

# Estimating an Aggregate Import Demand Function for Papua New Guinea

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## **Abstract**

The investigation into estimation of a country's import demand function has gained much literature in international economics. Establishing the determinants of import demand assists policy makers to design policies that enable macroeconomic stability and encourage growth. The explanatory variables that influence import demand differ across countries, simply because each economy has its own structural underpinnings that influence trade.

Cointegration techniques were used to model a traditional aggregate import demand function for Papua New Guinea. The model found that the price variable does not affect import demand in Papua New Guinea, while the income variable has considerable influence on import demand in Papua New Guinea, both in the short and long run. In the short run, income elasticity of demand is more elastic than in the long run.

## Table of Contents

1. Introduction.....	4
2. Literature Review .....	5
(a) Theoretical literature review.....	5
(b) Empirical literature review .....	6
3. Descriptive Analysis.....	9
(a) Merchandise Trade Trends in Papua New Guinea .....	9
(b) Import Volumes .....	10
(c) Relative Price .....	11
(d) Gross Domestic Product .....	13
4. Empirical Section .....	14
(a) Single Equation – Residual Based Cointegration Tests.....	16
(b) The Johansen Multi-variant Cointegration Test .....	18
(c) Error-Correction Model .....	20
5. Discussion on estimated model.....	25
6. Conclusion .....	26
References .....	28
Appendix.....	31
(a) Cointegration Tests.....	31
(b) Diagnostics Test.....	34

## 1. Introduction

The investigation into estimation of a country's import demand function has gained much literature in international economics. Establishing the determinants of import demand assists policy makers to design policies that enable macroeconomic stability and encourage growth. The explanatory variables that influence import demand differ across countries, simply because each economy has its own structural underpinnings that influence trade.

The conventional wisdom on the determination of import demand view relative price and Gross Domestic Product (GDP) as a proxy of income variable are widely used in empirical research. Income is said to have a significant relationship with import demand while relative price has a low elasticity with respect to import demand (Siddique(1997), Dutta and Ahmed (2004),Gafar(1988),Carone(1996), Tang (2003)). The model which engages only relative price and GDP is known as the traditional model and has triumph in the literature due to unavailability of updated data for alternative macroeconomic variables.

Apart from the traditional model, there are four other prevalent empirical models that are widely used in the estimation of import demand function in the existing empirical literature. These models are explained in detail in the literature review section of this paper.

For Papua New Guinea, by far, the only study that was done on the estimation of the import demand function was by Senhadji (1998). Senhadji investigated the determinants of import demand using a structural model for a pool of 77 countries, including Papua New Guinea, by employing relative price and GDP minus exports as independent variables, using recent time series techniques. He used 34 annual observations from the period 1960 to 1993 and estimated the variables by applying ordinary least squares (OLS) and Philips-Hansen fully modified (FM) estimator models. Senhadji's model diverges from the traditional model by subtracting exports from GDP as a measure of income.

This paper differs from the existing empirical model by Senhadji, reverting back to the traditional import demand model, using relative price and GDP as a proxy for income variable in estimating the import demand function for Papua New Guinea.It further diverges from the modelling technique by applying cointegration techniques to estimate both the short and long run models for aggregate import demand function for Papua

New Guinea, using quarterly data series from 1996 to 2012. The outcomes of this empirical research will compare and contrast with the existing estimates by Senhadji and shed some light on the income and price elasticities of import demand in Papua New Guinea, to assist in policy discussions. The rest of the paper is organised as follows; the next section provides theoretical and empirical literature review, where both theory and empirical literature will be discussed in detail. This will be followed by descriptive analysis on the variables that are used in the model. The next section will cover the empirical analysis of the model and derivation of model estimates, followed by discussions on the estimated model. The final section will conclude and provide policy recommendations and suggest further research areas.

## **2. Literature Review**

### **(a) Theoretical literature review**

According to Bathalomew(2010), the existing international trade literature has three major theories of import demand function, distinctively explaining the functions of income and price in the determination of import demand. Firstly the neoclassical theory of comparative advantage which is embedded in the Heckscher-Ohlin framework which focuses on how the volume and direction of international trade are affected by changes in relative prices alone, which in turn is explained by differences in factor endowments between countries. The theory has microeconomic foundations on consumer behaviour and general equilibrium and does not concern with the effects of changes in income on trade, as the level of employment is assumed to be fixed and output is assumed to be always on a given production frontier.

The second theory, the Keynesian trade multiplier is embedded on macroeconomic foundation and assumes relative price rigidity with variability in employment and some international capital movements, which would result in passive adjustment towards restoring trade balance. The impetus of this framework is the relationship between income and import demand at the aggregate level, which is defined by ratios, such as, the average and marginal propensity to import and the income elasticity of imports.

The third theory, also called the new theory, sometimes known as the imperfect competition theory of trade (see Hong (1999)), and focuses on intra-industry trade, a concept that is not well defined by the comparative advantage theory. The new theory explains the effects of economies of scale, product differentiation, and monopolistic

competition in international economics. Three approaches used in this theory are the Marshallian approach which assumes constant returns at the firms' level but increasing returns at the industry level. The second approach is the Chamberlinian approach which assumes an industry consisting of many monopolistic firms and new firms are able to enter the market and differentiate products from existing firms so that any monopoly profit at the industry level is eliminated. The third approach is the Cournot approach which assumes markets with only few imperfectly competitive firms, where each takes each other's outputs as given. With any of these approaches, opening of international trade will lead to larger market size, decreasing costs and more output and trade. The new trade theory therefore suggests a new link between trade and income as the role of income in determining imports goes beyond that defined in both the neoclassical and the Keynesian import demand functions, where income only affects purchasing power.

### **(b) Empirical literature review**

Conventional import demand equation uses the three theories to estimate two commonly used models; the imperfect substitute model and the perfect substitute model (Xu (2002)). The imperfect substitute model assumes that neither imports nor exports are perfect substitutes for domestic goods of the representation country. Existing empirical literature reveal that this model is used to study imports of manufactured goods and aggregate import. The perfect substitute model assumes perfect substitution between domestic and foreign goods and each country is assumed to be only an exporter or an importer of traded good but not both. The contemporary world does not confirm existence of such an economy displaying the characteristics of a perfect substitute model, hence this model has attracted less attention in empirical studies than the imperfect substitutes model (Goldstein and Khan (1985)).

According to established empirical literature, there are five types of commonly used models with regard to estimating import demand function. The first is the traditional model with income measure as real GDP. The conventional wisdom on the determinants of import demand view relative price and income measured by real GDP as the two main factors that determine import demand. Here, income is said to have a significant relationship with import demand while relative price has a low elasticity with respect to import demand (Siddique (1997), Dutta and Ahmed (2006), Gafar (1988), Carone (1996), Tang (2003)). The model which engages only relative price and GDP is known as the traditional model and has triumph in the literature, due to data unavailability of alternative macroeconomic variables.

The second model is the revised traditional model with income, measured as the real value of GDP minus exports (or the Senhadji model). A study done by Senhadji(1998), on the import demand functions of 77 countries, replaced the income variable (GDP) with (real GDP minus exports), whilst maintaining relative price as the other variable in the model. Senhadji tried to capture both the long and short run effects of the two explanatory variables on the dependent variable and derive both short and long run import demand functions for the 77 countries, using recently used time series modelling techniques. Overall the 77 different models empirical estimates showed income to be significant in both the short and long run but had an inelastic response in the short run with an average of 0.5 compared to an elastic long run response with an average of 1.5. In addition he concluded that, relative price is inelastic in the short run and elastic in the long run. Senhadji further concluded that, both relative price and income are significant in determining import demand for the 77 countries in his study.

The third model is the disaggregated or decomposed GDP model. This model was adopted by many studies to take into account the fact that different macro components of final expenditure have different import contents (Bathalomew (2010), Alias and Tang (2000), Aziz and Horsewood (2008), Giovannetti(1989), Abbott and Seddighi(1996), Min, Mohammad and Tang (2002), Mohammad and Tang (2000), Tang (2002) and Tang(2003)). In this concept, final expenditure is disaggregated into three components: final consumption expenditure, expenditure on investment goods and exports. Using this concept, Min, Mohammad and Tang (2002), estimated the import demand for Korea. They used the variables relative price and disaggregated or decomposed GDP as independent variables to estimate the import demand function. The model employed Johansen multivariate cointegration analysis and error correction modelling techniques. The model found that, estimating aggregated import demand can cause bias empirical estimates but disaggregating the final expenditure clearly identified the import content of each final expenditure component.

The fourth model is the dynamic structural import demand model (or the “National Cash Flow” model) which is developed by Xu (2002). This model takes into account a growing economy, rather than an endowment economy, and investment and government activity. Xu (2002) suggested that GDP be replaced with national cash flow variable which is measured as GDP minus investment, government expenditure and exports. Using intertemporal optimization approach, Xu’s model takes into account a growing economy. Therefore, the application of national cash flow, which is a more flexible measure of real domestic activity, with relative price will estimate a more precise import demand function in the long run (Xu(2002) and Cheong(2003))



The final model is the structural model that incorporates a binding foreign exchange constraint (or the “Emran and Shilpi” model). This is a structural model of two goods representative agent economy. They circumvent the issue of unavailability of data on the domestic market clearing price of imports by parameterizing the langrange multiplier of a binding foreign exchange constraint at the administered prices of imports. A group of studies added a foreign exchange availability variable on an ad hoc basis to a standard import demand model to reflect a binding foreign exchange contract (Moran (1989)). However, Emran and Shilpi (2010) pointed out that these studies suffer from the problem that if foreign exchange availability variable is used as a regressor when foreign exchange constraint is binding, it alone determines the volume of imports completely. The empirical results argued that, despite of the presence of foreign exchange in the model the elasticity of price is still consistent with the traditional estimates while income too is significantly related to import demand.

For Papua New Guinea, by far, the only study that was done on the estimation of the import demand function was that by Senhadji (1998). Senhadji investigated the determinants of import demand using a structural model for a pool of 77 countries including Papua New Guinea, by employing two independent variables, relative price and GDP minus exports, using recent time series modelling techniques. He used 34 annual observations from the period 1960 to 1993 and estimated the variables by applying ordinary least squares (OLS) and Philips-Hansen fully modified (FM) estimator models. In the case of PNG, his results indicate short run relative import price elasticity of -0.27 and income elasticity of 0.79 using the OLS model, with  $R^2$  of 0.96, while the FM model estimates a price elasticity of -0.27 and an income elasticity of 0.47, with  $R^2$  of 0.96. In the long run he calculated a price elasticity of -1.08 and income elasticity of 1.86. In both the short and long run the signs of the coefficient of estimates are correct, with 96 percent of the variation in import demand for Papua New Guinea explained by the two models respectively. Eyeballing the results from the table indicate that, the relative price variable is insignificant in both the short and long run. In the long-run both the variables price and income elasticities are elastic while in the short run both variables are inelastic.

There are few issues with the models; a high explanatory power of the short run model alludes to spurious regression issues. The partial adjustment component of the short-run model i.e. addition of a lagged dependent variable does not tend to correct the spurious nature of the models, therefore, estimated coefficients of the models can be thrown off, hence unstable coefficient estimates, which can be tested by applying various methods of model stability tests. Our model corrects this issue by using co-integration techniques to estimate both the long and short run import demand function for Papua New Guinea.

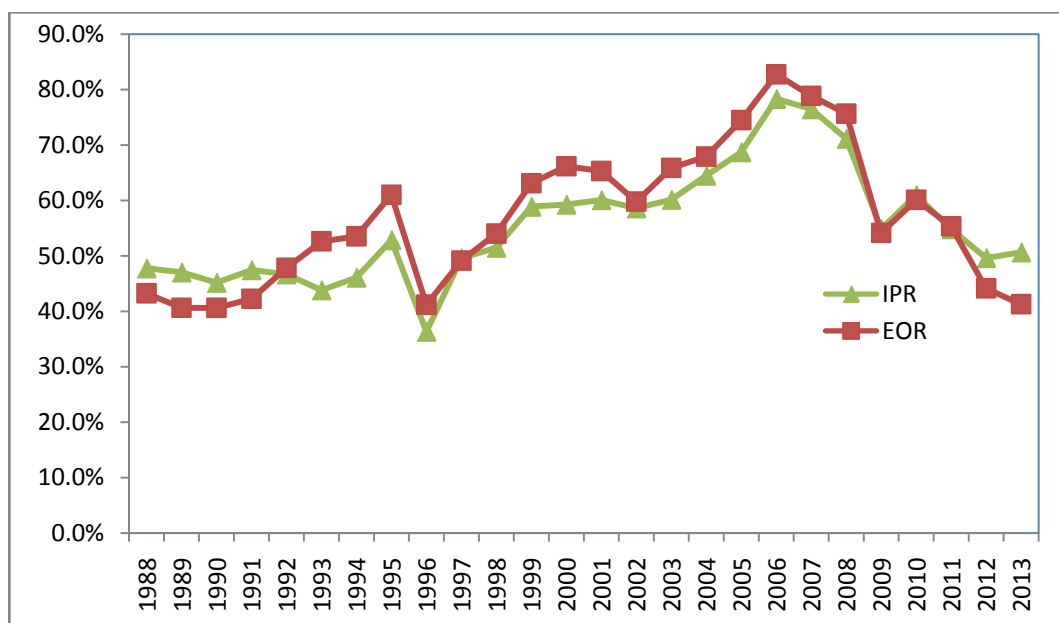
Instead of GDP minus exports, as a proxy for income variable, we revert back to traditional import demand model, using relative price and GDP as a proxy for income variable in calculating the import demand function for Papua New Guinea.

### 3. Descriptive Analysis

#### (a) Merchandise Trade Trends in Papua New Guinea

Papua New Guinea (PNG), a small open developing economy dependent highly on trade, exports mostly primary products and imports industrial/manufactured products. Domestic capacity to produce internationally competitive industrial/manufactured products is impeded with lack of skilled labor and unavailability of capital. Between the late 1990's and mid-2000s PNG took strides in eliminating trade barriers, apart from excise duties charged on many imports and luxury goods which effectively act as barriers to imports. The removal of trade barriers have resulted in high Import Penetration Rate (IPR) and Export Orientation Ratio (EOR).

**Figure 1: Import Penetration Rate and Export Orientation Ratio for PNG between 1988 - 2013**



Source: Author's calculations

The EOR is calculated as a percentage of domestic output which is exported, that is, the ratio of Total exports over GDP. The IPR on the other hand is the percentage of domestic demand fulfilled by imports, that is;

$$\text{IPR} = \text{Imports} / ((\text{GDP} - \text{Exports} + \text{Imports})) \quad (1)$$

On a macro level developed countries that have a tendency to produce manufactured goods with high degree of international competitiveness will see increasing EOR and decreasing IPR, while developing countries who are price takers in international trade would have high IPR and low EOR.

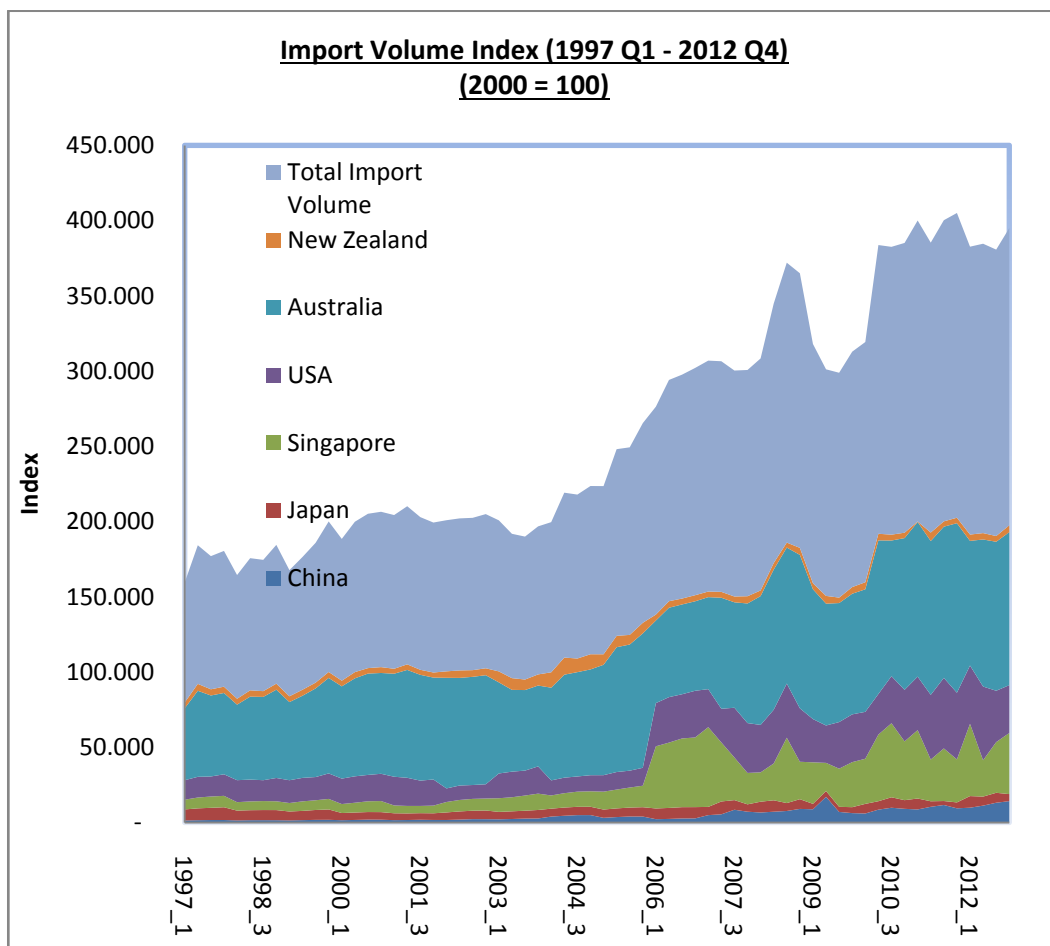
On an industry level, it has been found that developing countries that are more dependent on primary product exports and import of industrial goods have high IPR and EOR. On the other hand industrial countries that are dependent on import of primary products and export of industrial goods also tend to have high IPR and EOR.

According to figure 1, on an industry level Papua New Guinea depends mainly on primary products or raw material exports which constitutes more than 90 percent of Papua New Guineas exports, hence PNG has a high EOR, averaging at 57 percent between 1988 and 2013, whilst IPR averaged at 55.5 percent during the same period, alluding to PNG's dependence on industrial product imports, as domestic capacity to produce competitive industrial products is impeded by lack of skilled labor and capital.

## **(b) Import Volumes**

According to figure 2, import volumes remained flat between 1997 and 2003, however from early 2004 to current, import volume growth has picked up in Papua New Guinea, as a result of significant developments in the mining, petroleum and natural gas sectors. High end capital goods were imported into the country for initial construction of major projects in this sector, with spill over effects to other sectors of the economy, hence stimulating growth in import volumes during the period.

**Figure 2**      **Import Volume Index**



*Source: Author's Calculations*

From the top 6 countries of origin of imports, Australia leads the list as the main source of import for Papua New Guinea, followed by Singapore, USA, China, Japan and New Zealand. Papua New Guinea's share of imports from Japan has declined over time, while imports from China tend to take prominence in the recent past.

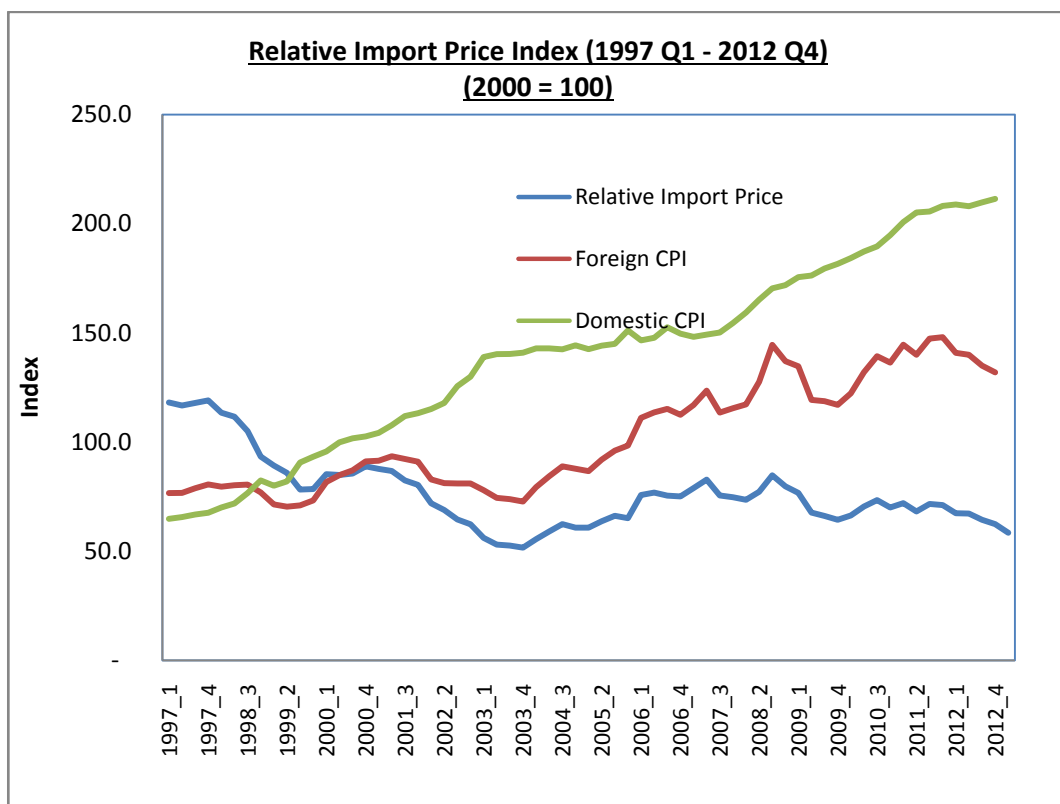
**(c) Relative Price**

Relative import price is the ratio of import price index over domestic price index (CPI). Due to non-availability of import price data, the trade weighted CPI of major trading

partner countries was used as a proxy for import prices. The relative import price is therefore calculated as;

$$\text{Relative Import Price} = \frac{\text{Foreign Price Index}}{\text{Domestic Price Index}} \quad (2)$$

**Figure 3**      **Relative Import Price Index**



Source: Authors calculations

Papua New Guinea’s relative import price has declined between 1997 and 2003; however it picked up slowly and remained stagnant in the recent past. Although domestic prices trended upwards during the period, the trade weighted CPI of major trading partner countries remained stagnant or had grown at a negligible pace during the period, with slight increases in recent times. This can be deduced to the fact that Papua New Guinea’s import origin countries are all industrialised countries with impeccably low CPI movements, whilst Papua New Guinea is prone to major external shocks which resulted in volatile domestic prices. Ultimately, relative import price movements moved in line

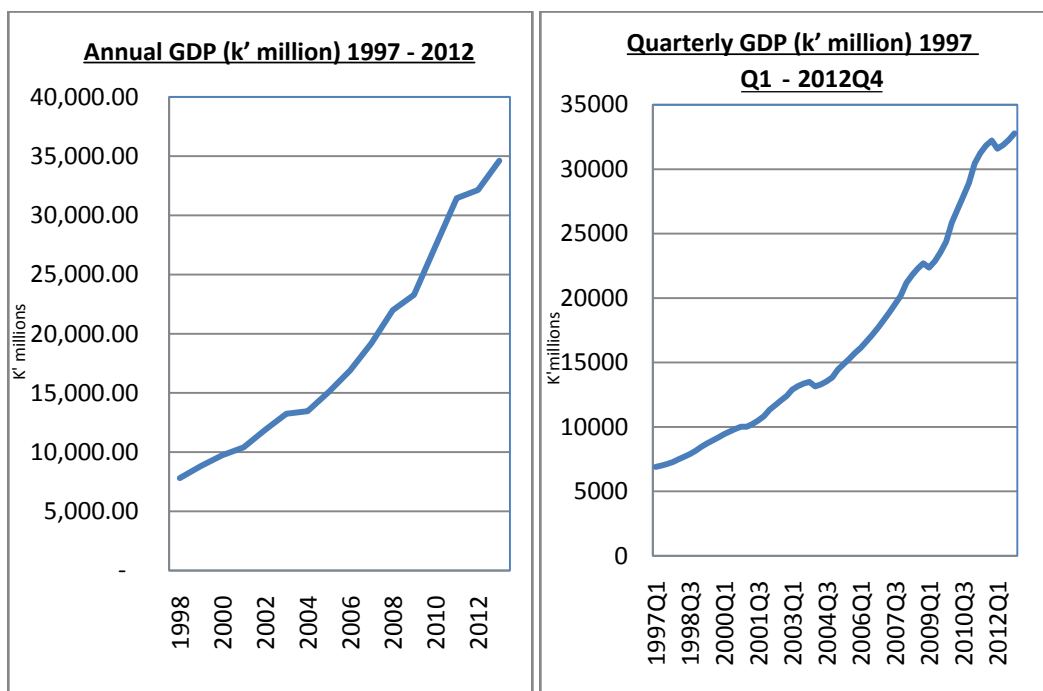
with foreign prices and have remained stagnant during the recent past, as opposed to an upward trending domestic CPI.

Traditional demand theory stipulates that, changes in relative price have influential impact on demand. A low relative price for imports would imply that less foreign goods and services can be traded for a basket of domestic goods and services, thus resulting in a decline in import demand and volume. On the other hand, import demand and volume will increase when relative price rise. This will be investigated in the empirical section of this paper.

**(d) Gross Domestic Product**

Unavailability of quarterly Gross Domestic Product (GDP) data for Papua New Guinea has prompted the use of interpolated quarterly data from annual GDP data generated using Eviews, Quadratic: Match Average, Low frequency (Annual) data to High Frequency (Quarterly) data conversion methodology.

**Figure 4 Annual and Quarterly Real GDP**



Source: Author's Calculations

Eyeballing the two graphs in figure 4, depicting annual and quarterly GDP between the years 1997 and 2012 reveals similar trends, affirming the conversion methodology.

Papua New Guinea's growth path has been well defined by big mineral, oil and gas projects, while impact of international commodity price movements has featured prominently in certain years. Growths experienced in the early 2000's were the result of strengthening of PNG's major institutions, especially the financial sector reforms after the 1997 Asian financial crisis. The country experienced rapid growth between 2003 to 2012 as a result of increase in international commodity prices of Papua New Guinea's major export commodities and the construction of a multi-billion dollar Liquefied Natural Gas (LNG) project which was completed in 2013.

Traditionally, import demand theory suggests that, import demand and income level of a country are positively related. An increase/decrease in income levels would result in an increase/decline in import demand. This hypothesis will be tested in the empirical section of this paper.

#### 4. Empirical Section

As Faini, Pritchett and Clavijo (1988), a traditional import demand function relating to real imports ( $M$ ) to real income ( $Y$ ) and the ratio of import prices ( $P_m$ ) to domestic prices ( $P_d$ ) was estimated for Papua New Guinea. The long run aggregated import demand function for Papua New Guinea therefore is specified as;

$$\ln Mt = b_0 + b_1 \ln Yt + b_2 \ln [P_m(t) / P_d(t)] + ut \quad (3)$$

Where ' $\ln Mt$ ' is the log of aggregate import volume at time ' $t$ ', ' $\ln Yt$ ' is the log of real GDP at time ' $t$ ', which is used as a proxy for domestic real income, while  $\ln P_m(t) / \ln P_d(t)$  is the ratio of import price to domestic price at time ' $t$ ',  $u$  is the disturbance term at time  $t$ , with zero mean and constant variance. Since import price is not readily available, weighted CPI of major trading partners is used as a proxy. Conversely, domestic CPI is used as a proxy for domestic prices.

In a normal functional form demand equation, a priori expectations are that  $b_1 > 0$ , while  $b_2 < 0$ .

The long run aggregate import demand function for Papua New Guinea is;

$$\ln Mt = -3.199 + 0.688Y_t + 0.326 P_m/P_d t \quad (4)$$

$$(-11.13) \quad (41.49) \quad (8.87)$$

$$R^2 = 0.97 \quad DW = 0.85$$

\*\*\* t-statistics in brackets ( )

The standard statistical properties of ordinary least squares (OLS) hold only when the time series variables involved are stationary. A time series is said to be stationary if its mean, variance and auto-covariance are independent of time. Time series data are known to possess unit root and are non-stationary at levels which can produce spurious OLS regression results with high  $R^2$  and low Durbin Watson statistics, invalidating all coefficients in the equation. Tests therefore have to be carried out to ascertain stationarity of each variable in the model. The generated long run model for Papua New Guinea's aggregate import demand function in equation 4 has all the features of a spurious regression result as all variables are significant with high  $R^2$  of 0.97. However the Durbin Watson statistics which is 0.85 shows that the regression results have autocorrelation problem, therefore statistical properties for the OLS estimates for the long run aggregate import demand function for PNG does not hold. This can be corrected if the variables are cointegrated.

In this case the Augmented Dickey-Fuller (ADF) test is carried out to ascertain the stationarity of each of the variables in equation 1. The following equation specification is applied for the ADF test;

$$\Delta Y_t = \alpha_0 + \beta Y_{t-1} + \sum_{i=1}^k \varphi_i \Delta Y_{t-i} + \mu_t \quad (5)$$

where 'Y' represents the variables (import volume, real GDP and relative price) and 'k' is the maximum lag length applied on each of the variables.

ADF test results are presented in table 1

**Table 1: Results of Augmented Dickey-Fuller (ADF) unit root test with no trend for individual data series, (1996 Q1 – 2012 Q4)**

Variable	ADF	Variable	ADF
Level	t-statistics	First Difference	t-statistics



$\ln Mt$	-0.804	$\Delta \ln Mt$	-8.852***
$\ln Yt$	0.625	$\Delta \ln Yt$	-4.403***
$\ln P_m(t)/\ln P_d(t)$	-1.926	$\Delta \ln P_m(t)/\ln P_d(t)$	-6.077***

Test critical values

1% level	-3.533
5% level	-2.906
10% level	-2.590

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Note

- \*\*\* represents 1 percent significance level
  - \*\* represents 5 percent significance level
  - \* represents 10 percent significance level
- 

*Source: Author's calculation*

Results of ADF test indicate that all variables, import volume, relative price of import and real GDP are  $I(1)$ , that is stationary at first difference. Since all variables are non-stationary at levels but stationary at first difference, regression results run on levels would produce spurious results, i.e. highly significant coefficient estimates with high R-squared and low Durbin-Watson statistics indicating serial correlation in the error term, hence invalidating the estimates.

Engle and Granger (1987), however, noted that a linear combination of two or more  $I(1)$  series may be stationary, or  $I(0)$ , in which case the series are cointegrated. Such linear combination defines a cointegrating equation with cointegrating vector of weights characterizing the long-run relationship between the variables.

### **(a) Single Equation – Residual Based Cointegration Tests**

Fully Modified OLS (FMOLS) Philips and Hansen (1990) method for estimating a single cointegrating vector along with two testing procedures: Engle and Granger (1987) and Philips and Ouliaris (1990) residual-based tests were used to test for long run

cointegration of the three variables in the model. The two tests differ in the method of accounting for serial correlation in the residual series; the Engle-Granger test uses a parametric, augmented Dickey-Fuller (ADF) approach, while the Philip-Ouliaris test uses nonparametric Philips-Perron (PP) methodology. The Engle-Granger test estimates a p-lag augmented regression of the form

$$\Delta u_{1t} = (\rho - 1)u_{1t-1} + \sum_{j=1}^p \delta_j \Delta u_{1t-j} + v_t \quad (6)$$

The number of lagged differences 'p' should increase to infinity with the (zero-lag) sample size 'T' but at a rate slower than  $T^{1/3}$ .

The two standard ADF test statistics, one based on the t-statistics for testing null hypothesis of nonstationarity ( $\rho = 1$ ) and the other based on normalized autocorrelation coefficient  $\check{\rho} - 1$ :

$$\hat{\mathcal{J}} = \frac{\check{\rho} - 1}{se(\check{\rho})} \quad (7)$$

$$\check{\mathcal{Z}} = \frac{T(\check{\rho} - 1)}{(1 - \sum_j \hat{\delta}_j)} \quad (8)$$

Where  $se(\check{\rho})$  is the usual OLS estimator of the standard error of the estimated  $\check{\rho}$ , T is the sample size,  $\hat{\mathcal{J}}$  is the tau-statistics and  $\check{\mathcal{Z}}$  is the z-statistics.

In contrast to Engle-Granger test, Philip-Ouliaris test generates an estimate of  $\rho$  by running an unaugmented Dickey-Fuller regression of the form.

$$\Delta u_{1t} = (\rho - 1)u_{1t-1} + \omega_t \quad (9)$$

The corresponding two ADF test statistics for the Philip-Ouliaris test are derived from the following equations:

$$\hat{\mathcal{J}} = \frac{\check{\rho} - 1}{se(\check{\rho})} \quad (10)$$

$$\check{\mathcal{Z}} = T(\check{\rho} - 1) \quad (11)$$

As with ADF and PP statistics, the asymptotic distributions of the Engle-Granger and Philips-Ouliaris Z and T statistics are non-standard and depend on the deterministic repressors specification, so that critical values for the statistics are obtained from simulation results. Note that, the dependence on deterministic occurs despite the fact that the auxiliary regressions themselves exclude the deterministic (since those terms have already been removed from the residuals). In addition, the critical values for the ADF and PP test statistics must account for the fact that the residuals used on the tests depend on estimated coefficients.

The tau-statistics and z-statistics for the Engel-Granger test were -4.812 and -31.5 respectively, thus we reject the null hypothesis of series are not cointegrated at 1 percent significance level. Even the residual test reveals that the series are cointegrated. The tau-statistics and z-statistics for the Philips-Ouliaris test were -4.805 and -30.391 respectively and reject the null hypothesis of series are not cointegrated at 1 percent significance level. Residual test also confirms long run cointegration of the 3 variables.

To test for robustness of the cointegrating relationship established by the single vector, residual-based test, Johansen multi-variant cointegration test was applied, using Vector Autoregression (VARs).

## (b) The Johansen Multi-variant Cointegration Test

The Johansen (1988, 1991) procedure derives a maximum likelihood procedure for testing cointegration in a finite-order Gaussian vector autoregression (VAR). The system is represented by the following equation:

$$y_t = \sum_{i=1}^k \pi_i y_{t-i} + \Phi D_t + \varepsilon_t \quad \varepsilon_t \sim IN(0, \Omega), \quad t = 1, \dots, T, \quad (12)$$

Where  $y_t$  is a vector of  $n$  variables at time  $t$ ;  $\pi_i$  is a  $n \times n$  matrix of coefficients on the  $i$ th lag of  $y_i$ ;  $k$  is the maximum lag length;  $\Phi$  is a  $n \times d$  matrix of coefficients on  $D_t$ , a vector of deterministic variables (such as a constant term and a trend);  $\varepsilon_t$  is a vector of  $n$  unobserved, sequentially independent, jointly normal errors with mean zero and constant covariance matrix  $\Omega$ ; and  $T$  is the number of observations. Throughout,  $y$  is restricted to be (at most) cointegrated of order one, that is  $I(1)$ , where an  $I(n)$  variable requires  $k^{\text{th}}$  differencing to make it stationary.

A vector error correction model can be rewritten from the VAR in equation (12) as;

$$\Delta y_t = \pi y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i y_{t-i} + \Phi D_t + \varepsilon_t \quad \varepsilon_t \sim IN(0, \Omega), \quad (13)$$

Where  $\pi$  and  $\Gamma_i$  are:

$$\pi = \left( \sum_{i=1}^k \pi_i \right) - I_l \quad (14)$$

$$\Gamma_i = -(\pi_{i+1} + \dots + \pi_k) \quad i = 1, \dots, k-1, \quad (15)$$

$I_l$  is the identity matrix of dimension  $l$ , and  $\Delta$  is the difference operator. For any specified number of cointegrating vectors  $r$  ( $0 \leq r \leq l$ ), the matrix  $\pi$  is of (potentially reduced) rank  $r$  and may be rewritten as:

$$\pi = \alpha\beta', \quad (16)$$

where  $\alpha$  and  $\beta$  are  $l \times r$  matrices of full rank. By substitution, equation (13) is:

$$\Delta y_t = \alpha\beta' y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta y_{t-i} + \Phi D_t + \varepsilon_t \quad \varepsilon_t \sim IN(0, \Omega), \quad (17)$$

In equation (17),  $\beta$  is the matrix of cointegrating vectors, and  $\alpha$  is the matrix of “weighting elements”.

Johansen (1988, 1991) derives two maximum likelihood statistics for testing the rank of  $\pi$  in equation (13) and hence for testing the number of cointegrating vectors in (17). Critical and p-values are calculated by MacKinnon, Haug and Michelis (1999) and is automatically generated by E-views.

**Table 2 Model with no Deterministic Trend (restricted constant) in the Cointegrating Vector and no Intercept in the Var**

95 %			$\lambda$ - Trace Test	
$H_0$	$H_A$	$n - r$	0.05 Critical Value	Trace Statistics
$r = 0$	$r \geq 1$	3	35.193	49.061***
$r = 1$	$r \geq 2$	2	20.262	14.637
$r = 2$	$r \geq 3$	1	9.165	3.928

95 %			$\lambda$ - Max Test	
$H_0$	$H_A$	$n - r$	0.05 Critical Value	Max-Eigenvalue Statistics
$r = 0$	$r = 1$	3	22.300	34.971***
$r = 1$	$r = 2$	2	15.892	10.709
$r = 2$	$r = 3$	1	9.165	3.928

Note:

$H_0$  is null hypothesis and  $H_A$  is the alternative hypothesis. The number of variables and cointegrating vectors are 'n' and 'r', respectively. The critical values for the  $\lambda$ -max and  $\lambda$ -trace tests are from the MacKinnon, Haug and Michelis (1999) critical values, generated by E-views.

\*\*\* means significant at 1-percent significance level, i.e. rejection of null hypothesis at 1-percent level.

\*\* means significant at 5-percent significance level, i.e. rejection of null hypothesis at 5-percent level.

\* means significant at 10-percent significance level, i.e. rejection of null hypothesis at 10-percent level.

---

*Source: Author's calculations*

Results from the VAR based Johansen cointegration test indicate that both the  $\lambda$  - trace and  $\lambda$  - Maximum Eigenvalue test reject the null hypothesis of no cointegration at 1 percent significance level. There is one cointegrating relationship between the three variables, hence the variables, though not stationary at levels, move together in the long run. Both uni-variant and multi-variant cointegration test on the three variables confirm cointegration.

### **(c) Error-Correction Model**

According to Granger-Engle (1987) representation theorem, systems with cointegrated I(1) variables have three equivalent representations

- Common Trends
- Moving average, MA
- Equilibrium correction (error correction), ECM

According to ADF and cointegration test results; import volume, real GDP and relative price for Papua New Guinea are I(1) variables and cointegrated, hence an error correction model is validated according to Granger-Engle representation theorem.

The long run model is specified by equation 3 and the results are presented in equation 4. The short-run reduced form adjustment follows an error correction specification and is represented as follows:

$$\begin{aligned} \Delta M_t = & b_1 + \lambda(\beta_0 M_{t-1} - b_0 - \beta_1 Y_{t-1} - \beta_2 (Pm_{t-1}/Pd_{t-1})) \\ & + \sum_{i=1}^k a_i \Delta M_{t-i} + \sum_{i=0}^k b_i \Delta Y_{t-i} + \sum_{i=0}^k c_i (\Delta Pm_{t-i}/Pd_{t-i}) + DQ21997 \\ & + DQ31999 + DQ12010 + \varepsilon_t \end{aligned} \quad (18)$$

where

$\beta_0 M_{t-1} - b_0 - \beta_1 Y_{t-1} - \beta_2 (Pm_{t-1}/Pd_{t-1})$  represents the lagged residual of the cointegrating relationship

$\lambda$  represents the speed of adjustment coefficient

$k$  represents the lag length of the short-run equation. The over-parameterised model ( $k = 4$ ), since quarterly data is used.

$DQ21997$  Dummy variable for the June quarter of 1997, represents construction work at the Lihir gold mine.

$DQ31999$  Dummy variable for September quarter of 1999, represents construction work at the Gobe oil fields

$DQ12010$  Dummy variable for March quarter 2010, represents industrial strike by OK Tedi mine workers.

Notably, the LNG construction does not have a dummy variable in the model because the generated model was unable to flag any outliers in the data. This implies that published import data does not include all of the LNG imports, especially the machinery and technical equipment that were shipped in from offshore for the construction phase of the project and then shifted back after project completion.

Results of the equation (18) are provided in table 3.

**Table 3. Estimates of over-parameterised error correction model (ecm), 1996 Q1 – 2012 Q4, Dependent variable:  $\Delta M_t$**

<b>Variable</b>	<b>Coefficient</b>	<b>t-statistics</b>	<b>p-value</b>
$\Delta \ln M_{t-1}$	-0.160	-1.070	0.290
$\Delta \ln M_{t-2}$	0.028	0.224	0.823
$\Delta \ln M_{t-3}$	-0.397	-3.506	0.001
$\Delta \ln M_{t-4}$	0.012	0.111	0.912
$\Delta \ln Y_t$	1.556	3.936	0.000
$\Delta \ln Y_{t-1}$	-0.009	-0.021	0.983
$\Delta \ln Y_{t-2}$	0.045	0.121	0.904
$\Delta \ln Y_{t-3}$	0.588	1.587	0.120
$\Delta \ln Y_{t-4}$	-0.342	-0.832	0.409
$\Delta(\ln Pm_t / \ln Pd_t)$	0.564	6.721	0.000
$\Delta(\ln Pm_{t-1} / \ln Pd_{t-1})$	0.248	2.487	0.017
$\Delta(\ln Pm_{t-2} / \ln Pd_{t-2})$	0.240	2.430	0.019
$\Delta(\ln Pm_{t-3} / \ln Pd_{t-3})$	-0.001	-0.012	0.990
$\Delta(\ln Pm_{t-4} / \ln Pd_{t-4})$	-0.103	-1.153	0.255
$ecm_{t-1}$	-0.482	-3.214	0.002
<b>DumQ21997</b>	0.095	2.772	0.008
<b>DumQ31999</b>	0.105	2.967	0.005
<b>DumQ12010</b>	-0.230	-4.368	0.000
<b>C</b>	-0.013	-1.002	0.322

$R^2 = 0.772$       Adjusted  $R^2 = 0.678$       S.E of Regression = 0.030      DW = 2.127  
 $F(3, 63) = 8.256 [0.000]$       AIC = -3.906      SIC = -3.260      HQIC = -3.652

---

*Source: Author's calculation*

From the over-parameterised model, an economically interpretable model was generated. Stepwise regression was used to reduce the model. Lags were reduced and variables were omitted to achieve a parsimonious ECM model which has a better fit. The reduction process was carried out using intuition and statistical significance of variables in the model. The parsimonious reduction process made use of stepwise regression, subjecting each stage of the reduction process to several diagnostics test especially the AIC and SIC information criterions before arriving at an interpretable model which is presented in table 4.

---

**Table 4. Estimates of parsimonious error correction model (ecm), 1996 Q1 – 2012 Q4, Dependent variable:  $\Delta M_t$**

Variable	Coefficient	t-statistics	p-value
$\Delta \ln M_{t-3}$	-0.386	-4.767	0.000
$\Delta \ln Y_t$	1.618	5.905	0.000
$\Delta(\ln Pm_t / \ln Pd_t)$	0.516	6.742	0.000
$\Delta(\ln Pm_{t-1} / \ln Pd_{t-1})$	0.240	3.165	0.003
$\Delta(\ln Pm_{t-2} / \ln Pd_{t-2})$	0.235	2.772	0.008
$ecm_{t-1}$	-0.555	-5.689	0.000
DumQ21997	0.100	3.257	0.002
DumQ31999	0.100	3.154	0.003
DumQ12010	-0.219	-4.789	0.000
C	-0.009	-1.204	0.234

$R^2 = 0.736$       Adjusted  $R^2 = 0.691$       S.E of Regression = 0.030      DW = 2.212



F (3, 63) = 16.685 [0.000]

AIC = -4.054

SIC = -3.717

HQIC = -3.921

*Diagnostic tests*

Jarque-Bera F-statistics 1.328 [0.515]

B-G LM test F-statistics 0.788 [0.460]

ARCH test F-statistics 0.292 [0.591]

Ramsey Reset F-statistics 0.057 [0.813]

\* values in [ ] are p-values for the test statistics

---

*Source: Author's calculation*

The parsimonious model has a better fit compared to the over parameterised model as indicated by a high value of the F-statistics (16.685), which is significant at 1 percent significance level compared with a F statistics of (8.256) which is also significant, however some of the variables in the over-parameterised model are insignificant.

The structural variables in the parsimonious model explain aggregate import demand for Papua New Guinea better than the over parameterised model as indicated by the coefficient multiple determination. The adjusted  $R^2$  of the over parameterised model is 0.678, which is lower than the parsimonious model which is 0.691. This implies that the more variable that was added to the model reduces the explanatory power of the model because of degree of freedom problem. Once the variables in the model are reduced, the explanatory power is increased; hence it's evident in the parsimonious model.

Apart from the DW statistics, other diagnostic tests were done on the parsimonious model to test the validity of the estimates.

The Jarque-Bera test on the residuals, with the F-statistics of 1.328, could not reject the null hypothesis of normality in the residuals. The Bruesch-Godfrey serial correlation Lagrange Multiplier (LM) test for higher order serial correlation with a calculated F-statistics of 0.788 could not reject the null hypothesis of absence of serial correlation in the residuals. Finally, the Autoregressive Conditional Heteroskedasticity (ARCH) tests were used to test for heteroskedasticity in the error process in the mode. The calculated F-statistics of 0.292 indicated absence of heteroskedasticity in the model.

Apart from the residual diagnostics tests, tests were also done on the stability of the model. Ramsey Regression Specification Error Test (Reset) t-statistics of 0.238 and z-

statistics of 0.057 fail to reject the null hypothesis of the mean of the error term equal to zero. The Cusum test also finds that the parameters are stable as the cumulative sum of the recursive residuals are within the two 5 percent significance lines.

From the array of diagnostics tests the model is asserted to be well estimated and stable over the period under study and the observed data fits the model specification adequately, thus, residuals are distributed as white noise and the coefficients valid for policy discussions.

## 5. Discussion on estimated model

In Papua New Guinea income elasticity of aggregate demand for import is elastic in the short-run than in the long run. A percentage increase/decrease in income level of Papua New Guineans would result in 1.618 percent increase/decrease in aggregate import demand in the short run, and the result is immediate. While in the long run a percent increase/decrease in income levels of Papua New Guineans would result in 0.688 percent increase/decrease in aggregate import demand.

The price elasticity of aggregate import demand in Papua New Guinea has the wrong sign on its coefficient of estimate. A prior expectation are that, the coefficient should be negative, while the estimated model for both the short and long run shows a positive relationship between relative price and aggregate import demand. However, if we discard the sign on the coefficient of estimate, price elasticity for aggregate import demand is inelastic both in the short and the long run. In the long run a percentage change in relative price would result in 0.326 percent change in aggregate import demand, while in the short run; a percentage change in relative price would result in 0.991 percent change in aggregate import demand.

Papua New Guinea a third world country depends largely on imported goods, with minimal import substitution or internal capacity to produce enough to sustain local demand, hence price is not sensitive to aggregate import demand. Even the large enclave mining, petroleum and gas sectors which need imported items for their operations don't have locally produced substitutes to meet their needs. Hence aggregate import demand is more sensitive to changes in the income level of Papua New Guineans than the relative price.

Dummy variable for June quarter 1997 and September quarter 1999, shows that when a new mining or petroleum project is under construction, import demand increases by 0.1 percent, while any problems associated with any mines which last for a few weeks would result in decline in import demand by 0.219 percent.

The coefficient of the error term for the previous period ( $ECM_{t-1}$ ), as expected has a negative sign in the parsimonious model and is significant at 1 percent significance level. The significance of the error term authenticates cointegration of the variables and validates the existence of long run steady-state equilibrium of the import demand function. The results indicate that 55.5 percent of previous quarter's disequilibrium from long run equilibrium of aggregate import demand for Papua New Guinea is corrected in the current period. It takes 1 and a half year for dynamic short run aggregate import demand function to adjust to its long run equilibrium level.

## 6. Conclusion

The results generated from this paper differ significantly from those generated by Senhadji (1998). Senhadji's estimate shows a short run income elasticity of 0.79 while this paper generated a short run income elasticity of 1.618. This paper also diverges in its long run estimated outcomes from that of Senhadji, with an estimate of 0.688 while Senhadji estimated 1.86. From the model outcomes, Senhadji estimates elastic income response in the long run while in the short run income is inelastic. This is contrary to the model results generated by this paper, where in the short run income is elastic while in the long run income is inelastic. The differing results highlight structural changes, as Senhadji's results were generated during a period, where PNG had high import protectionism, exchange controls were in place and a fixed exchange rate regime, tied to PNG's major trading partner currencies. The opposite is true for the period covered in this paper, with a flexible exchange rate regime, liberalised trade and foreign exchange control environments. This tend to confirm that with protectionism, increase in income levels would mean a sticky adjustment to import demand, hence elastic long run income elasticity while less protectionism results in instant adjustment to import demand in the short run with less lagged effects.

For policy makers, monitoring of short run income growth path is crucial as changes in income levels have an elastic effect on import demand. For PNG the recent boost in income growth has been driven by the enclave mining, gas and petroleum sectors, and

its flow on effects to the other sectors of the economy. The impact of this on other macroeconomic variable such as exchange rate, foreign exchange availability and ultimately macroeconomic stability is crucial.

The relative price variables in this model tend to have negligible effect as it has the wrong sign on the variable. With no import substitution, this is also a cause for concern for PNG. Price does not seem to matter in importing of manufactured products in PNG.

Whilst this is an aggregate import demand function for PNG, future work on this can concentrate on industry specific import demand functions, separating mining imports from general imports to capture the real impact of import demand on other macroeconomic variables, such as exchange rate.

## References

Abbott, A.J., and H.R. Seddighi (1996), "Aggregate Imports and Expenditure Components in the U.K.: An Empirical Analysis," *Applied Economics*, 28, pp. 1119-1125.

Alias, M. H. & Tang, T. C. (2000), "Aggregate Import and Expenditure Components in Malaysia: A Cointegration and Error Correction Analysis", *ASEAN Economic Bulletin*, 17, pp. 257.

Aziz, N., and Horsewood, N. J. (2008), "Determinants of Aggregate Import Demand of Bangladesh: Cointegration and Error Correction Modelling", *International Trade and Finance Association*, Working Paper 1

Bathalomew, D. 2010, "An Econometric Estimation of the Aggregate Import Demand Function for Sierra Leone", *Journal of Monetary and Economic Integration* 10(4).

Carone, G. (1996), "Modelling the U.S. Demand for Imports through Cointegration and Error Correction", *Journal of Policy Modelling*. Vol. 18(1): pp. 1-48.

Cheong, T. T., (2003), "Aggregate Import Demand Function for Eighteen OIC Countries: A Cointegration Analysis", *IJUM Journal of Economics and Management* 11, no. 2, pp. 167-195

Dutta, D., and Ahmed, N. (2004), "An Aggregate Import Demand Function For India: A Cointegration Analysis", *Applied Economics Letters*, 11(10), pp. 607-613.",

Emran, M. S., and Shilpi, F., (2010), "Estimating Import Demand Function in Developing Countries: A Structural Econometric Approach to Applications to India and Sri Lanka", *Institute for International Economics*, Working Paper Series

Engle, R. F. and C. W. J. Granger (1987), "Cointegration and Error Correction: Representation, Estimation and Testing," *Econometrica*, 55: pp. 251-76.

Faini, R., et al, (1988), "Import Demand in Developing Countries", *The World Bank*, Working Papers 122

Gafar, J.S. (1988), "The Determinants of Import Demand in Trinidad and Tobago: 1967-84," *Applied Economics*, 20, pp. 303-313.

Giovannetti, G. (1989), "Aggregated imports and expenditure components in Italy: An econometric analysis", *Applied Economics*, 21, pp. 957-971.

- Goldstein, & Khan (1985). "Income and Price Effects in Foreign Trade. In Jones, R.W. and Kenen, P.B (EDS)", *Handbook of international Economics, North Holland, Amsterdam*, pp. 1042-99.
- Hong, P. (1999) 'Import elasticities revisited', *Discussion Paper No. 10*, Department of Economic and Social Affairs, United Nations.
- Johansen, S. (1988), "Statistical Analysis of Cointegrating Vectors," *Journal of Economic Dynamics and Control*, 12: pp. 231-54.
- Johansen, S. (1991), "Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models," *Econometrica*, 59: pp. 1551-80.
- MacKinnon, J.G., Haug, A.A. and L. Michelis, (1999), "Numerical distribution functions of likelihood ratio tests for cointegration", *Journal of Applied Econometrics* 14, pp. 563-577.
- Min, B.S., Mohammed, H.A. and Tang, T.C., (2002), "An analysis of South Korea's import demand." *Journal of Asia Pacific Affairs* 4: pp. 1-17.
- Mohammed, H. A. and Tang, T.C. (2000), "Aggregate imports and expenditure components in Malaysia: a cointegration and error correction analysis", *ASEAN Economic Bulletin* 17: pp. 257- 69.
- Moran. C., (1988), "Imports Under a Foreign Exchange Constraint", *The World Bank, Working Paper Series* 1
- Philips, P.C.B. and B.E. Hansen (1990), "Statistical Inference in Instrumental Variables Regression with (I1) Process", *Review of Economic Studies*.
- Philips, P.C.B., and S. Quliaris, (1990), "Asymptotic properties of residual based tests for cointegration", *Econometrica*, 58, pp: 164-194
- Senhadji, A., (1998), "Time Series Estimation of Structural Import Demand Equation: A Cross-Country Analysis", *IMF Staff Working Paper*, Vol 45, no. 2, pp 236-268
- Siddique, M.A. B., (1997), "Estimation of Import Demand Function for Indonesia: 1971-1993", *International Congress on Modelling and Simulation. Newcastle*, 4, pp. 259-264.
- Tang, T.C. (2002), "An aggregate import demand function for Hong Kong, China: New evidence from bounds test", *International Journal of Management*, 19, pp. 561-567.

Tang, T. C. (2003), "An empirical analysis of China's aggregate import demand function", *China Economic Review*, Vol. 12, No. 2, pp. 142-63.

Xu. X, (2002), "The Dynamic-optimizing Approach to Import Demand: A Structural Model". *Economics Letters*. Vol. 74: pp 265-270.

# Appendix

## (a) Cointegration Tests

### 1. Cointegration Test - Engle-Granger

Date: 10/10/14 Time: 04:55

Equation: UNTITLED

Specification: LIMPVOL LRELPRICE LGDP C

Cointegrating equation deterministics: C

Null hypothesis: Series are not cointegrated

Automatic lag specification (lag=0 based on Schwarz Info Criterion, maxlag=10)

	Value	Prob.*
Engle-Granger tau-statistic	-4.812044	0.0044
Engle-Granger z-statistic	-31.51373	0.0074

\*Mackinnon (1996) p-values.

Intermediate Results:

Rho - 1	-0.470354
Rho S.E.	0.097745
Residual variance	0.001733
Long-run residual variance	0.001733
Number of lags	0
Number of observations	67
Number of stochastic trends**	3

\*\*Number of stochastic trends in asymptotic distribution.

Engle-Granger Test Equation:

Dependent Variable: D(RESID)

Method: Least Squares

Date: 10/10/14 Time: 04:55

Sample (adjusted): 1996Q2 2012Q4

Included observations: 67 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID(-1)	-0.470354	0.097745	-4.812044	0.0000
R-squared	0.258820	Mean dependent var		0.001676
Adjusted R-squared	0.258820	S.D. dependent var		0.048357
S.E. of regression	0.041632	Akaike info criterion		-3.505101
Sum squared resid	0.114391	Schwarz criterion		-3.472195
Log likelihood	118.4209	Hannan-Quinn criter.		-3.492080
Durbin-Watson stat	2.164639			



## 2. Cointegration Test - Phillips-Ouliaris

Date: 10/10/14 Time: 04:56

Equation: UNTITLED

Specification: LIMPVOL LRELPRICE LGDP C

Cointegrating equation deterministics: C

Null hypothesis: Series are not cointegrated

Long-run variance estimate (Prewhitening with lags = 0 from SIC maxlags = 4, Bartlett kernel, Newey-West fixed bandwidth = 4.0000)

No d.f. adjustment for variances

	Value	Prob.*
Phillips-Ouliaris tau-statistic	-4.805073	0.0045
Phillips-Ouliaris z-statistic	-30.39117	0.0099

\*Mackinnon (1996) p-values.

Intermediate Results:

Rho - 1	-0.470354
Bias corrected Rho - 1 (Rho* - 1)	-0.453600
Rho* S.E.	0.094400
Residual variance	0.001707
Long-run residual variance	0.001617
Long-run residual autocovariance	-4.54E-05
Number of observations	67
Number of stochastic trends**	3

\*\*Number of stochastic trends in asymptotic distribution.

Phillips-Ouliaris Test Equation:

Dependent Variable: D(RESID)

Method: Least Squares

Date: 10/10/14 Time: 04:56

Sample (adjusted): 1996Q2 2012Q4

Included observations: 67 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID(-1)	-0.470354	0.097745	-4.812044	0.0000
R-squared	0.258820	Mean dependent var		0.001676
Adjusted R-squared	0.258820	S.D. dependent var		0.048357
S.E. of regression	0.041632	Akaike info criterion		-3.505101
Sum squared resid	0.114391	Schwarz criterion		-3.472195
Log likelihood	118.4209	Hannan-Quinn criter.		-3.492080
Durbin-Watson stat	2.164639			

### 3. Johansen Cointegration Test

Date: 10/10/14 Time: 05:03

Sample (adjusted): 1996Q4 2012Q4

Included observations: 65 after adjustments

Trend assumption: No deterministic trend (restricted constant)

Series: LIMPVOL LGDP LRELPRICE

Lags interval (in first differences): 1 to 2

#### Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.416091	49.60761	35.19275	0.0008
At most 1	0.151899	14.63691	20.26184	0.2479
At most 2	0.058638	3.927778	9.164546	0.4230

Trace test indicates 1 cointegratingeqn(s) at the 0.05 level

\* denotes rejection of the hypothesis at the 0.05 level

\*\*MacKinnon-Haug-Michelis (1999) p-values

#### Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.416091	34.97071	22.29962	0.0005
At most 1	0.151899	10.70913	15.89210	0.2741
At most 2	0.058638	3.927778	9.164546	0.4230

Max-eigenvalue test indicates 1 cointegratingeqn(s) at the 0.05 level

\* denotes rejection of the hypothesis at the 0.05 level

\*\*MacKinnon-Haug-Michelis (1999) p-values

#### Unrestricted Cointegrating Coefficients (normalized by b\*S11\*b=I):

LIMPVOL	LGDP	LRELPRICE	C
26.91857	-17.65871	-8.459915	77.31079
-5.301974	3.497407	3.833009	-22.92974
-2.037935	0.665639	-4.352469	23.24002

#### Unrestricted Adjustment Coefficients (alpha):

D(LIMPVOL)	-0.025229	0.003390	0.006999
D(LGDP)	0.002877	0.004250	0.001493
D(LRELPRICE)	-0.001576	-0.011033	0.009395

1 Cointegrating Equation(s):                      Log likelihood                      422.4648

Normalized cointegrating coefficients (standard error in parentheses)

LIMPVOL	LGDP	LRELPRICE	C
1.000000	-0.656005 (0.01581)	-0.314278 (0.03420)	2.872025 (0.26689)

Adjustment coefficients (standard error in parentheses)

D(LIMPVOL)	-0.679119 (0.15014)
D(LGDP)	0.077447 (0.04589)
D(LRELPRICE)	-0.042414 (0.16988)

2 Cointegrating Equation(s):                      Log likelihood                      427.8193

Normalized cointegrating coefficients (standard error in parentheses)

LIMPVOL	LGDP	LRELPRICE	C
1.000000	0.000000	73.37961 (50.6502)	-259.0985 (222.314)
0.000000	1.000000	112.3374 (77.2059)	-399.3425 (338.872)

Adjustment coefficients (standard error in parentheses)

D(LIMPVOL)	-0.697095 (0.15254)	0.457363 (0.10009)
D(LGDP)	0.054912 (0.04419)	-0.035941 (0.02900)
D(LRELPRICE)	0.016085 (0.16852)	-0.010764 (0.11057)

## (b) Diagnostics Test

### 4. Correlogram

Date: 10/10/14 Time: 05:47

Sample: 1996Q1 2012Q4

Included observations: 64

Q-statistic probabilities adjusted for 9 dynamic regressors

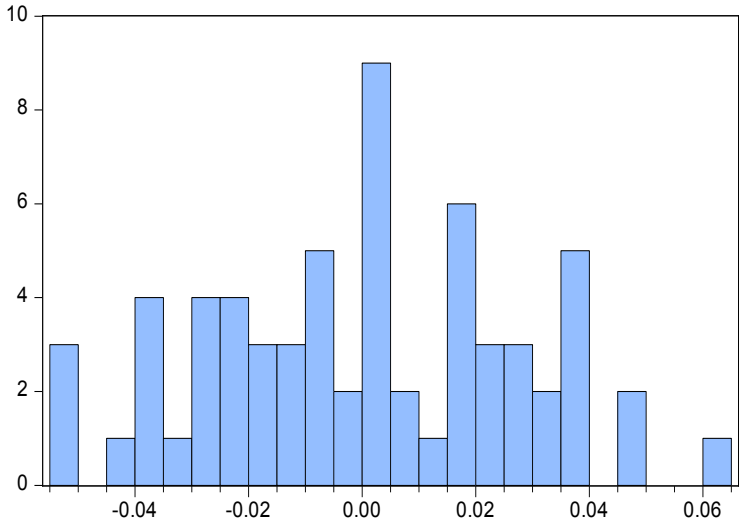
Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob*
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. .	. .	1	-0.106	-0.106	0.7548	0.385
. .	. .	2	0.001	-0.011	0.7548	0.686
. .	. .	3	-0.003	-0.004	0.7554	0.860
. *	. *	4	0.081	0.081	1.2201	0.875
** .	** .	5	-0.237	-0.224	5.2525	0.386
. *	. .	6	0.085	0.043	5.7727	0.449
. *	. *	7	0.157	0.178	7.5937	0.370
. .	. .	8	-0.109	-0.095	8.4824	0.388
. .	. .	9	0.007	0.022	8.4867	0.486
. .	. .	10	0.029	-0.025	8.5541	0.575
. .	. *	11	0.071	0.085	8.9517	0.626
. .	. .	12	-0.091	0.003	9.6279	0.649
. *	. .	13	0.080	-0.003	10.155	0.681
. .	. .	14	-0.061	-0.063	10.473	0.727
. .	. .	15	-0.100	-0.103	11.343	0.728
. .	. *	16	0.049	0.077	11.555	0.774
. .	. .	17	-0.037	-0.072	11.678	0.819
. .	. .	18	-0.036	-0.047	11.795	0.858
. .	. .	19	-0.105	-0.114	12.836	0.847
. .	. .	20	0.068	-0.009	13.283	0.865
. .	. .	21	-0.156	-0.083	15.680	0.787
. *	. *	22	0.120	0.092	17.130	0.756
. .	. .	23	-0.033	-0.041	17.241	0.797
. *	. *	24	0.113	0.089	18.598	0.773
. .	. .	25	-0.055	0.024	18.926	0.801

.  *.		.  *.		26	0.173	0.162	22.245	0.675
.  .		.  .		27	-0.052	0.004	22.557	0.709
.  .		.  .		28	0.007	0.021	22.562	0.755

\*Probabilities may not be valid for this equation specification.

### 5. Histogram



Series: Residuals	
Sample 1997Q1 2012Q4	
Observations 64	
Mean	5.42e-20
Median	4.34e-17
Maximum	0.061091
Minimum	-0.054927
Std. Dev.	0.027478
Skewness	-0.007955
Kurtosis	2.294600
Jarque-Bera	1.327580
Probability	0.514896

### 6. Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.788850	Prob. F(2,52)	0.4597
Obs*R-squared	1.884604	Prob. Chi-Square(2)	0.3897

Test Equation:  
 Dependent Variable: RESID  
 Method: Least Squares  
 Date: 10/10/14 Time: 05:48  
 Sample: 1997Q1 2012Q4  
 Included observations: 64  
 Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LIMPVOL(-3))	-0.022914	0.086004	-0.266426	0.7910
D(LGDP)	-0.112697	0.293872	-0.383488	0.7029
D(LRELPRICE)	0.004706	0.081823	0.057510	0.9544
D(LRELPRICE(-1))	-0.015070	0.078932	-0.190922	0.8493
D(LRELPRICE(-2))	-0.051175	0.095075	-0.538260	0.5927
LONGRUNRESID(-1)	0.142710	0.155381	0.918451	0.3626
DQ12010	-0.018700	0.048320	-0.386995	0.7003
DQ21997	0.007013	0.031252	0.224394	0.8233
DQ31999	0.009352	0.032379	0.288819	0.7739
C	0.001760	0.007605	0.231353	0.8179
RESID(-1)	-0.278063	0.221378	-1.256056	0.2147
RESID(-2)	-0.100089	0.181774	-0.550625	0.5842
R-squared	0.029447	Mean dependent var		5.42E-20
Adjusted R-squared	-0.175862	S.D. dependent var		0.027478
S.E. of regression	0.029796	Akaike info criterion		-4.021535
Sum squared resid	0.046165	Schwarz criterion		-3.616744
Log likelihood	140.6891	Hannan-Quinn criter.		-3.862067
F-statistic	0.143427	Durbin-Watson stat		2.069478
Prob(F-statistic)	0.999331			

## 7. Heteroskedasticity Test: ARCH

F-statistic	0.291840	Prob. F(1,61)	0.5910
Obs*R-squared	0.299973	Prob. Chi-Square(1)	0.5839

Test Equation:

Dependent Variable: RESID^2

Method: Least Squares

Date: 10/10/14 Time: 05:49

Sample (adjusted): 1997Q2 2012Q4

Included observations: 63 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000703	0.000145	4.849244	0.0000
RESID^2(-1)	0.069000	0.127725	0.540222	0.5910
R-squared	0.004761	Mean dependent var		0.000755
Adjusted R-squared	-0.011554	S.D. dependent var		0.000854
S.E. of regression	0.000859	Akaike info criterion		-11.25059
Sum squared resid	4.50E-05	Schwarz criterion		-11.18256
Log likelihood	356.3937	Hannan-Quinn criter.		-11.22383
F-statistic	0.291840	Durbin-Watson stat		2.012654
Prob(F-statistic)	0.591011			

## 8. Ramsey RESET Test

Equation: SHORTRUNPARSIMONIOUS

Specification: D(LIMPVOL) D(LIMPVOL(-3)) D(LGDP) D(LRELPRICE)

D(LRELPRICE(-1)) D(LRELPRICE(-2)) LONGRUNRESID(-1)

DQ12010 DQ21997 DQ31999 C

Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	0.237950	53	0.8128
F-statistic	0.056620	(1, 53)	0.8128
Likelihood ratio	0.068335	1	0.7938

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	5.08E-05	1	5.08E-05
Restricted SSR	0.047566	54	0.000881
Unrestricted SSR	0.047515	53	0.000897

LR test summary:

	Value	df
Restricted LogL	139.7327	54
Unrestricted LogL	139.7668	53

Unrestricted Test Equation:

Dependent Variable: D(LIMPVOL)

Method: Least Squares

Date: 10/10/14 Time: 05:50

Sample: 1997Q1 2012Q4

Included observations: 64

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LIMPVOL(-3))	-0.386774	0.081762	-4.730501	0.0000
D(LGDP)	1.620695	0.276683	5.857589	0.0000
D(LRELPRICE)	0.513184	0.078293	6.554639	0.0000
D(LRELPRICE(-1))	0.239831	0.076697	3.126975	0.0029
D(LRELPRICE(-2))	0.233249	0.085725	2.720885	0.0088
LONGRUNRESID(-1)	-0.549572	0.100886	-5.447478	0.0000
DQ12010	-0.217688	0.046323	-4.699307	0.0000
DQ21997	0.094956	0.036769	2.582480	0.0126
DQ31999	0.097054	0.031213	3.109392	0.0030

C	-0.009503	0.007913	-1.200922	0.2351
FITTED^2	0.271309	1.140192	0.237950	0.8128
R-squared	0.735789	Mean dependent var	0.013663	
Adjusted R-squared	0.685938	S.D. dependent var	0.053428	
S.E. of regression	0.029942	Akaike info criterion	-4.023963	
Sum squared resid	0.047515	Schwarz criterion	-3.652905	
Log likelihood	139.7668	Hannan-Quinn criter.	-3.877785	
F-statistic	14.75970	Durbin-Watson stat	2.209992	
Prob(F-statistic)	0.000000			

### 9. Recursive Residual Test

