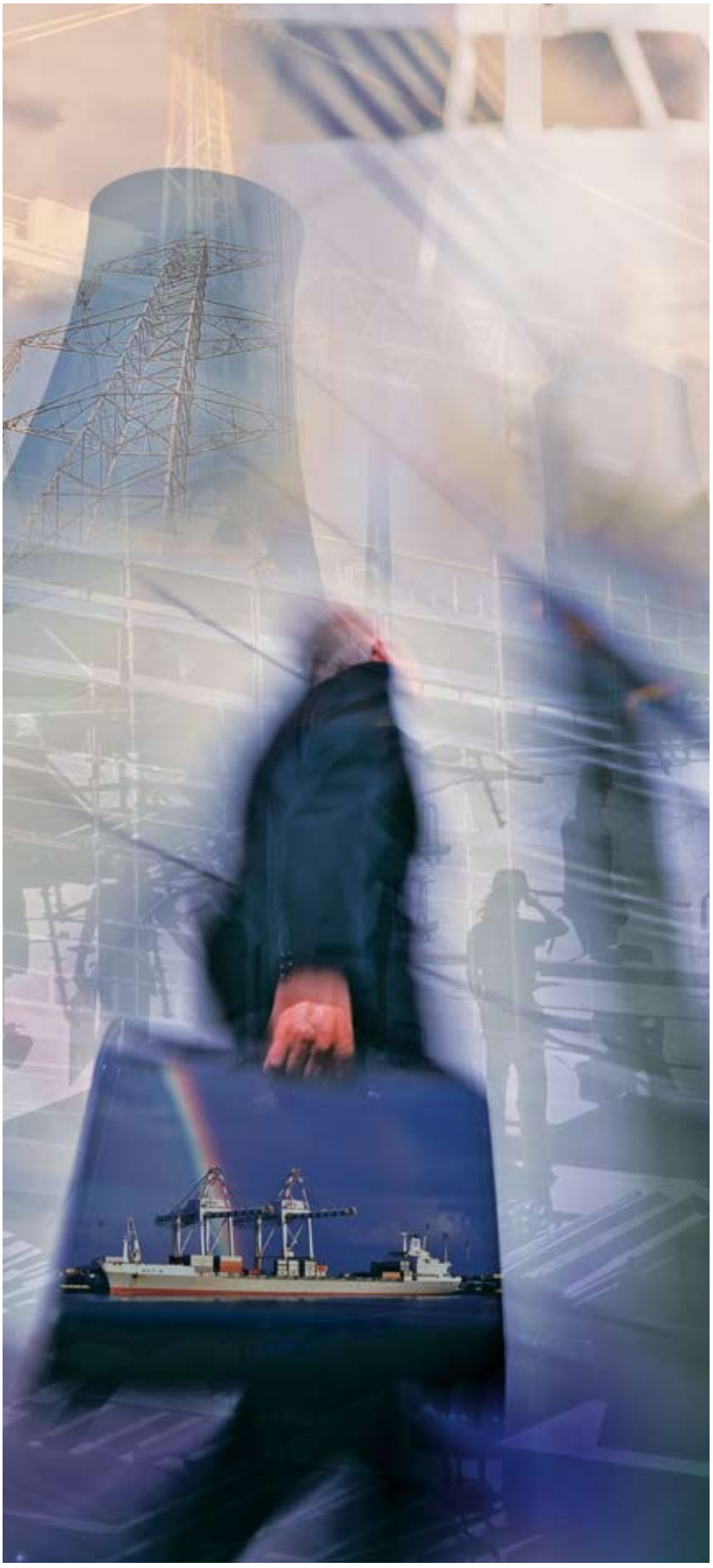

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An Empirical Analysis of Price and Income Elasticities of Papua New Guinea's Exports[i]

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Abstract

A large amount of existing trade literature focusses on the estimation of aggregate trade elasticities and their implications for trade policy. Although the use of aggregate data is often necessary due to disaggregated data being unavailable, policies based upon such trade models may be inapplicable to individual export sectors. This research contributes to the literature through estimating both disaggregated and aggregated export demand elasticities for Papua New Guinea's exports using a single-equation specification under a cointegrating framework. We find a cointegrating relationship exists in all instances and that disaggregated price and income elasticities differ from our aggregate estimates. Whilst our results support currency appreciation, the research is limited by use of a single-equation functional form.

[i] The authors would like to thank a number of anonymous reviewers for their contributions. The research and the opinions contained herewith represent those of the authors and not those of the University of New England or Petroleum Institute.

1. Introduction

Papua New Guinea (PNG) is a small island nation north-east of Australia. Since independence the country has achieved an inconsistent record of economic growth and development. External trade has been a major driver of economic growth throughout the period due to strong commodity prices and transitory increases in mineral and petroleum export volumes. This has stimulated a growing interest in the performance of PNG's export sector.

Existing studies on PNG exports have relied upon aggregate data and aggregate export elasticities as their main tool in analysing export sector performance in PNG. However, with growth inconsistent amongst sectors, it is difficult to accept that analyses of PNG based on aggregate export data produce reliable results. This paper attempts to fill this gap by estimating disaggregated export demand elasticities of PNG and comparing them to those of aggregated elasticities. This research also seeks to determine whether long-run export elasticities differ from short-run elasticities.

In order to achieve this aim, we decompose PNG's exports into two main sectors; petroleum and mineral exports (hereinafter referred to as the mineral sector) and farming, forestry and fishery exports (hereinafter non-mineral sector). A single-equation export demand function is then used to estimate disaggregated export price and income elasticities which are compared with aggregate elasticities. Quarterly trade data from 1994 to 2006 is used to estimate demand elasticities under the Engle and Granger (1987) two-step cointegration procedure.

The paper is divided into six sections. Section 2 provides a brief review of previous literature on the topic. Section 3 provides a historical, institutional and economic background with particular reference to PNG's exports. The methodology and data sources used in the analysis are detailed in section 4, while section 5 discusses the findings. Section 6 concludes.

2. Review of the Literature

It is perhaps unsurprising when considering the hypothesised positive relationship between trade openness and economic growth (Edwards, 1991) that such a large amount of attention has been paid to the empirical modelling of trade flows. Central to this research is whether currency devaluation will improve the balance of trade and how a country can most effectively benefit from trade. An important contribution to this line of enquiry was made by Horner (1952) who provided a detailed empirical and theoretical investigation of price elasticities.

Economic theory suggests that export demand depends on the real exchange rate and the real income of the importer (See: Murray and Ginman 1975; Paulino and Thirlwall 2004). Although the importance of price elasticity as a determinant of export demand is well documented within the literature, the work of Houthakker and Magee (1969) argues that income elasticities are equally as important in the determination of trade flows.

Numerous studies have estimated export demand elasticities using differing data and methodologies. However doubt has been cast on the validity of many of the previous estimates of trade elasticities due to the use of non-stationary data series under regression analysis (Granger and Newbold, 1974). Recent advances in time-series econometrics, particularly in cointegration analysis has resulted in a re-emergence of the application of regression to trade research (see: Lopez 2005; Nur, Wijeweera and Dollery 2007; Paulino and Thirlwall 2004). We a follow similar approach and use the cointegration method to estimate export elasticities for PNG.

One of the first broad applications of the cointegration technique applied to trade flows was that of Bahmani-Oskooee (1991). Importantly Bahmani-Oskooee suggested that the existence of a long-term relationship between the real-exchange rate and trade volumes was equivalent to testing for the 'Marshall-

Lerner' condition.[ii] Arize (1994) also applied the cointegration technique to test for a relationship between the trade balance and the real exchange rate. The research suggested that currency devaluation would improve the trade balance for eight of the nine economies examined. Whilst not specifically focussed on export elasticities the research statistically confirmed that there existed a long-term relationship between trade volumes and relative price.

Bahmani-Oskooee (1998) also used cointegration techniques to explicitly test the Marshall-Lerner condition by estimating price and income elasticities of import and export demand. Importantly the study provided additional support that currency devaluation could improve the trade balance of less-developed countries. The research also confirmed that single-equation estimates of elasticities were compatible with cointegration.

Senhadji and Montenegro (1999) conducted a wider exploration of the topic, focussing on the estimation of export demand elasticities for a group of fifty three industrial and developing countries throughout 1960 to 1993. It was found that price elasticities increased over time, as economic theory would predict (Leamer and Stern, 2006) and that they were significantly lower for developing countries than industrial countries. Income elasticities of demand were found to be the highest in Asia suggesting that exports were an engine of growth for the region, as world demand for Asia's exports increased at a faster rate than world income growth. Further Research by Sinha (2001) confirms Senhaji and Montenegro's estimated price elasticities of demand, but not their income elasticities. A key feature of both studies was their use of single-equation functional form and annual data.

Bahmani-Oskooee and Kara (2005) estimated export demand equations for twenty eight countries using quarterly data spanning from 1973 to 1998. The findings suggested that developing countries faced lower income elasticities of demand than developed countries. In most cases the Marshall-Lerner condition was satisfied.

[ii] Insofar the stability of the cointegrating relationship is confirmed.

Nur, Wijeweera and Dollery (2007) used cointegration to examine the impacts of trade liberalisation policies in Bangladesh for the period 1973 to 2004. It was found that the bilateral export price and income elasticities were significantly different between trading partners providing further support to the importance of estimating disaggregated trade elasticities.

2.1 Empirical Results Relevant to Papua New Guinea

Two existing estimates of PNG's price elasticities of demand are provided by Gibson (1994) and Kauzi (1992), as cited in Gibson (1994). Gibson's research, in contrast to that of Kauzi (1992),[iii] found that the own-price elasticity of export demand for coffee and cocoa was significantly greater than one. This cast doubt on the cross-sector validity of Kauzi's (1992) low price-elasticity of demand estimate.

As literature directly related to PNG's exports, is unavailable, we review research on nations with export compositions comparable to that of PNG's mineral and non-mineral sectors. We note this to be less than ideal due to the differences in the composition of exports, trading partners and techniques used, however, it is likely to provide insight for our research.

PNG's major mineral exports include copper, gold and petroleum (BPNG, 2006a). Economies with similar export compositions include Peru, Chile and Zambia (CIA, 2007e; 2007a; 2007f). Estimated price and income elasticities were examined for Peru from the work of Fullerton Jr., Sawyer and Sprinkle (1999) and Senhadji and Montenegro (1999). Chile's elasticity estimates were taken from Senhadji and Montenegro (1999), Fullerton Jr., Sawyer and Sprinkle (1999). Estimates for Zambia were taken from research by Arize (1987) and Tegene (1989).

From the reviewed research a number of generalisations can be made. In terms of estimates of income elasticities, it was found that in all cases they are less than unity. Appleyard *et al* (2006) suggests this is

[iii] Kauzi found that the price elasticity of export demand was less than unity

generally the case for primary commodities. In terms of estimates of price elasticity a similar pattern is noticed with five of six studies suggesting the price elasticity of demand is inelastic. The results therefore suggest that PNG's mineral and petroleum sector may exhibit inelastic price and income elasticities of export demand.

Some of PNG's major non-mineral exports include palm oil, coffee and cocoa (BPNG, 2006a). As it is expected that agricultural related commodities have similar elasticities, nations who export a large proportion of agricultural commodities have been chosen for comparison including Cote d'Ivoire, Fiji and Paraguay (CIA, 2007b; 2007c; 2007d). Price and income elasticity estimates for Cote d'Ivoire and Paraguay were taken from Senhadji and Montenegro (1999). Estimates for Fiji were taken from Asafu-Adjaye (1999), Prasad (2000), Rao and Singh (2007).

Estimated income elasticities in the mineral sector for both Fiji and Paraguay were above unity, although this conflicts with the results for Cote d'Ivoire. The survey of results appears to provide much less of a consensus than for the mineral sector, whilst the range of estimates calculated by Rao and Singh suggest a number of elasticities are plausible for PNG's non-mineral sector.

Overall, the literature suggests a low price and income elasticity of demand for mineral and petroleum exports, but there is no agreement regarding the likely magnitude of the non-mineral sector elasticities. Similarly, the results of Kauzi (1992) imply a low price elasticity for PNG's aggregate exports, this provides little insight into sector-specific elasticities.

3. Institutional Background

Papua New Guinea has a population approximating 6.1 million, of which eighty seven per cent live in rural areas, relying mainly on subsistence agriculture (DFAT, 2004). PNG is ranked one hundred and thirty nine out of one hundred and seventy seven countries in terms of the 'human development index' (UNDP, 2006). In 2006 gross domestic product (GDP) was estimated at $4.3 billion US dollars (USD) with a GDP per capita of $2,751 USD in purchasing power parity terms (DFAT, 2006). The country's principal exports include copper, gold, silver, crude oil, forestry related goods, palm oil, coffee and cocoa. PNG's domestic currency the 'kina' had an average exchange value of $0.32 USD in 2006 (BPNG, 2007a).

Until the mid 1990s, PNG adopted a fixed exchange rate regime or 'hard kina policy'. This eventually became unmanageable when exchange reserves fell to critical levels in 1993; covering only an estimated one month's worth of import expenditure. In late 1994, after partial devaluations failed to stem the crisis, the kina was floated (Mawuli, 1996). More recently there appears to have been an improvement in economic growth and stability. Trade has been a major driver of economic growth throughout the 1990s due to strong commodity prices. Production of exported commodities has exhibited a downward trend in volumes of all major mineral and petroleum exports (Baxter, 2001). In contrast the volume of non-mineral commodities has increased steadily (BPNG, 2007j).

As mentioned, PNG's mineral sector chiefly exports copper, gold, crude petroleum and silver (Lyday, 2005). Since the opening of the first large-scale open-pit mine in Panguna in 1972, the mining and petroleum industry has achieved little of its original vision as a panacea for development, being commonly described as an 'enclave' industry. The sector contributed approximately seventy per cent of total export revenues in 2006. Despite large increases in the prices of key commodities such as gold, copper and petroleum as well as the weaker kina there has been little growth in export volumes from the sector. In 2006, mineral and petroleum exports accounted for $10.4 billion kina (3.4 Billion USD) (BPNG, 2007c).

The non-mineral sector comprises of farming, forestry and fishery. In order of importance, the main contributors of agricultural exports are palm oil, coffee and cocoa; accounting for around eighty five to ninety per cent of agricultural exports since 2000 (BPNG, 2007d). Other exports include copra oil, tea, rubber and copra. The lack of disaggregated revenue data in terms of 'other' exports makes it difficult to analyse individual components, although this category contains a negligible quantity of manufactured goods (BPNG, 2007d). The major contributor is likely to be vanilla which has experienced a relatively rapid boom in production driven mainly by rising world prices and internal promotion of the crop (DFAT, 2004).

Increases in the exports of non-mineral merchandise have been encouraging, with the volumes of the three major exports palm oil, coffee and cocoa increasing steadily since the early 1980s. Despite the non-mineral sector's small contribution to export revenue, it accounts for twenty eight to thirty per cent of GDP and approximately forty per cent of formal employment, levels significantly higher than that of the minerals and petroleum sector (DFAT, 2004; ERI, 2003). Individually agriculture amounted to thirteen per cent, forestry four per cent and fisheries, one per cent of total exports in 2006. Greater export volumes have been prevalent in all three industries (BPNG, 2007c).

PNG has enjoyed strong demand for exports from Australia and Japan, accounting for fifty five per cent of total exports in 2006 and an average of fifty two per cent since 1980 (BPNG, 2007k; 2007l; 2003; 2004, 2006a). Exports to Australia and Japan are principally composed of petroleum, minerals and coffee (DFAT, 2006; PIC, 2007). The remaining major export destinations as of 2006 include Germany, South Korea, the United Kingdom, China and the Philippines.

Although export revenues have risen over the past decade much of this relates to favourable prices rather than increased supply. In fact, as noted, the mineral and petroleum sector has experienced a long-term decline in export volumes. In contrast farming, forestry and fishery exports have shown a steady rise in output. Particularly within the production of palm oil (DFAT, 2004).

4. Methodology and Data

This study seeks to estimate export demand equations for Papua New Guinea's mineral sector, non-mineral sector and total exports. We follow the approach of similar studies and use a single-equation specification to estimate the model. According to standard economic theory, export demand is determined by the real exchange rate (relative price) and the real income of importers. By assuming Cobb-Douglas functional form and performing a logarithmic transformation, the export demand function becomes:

$$\ln X_d^t = \beta_0 - \beta_1 \ln\left[\frac{P_d^t}{E^t \cdot P_f^t}\right] + \beta_2 \ln Y_w^t + e_t \qquad (1)$$

Where:

X^t_d = Real export volumes

P^t_d = Kina Price of Papua New Guinea's exports

E^t = Kina price of foreign currency

P^t_f = Foreign currency price of similar foreign goods to the exports defined within the dependent variable

$\left[\frac{P_d^t}{E^t \cdot P_f^t}\right]$ = is denoted as RP in subsequent analysis

e_t = Random error

Y^t_w = Real world income

It is important to note a number of key properties relating to the specification. Throughout the analysis we have used real export volumes as the dependent variable. Real export volumes were generated by deflating export revenue data using the relevant export price index. Second, calculating relative price (RP) was performed by employing price indices reflecting the domestic price (P_d) and foreign price (P_f) of the relevant exports, and an exchange rate (E) measuring units of domestic currency per unit of foreign currency. Third, we use Australia's real GDP as a proxy for the 'world income' variable. This is justified due to the fact that Australia has consistently been the main importer of PNG products. A negative

coefficient is expected for the price variable while a positive coefficient is expected for the income variable.

Data for this research is obtained from two main sources. Export revenue and export price indices data are sourced from various issues of PNG Central Bank's Quarterly Economic Bulletin and the remainder, namely the relative price and foreign income data are extracted from the International Monetary Fund's International Financial Statistics database. Quarterly data was used from 1994 to 2006.

It is standard practice in the literature to test time series variables for unit roots because non-stationary variables with a unit root may result in unreliable inferences. Therefore we have conducted Augmented Dickey-Fuller unit root tests to assess the stationarity of the time series. The results suggest that all of the variables are non-stationary in levels and stationary in first differences. Though it is permissible to use first differenced data in the model, a significant disadvantage of this process is the model's inability to estimate long-run elasticities (Hill et al., 2001). Innovations in time-series econometrics, in particular, cointegration techniques have provided better ways of dealing with non-stationary data. After initial testing, we have decided to use the Engle and Granger (1987) two-step method to estimate all three export demand function models in this paper.

Engle and Granger (1987) suggest that non-stationary series may be used in levels provided that their linear combination results in a stationary error term. In such a case the series are said to be 'cointegrated' and 'ordinary least squares' (OLS) regression may be applied (Enders 2004). Conceptually this is reasonable as it is expected that the path of trade volumes themselves are influenced by world income and relative prices. Therefore as both factors vary over time they will jointly define the path of export volumes. This suggests that if world income and relative price are hypothesised as the key determinants of export demand, the divergence of export volumes from the jointly-defined cointegrated path will be limited.

In practice, testing for cointegration therefore becomes a matter of examining how the system of variables deviates from the estimated long-term influence of income and relative price. Mathematically this is achieved through taking the original regression equation (1) and solving for 'e_t' so that:

$$e_t = \ln X_d^t - \beta_0 + \beta_1 \ln RP_t - \beta_2 \ln Y_w^t \qquad (2)$$

If the system is cointegrated the error term will only reflect temporary movements around a long term path, that is, it would be stationary and approximate white noise (Hill et al., 2001).

Since the Engle and Granger (1987) cointegration model provides only long-run elasticities, in order to obtain short-run elasticities and adjustment parameters we need to estimate error correction equations for mineral, non-mineral and total export functions. This involves including the lagged error term e_{t-1} within a short-run model so that it has the form as in equation (3).

$$\Delta \ln X_d^t = \alpha_1 \Delta \ln RP_t + \alpha_2 \Delta \ln Y_w^t + \alpha_3 \ln e_{t-1} + u_t \qquad (3)$$

In terms of the error correction model α_1 and α_2, represent the percentage impact of a change in the relative price and foreign income on a change in export volumes. Whilst α_3 provides an estimate of export demand's convergence to the estimated cointegrated path.

Testing for serial correlation within the error term was conducted through use of the Breusch-Godfrey serial correlation LM test. The test was conducted up to a lag of eight. The null hypothesis of no autocorrelation was rejected for the total export equation. Hence the total export model was re-estimated under the 'Newey-West' procedure, which corrects for serial correlation (Brooks, 2005).

5. Discussion of the results

The final aim of this research is to construct long-run and short-run export demand elasticities for PNG's mineral, non-mineral and total exports. The specification is essentially the same for all three long-run and short-run models. However, as a result of initial breakpoint and specification tests, additional variables such as trend terms and dummy variables were added to achieve more reliable estimates. Dummies and trend variables are not included within the error correction equations.

5.1 Long-Run Mineral and Petroleum Exports Model

The mineral sector export demand function contains a linear trend term (T) and a dummy variable (MS) to capture supply disruptions in 1997 to 1998 as a result of drought and in late 2006 as a result of poor weather, routine maintenance and strikes (BPNG, 2006b; 2006a). It was expected that the trend variable would carry a negative sign due the downward trend in mineral and petroleum export volumes. A positive relationship was expected between world income and export volumes, whilst a negative sign was expected for the relative price variable. All variables were found to be statistically significant and carried the expected signs except for the world income variable. The model explains approximately seventy per cent of the total variation of the mineral export sector. Results are presented in Table 1.

Table 1: Long-run Elasticities of Mineral and Petroleum Exports

Variable	Coefficient	Standard Error	t-Statistic
Intercept	15.6081	7.3432	2.1256**
ln*RP* 7	-0.3302	0.1394	-2.3679**
ln $\frac{Y_t}{W}$	-1.1989	1.1344	-1.0568
MS	-0.2964	0.0406	-7.3060***
T	0.0058	0.0103	0.5629

Note: *, **, *** indicates significance at the 10%, 5% or 1% level respectively

$t_{0.05,\,47} = 1.678$ $t_{0.025,\,47} = 2.012$ $t_{0.005,\,47} = 2.685$ R^2**:** 0.719 Adjusted R^2**:** 0.695

The estimated coefficient for the relative price indicated that a ten per cent increase (decrease) in the relative price of mineral and petroleum exports would result in an approximate three per cent decrease (increase) in export volumes. The inelastic relative price coefficient is consistent with studies of countries with a relatively high proportion of mineral exports such as Chile and Peru (Senhadji and Montenegro, 1999). The low price elasticity of demand is plausible for a number of reasons. Firstly, as goods such as copper, gold and crude oil are likely to have relatively few or no substitutes, cross-price elasticities are likely to be low. Own-price elasticities are likely to be low due to both the costs and time required to adapt production processes to either improve efficiency to compensate for a price increase or switch input sources, particularly within a quarterly time-frame. Lastly, it is probable that most mineral and petroleum exports are sold through long-term contractual arrangements, as is the case with copper (DFAT, 2004). Such arrangements would result in a low responsiveness to price, particularly if importers hedge against foreign exchange risk.

The insignificance of the income variable may be a result of several factors. Firstly the selected proxy variable may not reflect income movements of PNG's major mineral and petroleum importers. An

alternative explanation could be that increased copper and gold production in PNG's main trading partner, Australia, has offset any income effect, particularly if domestic production of these goods is not discernibly associated with income movements (Mudd, 2005). It is also possible that importers are more concerned with 'permanent' or 'expected' real income levels rather than current real income.

The inclusion of the trend variable was necessary to take account of declining output during the sample period. We opt to retain the trend variable even though it was found to be insignificant. The inclusion of the dummy variable (MS) was found to significantly improve the model. The variable was found to be statistically significant and negative. This is to be expected as both supply shocks during the period resulted in a temporary decline of export volumes in the sector due to mine closures.

Long-run estimates do not provide information about the short-run dynamics and the adjustment process of the variables. However, once the cointegration model is estimated it is easy to obtain short-run estimates by applying the Engle and Granger (1987) error correction model. All variables in the error-correction model are in first differences except the error correction term. The results are given in Table 2.

Table 2: Short-Run Estimates of the Mineral Sector

Variable	Coefficient	Standard Error	t-Statistic
$\ln \Delta RP7$	-0.2087	0.1834	-1.1377
$\ln \Delta Y_w^t$	-0.8666	1.4197	-0.6104
e_{t-1}^M	-0.8262	0.1766	-4.6791***

Note: *, **, *** indicates significance at the 10%, 5% or 1% level respectively

$t_{0.05,\,48} = 1.677$, $t_{0.025,\,48} = 2.010$, $t_{0.005,\,48} = 2.680$ $R^2 = 0.315$, Adjusted $R^2 = 0.286$

The statistically significant error correction term reaffirms the validity of the cointegration results. The coefficient of the error correction term is statistically significant. The result suggests that any divergence from the long-term equilibrium path will be corrected by approximately eighty three per cent per quarter.

5.2 Long-Run Estimates of Non-mineral (Forestry, Farming and Fishery) Exports

The long-run export demand function for the non-mineral sector contains three variables. In addition to the price and income variable, a dummy (E) is designed to capture the impact of drought on the non-mineral sector. A negative coefficient is expected for the dummy variable. All variables except for relative price carry expected signs and are statistically significant. The results are presented in Table 3.

Table 3: Long-run Estimates of Non-mineral Sector Exports

Variable	Coefficient	Standard Error	t-Statistic
Intercept	-7.0446	2.1840	-3.2256***
lnRP	1.7070	0.2497	6.8367***
$\ln Y_w^t$	0.7953	0.1945	4.0885***
E	-0.1515	0.0597	-2.5383**

(*, **, *** indicates significance at the 10%, 5% or 1% level respectively)

$t_{0.05,\,48} = 1.677$, $t_{0.025,\,48} = 2.011$, $t_{0.005,\,48} = 2.682$, $R^2 = 0.52$, Adjusted $R^2 = 0.49$

The unexpected sign of the price variable is puzzling, but similar results have previously been obtained by comparable studies (see: Bahmani-Oskooee and Kara, 2005). One possible explanation may be that the positive supply response dominated during relative price changes. This could be the case for a number of reasons. To begin with, there has been a strong level of growth in the volume of exports since 1994, particularly in the case of palm oil. The removal of the institutionally fixed minimum rural wage has resulted in both a rise in private investment and likely a greater utilisation of labour (DFAT, 2004). The significant devaluation of the kina alongside the increased macroeconomic stability during the period has also resulted in large improvements in international competitiveness (Kannapiran and Fleming, 1999). The period was also associated with an improvement in both labour and land productivity (Fleming, 2007).

The positive income elasticity suggests that an increase (decrease) of world income by one per cent will result in a 0.795 per cent increase (decrease) in trade volumes such that ceteris paribus export volumes will grow slower than world income. The inelastic income elasticity is supported by similar research modelling the exports of developing nations (Bahmani-Oskooee and Kara, 2005). The dummy variable (E) is both significant and negative reflecting the drop in export volumes resulting from cyclone Justine

and large-scale drought from 1997 to 1998. The dummy's inclusion was found to improve the trade model.

Short-run estimates are obtained via an error correction model. The statistically significant and negative error correction term indicates that any deviation from the long-term equilibrium will be corrected at a rate of eighty per cent per quarter. The results are presented in Table 4.

Table 4: Short-Run Estimates of the Non-Mineral Sector

Variable	**Coefficient**	**Standard Error**	**t-Statistic**
$\ln \Delta RP$	0.9576	0.3426	2.7950***
$\ln \Delta Y_w^t$	0.3112	1.8188	0.1711
e_{t-1}^F	-0.7941	0.1360	-5.8388***

Note: *, **, *** indicates significance at the 10%, 5% or 1% level respectively)

$t_{0.05,\,48} = 1.677$, $t_{0.025,\,48} = 2.010$, $t_{0.005,\,48} = 2.680$, $R^2 = 0.431$, Adjusted $R^2 = 0.407$

5.4. Total Export Model

The long-run total export demand function contains a linear trend (T), quadratic trend (T^2), relative price (RP) and income (Y) variables. More than sixty per cent of the variation in total exports is explained by this model. Both price and income variables carry expected signs, but only income is statistically significant at the five per cent level. The results are provided in Table 5.

Table 5: Long-Run Estimates of Total Exports

Variable	Coefficient	Standard Error	t-Statistic
Intercept	-13.7499	8.1651	-1.6840*
lnRP	-0.1820	0.2656	-0.6853
$\ln Y_W^t$	3.5953	1.2937	2.7791***
T	-0.0602	0.0174	-3.4708***
T^2	0.0004	0.0002	2.3963**

Note: *, **, *** indicates significance at the 10%, 5% or 1% level respectively

$t_{0.05,\,47} = 1.678$ $t_{0.025,\,47} = 2.012$ $t_{0.005,\,47} = 2.685$, $R^2 = 0.636$, Adjusted $R^2 = 0.605$

Reason for the statistically insignificant price variable is not clear. One may attribute it to the wide range of goods exported by PNG and the difficulty of representing them with a single aggregate relative price variable. It is not uncommon to observe contrasting reactions of export volumes to relative price in individual industries.

The highly significant income variable suggests that export volumes exhibit a high level of income elasticity with a one per cent increase (decrease) in world GDP resulting in more than three per cent increase (decrease) in export volumes. The magnitude of the coefficient was unexpected due to income elasticities being typically below one for primary commodities (Naya, 1967; Bahmani-Oskooee and Kara, 2005).

Estimation of the error-correction model was performed after the final specification of the long-run total exports model. The error-correction model explained twenty three per cent of variations in the movement of export volumes. All but the error-correction term were found to be insignificant. The results are reported in Table 6.

Table 6: Short-Run Results of Total Export Demand Function

	Coefficient	**Standard Error**	**t-Statistic**
$\ln \Delta RP$	0.0219	0.2306	0.0948
$\ln \Delta Y_w^r$	-0.3263	1.2549	-0.2600
e_{t-1}	-0.5369	0.1410	-3.8081***

Note: *, **, *** indicates significance at the 10%, 5% or 1% level respectively

$t_{0.05,\,48} = 1.677$, $t_{0.025,\,48} = 2.010$, $t_{0.005,\,48} = 2.680$, $R^2 = 0.229$, Adjusted $R^2 = 0.197$

The error-correction term suggests that any movement away from the long-term equilibrium relationship will be corrected by fifty four per cent per quarter. An interesting feature of this result is that it suggests a slower convergence to the cointegrating relationship than both the mineral and non-mineral error-correction models. A possible reason for such a result is that as relative prices were found to be insignificant the estimated cointegrated relationship has been estimated by income alone. If it is likely that indeed relative price does influence the long-term path of export volumes then estimates for the rate of convergence to a path only defined by income are likely to be low.

5. Conclusions

This study employed quarterly data spanning from 1994 to 2006, to estimate the price and income elasticities of demand for PNG's disaggregated and aggregated exports using cointegration and error-correction econometric techniques under a single-equation functional form. Several important conclusions can be drawn from the research.

It was found that a cointegrating relationship exists in all three export sectors. Suggesting that in the long-term, export volumes can be predominantly explained by movements in world real income and relative prices. It was found that divergence from this long-run equilibrium path for both, farming, forestry and fishery exports and mineral and petroleum exports would be corrected at a rate approximating eighty per cent per quarter. It was also found that total exports were determined within the long-term by world income with any departure from the long-term path being corrected at approximately fifty four per cent per quarter.

We also find that not only are long-run export elasticities considerably different from short-run elasticities, but also the export elasticities are different between sectors. The differing estimated price elasticities suggest that export volumes of the mineral and petroleum sector and farming, forestry and fishery sector would react differently given an identical change in relative price.

Broadly the results suggest that a currency appreciation will increase the volume of non-mineral exports and cause a decline of mineral and petroleum exports. Provided the estimated relationship holds an appreciation would result in an elastic expansion of non-mineral exports and an inelastic decline in mineral export volumes. Under such circumstances any decline in mineral and petroleum exports will be offset by an increase in total revenue and government revenue arising from ad-valorem export taxes.

For the non-mineral sector the estimated inelastic income elasticity suggests that, world demand for PNG's non-mineral exports have grown more slowly than world real income growth. Provided this

relationship holds the sector can only serve as a viable long-term driver of economic growth whilst exporters can sustain price competition. Whilst this may be counterintuitive when considering the estimated positive response to profitability, it may suggest policies focussed on expanding producer and exporter profit margins, as a means of expanding export volumes.

Finally, although our results appear to provide empirical support for currency appreciation within PNG, the single-equation functional form does not allow the specific identification of price elasticities of supply and demand. Although this has been dealt with through assuming infinitely elastic supply, this is admittedly far from palatable from the perspective of policy formulation and a key weakness of this study.

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