majority of households will be made worse off because their most important food purchase will cost more than it need to. Resources used in producing rice will be wasted because they could have been used more efficiently elsewhere in the economy. This is especially the case for capital investments like roads and agricultural research, which are currently undersupplied.

It would be better to direct investment towards expanding production of cocoa and coffee because these two show the strongest relative prices of the crops studied. A potential criticism of this policy is that the price elasticity of demand for cocoa and coffee is low, so increased supply will cause prices to fall. This is true at the aggregate level but Papua New Guinea's small share of world exports allows world prices to be treated as exogenous. Even in the short-run, the price elasticity of demand for PNG exports of cocoa and coffee has been estimated to be -14.5 and -16.8 (Gibson 1993). Cocoa and coffee are also attractive candidates for expansion because of their high demand for unskilled labour. Amongst alternative food crops, the traditional root crops like sweet potato are also more intensive users of labour than is rice.

8. Conclusion

Papua New Guinea is on the path to making a costly economic mistake by attempting rice import substitution. If adhered to, the target of 40 percent self-sufficiency will cause major losses for households - especially in urban areas - and current export industries. Despite a recent fall in the rice purchasing power of tree crop exports, the long-run trend is for a given quantity of exports, especially cocoa and coffee, to buy increasing quantities of rice. Promoting a domestic rice industry would shift production towards a low valued use.

This conclusion has been reached using a simple model for estimating the terms of trade between rice and tree crops. However the model provides robust inferences because of the use of the Newey-West variance-covariance estimator. Consequently, the policy recommendations should not suffer the embarrassment of overturn when another economist runs a slightly different statistical model. Particularly when combined with graphical analysis, this robust approach is suited to the needs of policy advising in developing countries.

The method of robustly measuring the trend in relative world prices, *before* embarking on development of an import substitution industry, can be usefully applied in other cases. For example, its earlier application could have helped caution against the costly development of the sugar industry in Papua New Guinea.

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Appendix 1

Location of Price Data

Rice (US$/tonne):	Thai, white, milled, 5 % broken, government standard, f.o.b, Bangkok.
Cocoa (USc/kg):	daily average price New York and London, three nearest future months.
Coffee (USc/kg):	indicator price, other mild Arabicas, average New York and Hamburg markets.
Tea (USc/kg):	London auction average price received for all teas.
Copra Oil (US$/tonne):	Philippines/Indonesian, bulk, c.i.f, Rotterdam.
Copra (US$/tonne):	Philippines/Indonesian, bulk, c.i.f, Northwest Europe.
Palm Oil (US$/tonne):	Malaysian, 5 % bulk, c.i.f, Northwest Europe.

Source: World Bank, International Economics Department

Appendix 2

Coefficient Estimates, Ordinary Least Squares Standard Errors, and Autocorrelation and Unit Root Tests

Price of Rice relative to:	$\hat{\beta}$	OLS std error	Highest auto-correlation		Unit Root Tests Dickey-Fuller		Phillips-Perron	
Coffee	-0.98	0.50	12	(2.24)	-3.17 τ_τ	(0)	-3.40 τ_τ	(1)
Cocoa	-1.24	0.46	13	(3.09)	-2.66 τ	(0)	-2.87 τ	(1)
Tea	0.85	0.40	12	(2.14)	-1.68 τ_0	(4)	-2.81 τ	(4)
Beverages	-2.26	0.44	12	(2.32)	-1.74 τ_0	(5)	-2.87 τ	(5)
Copra	0.43	0.32	1	(2.02)	-2.38 τ_0	(4)	-4.33 τ_τ	(4)
Copra Oil	0.42	0.32	3	(1.91)	-2.58 τ	(4)	-4.15 τ_τ	(4)
Palm Oil	0.69	0.30	11	(2.08)	-2.29 τ_0	(4)	-3.17 τ	(4)
Oilseeds	0.44	0.30	1	(2.14)	-2.43 τ_0	(4)	-4.26 τ_τ	(4)
Tree Crops	-2.94	0.42	12	(2.00)	-3.27 τ_τ	(0)	-3.56 τ_τ	(1)
Total Exports	-4.50	0.36	13	(2.40)	-2.25 τ_0	(2)	-2.80 τ	(2)

Notes:

$\hat{\beta}$ and standard errors come from the regression model:

$$\ln (P_{Rice}/P_i) = \alpha + \beta \text{ Time} + u.$$

Highest autocorrelation is the longest statistically significant lag, from the model $u_t=\Sigma\rho_i U_{t-i}$, using a lagrange-multiplier test, distributed N(0,1). The maximum allowable lag was i=13.

Unit root tests follow a hierarchy based on the regression model:

$$\Delta u_t = a_0 + a_1 u_{t-1} + a_2 t + v_t.$$

The order of testing, hypotheses being tested, and critical values (for a sample size of 43 and α=0.10) were:

τ_τ	$a_1=0$	-3.13
Φ_3	$a_1=a_2=0$	5.34
Φ_2	$a_1=a_2=a_0=0$	4.03
τ	$a_1=0$ (sub. to $a_2=0$)	-2.57
Φ_1	$a_1=a_0=0$ (sub. to $a_2=0$)	3.78
τ_0	$a_1=0$ (sub. to $a_2=a_0=0$)	-1.62

The unit root hypothesis can be rejected if a τ-test is smaller than the critical value. The Φ_i test dictates the appropriate τ-test to use. The lag lengths for the (augmented) Dickey-Fuller test and the truncation parameter for the Phillips-Perron test (both in ( )) are automatically selected by *Shazam*, based on the highest significant lags from the autocorrelation functions of Δu_t. Using grid search to minimise the Akaike Information Criteria for choice of lag length and with/without trend and/or constant supported the specification choices made by *Shazam*.

Ordinary Least Squares and Robust Standard Errors

Price of Rice relative to:	OLS std error	Autocorrelation Robust Standard Errors (L=lag truncation length)		
		L=1	*L*=8	*L*=highest autocorrelation
Coffee	0.50	0.58	0.62	0.57
Cocoa	0.46	0.53	0.57	0.55 (0.47)
Tea	0.40	0.49	0.47	0.44
Beverages	0.44	0.49	0.47	0.43
Copra	0.32	0.36	0.28	0.36
Copra Oil	0.32	0.37	0.28	0.36
Palm Oil	0.30	0.34	0.32	0.30
Oilseeds	0.30	0.36	0.29	0.36
Tree Crops	0.42	0.50	0.45	0.43
Total Exports	0.36	0.43	0.63	0.65 (0.63)

Notes:

For Cocoa and Total Exports the highest autocorrelation lag was truncated at i=13, so a longer Newey-West truncation lag (L=18) was used (and is reported in parentheses) to check the robustness of results to a non-disappearing autocorrelation.