An Estimation of long-run Export Demand Function for Papua New Guinea by employing the Multivariate Cointegration and Vector Error Correction Models

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Abstract: For the sample period annual data between 1977 to 2020 ,for Papua new Guinea , there is a long-run relationship (cointegration) between the exports , the real GDP , the PGK/USD exchange rate , the variability of the exchange rate , the consumer prices , the imports , and the money supply .Most of the aforesaid relationships or the signs of the coefficients of the variables in the cointegrating vector , after transformation into equation form are as expected from the theory .For example , the depreciation of the exchange rate of PGK /USD increases the exports ; but the increase in the variability of the PGK/USD rate decreases the exports by discouraging the exporters from the heightened uncertainty as the exporters are risk averse . The increase in the consumer prices and money supply decreases the exports. The increase in GDP has of course a positive favourable effect on the exports. Granger -causality using the Error-correction model has established that the change in natural log of the exports from Papua New Guinea are Granger-caused by the past level or the past trend of other variables in the system, namely the money supply, kina-dollar exchange rates depreciation, and the real GDP., the consumer prices and the variability of the exchange rate.

Key words: C1 (Econometric and Statistical Methods), F14(empirical studies of Trade), F4 (macroeconomic Aspects of International Trade and Finnane)

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1. INTRODUCTION

In 2022, 40.5% of Papua New Guinea's GDP in purchasing power parity (PPP) came from exports. This compares to 33.7% in 2021, suggesting a relatively increasing reliance on products sold on international markets for the country's total economic performance. Overall Papua New Guinea achieved an estimated US$8 billion trade surplus for 2023, falling by -29.6% from the $11.3 billion in black ink one year earlier in 2022. The Papua New Guinean product shipments represent positive net exports or a trade balance surplus. This research paper investigates the importance of the exchange rates (PGK/USD), the variability of the exchange rate, the role of GDP, imports, and the domestic consumer prices, and money supply in the determination of total exports of Papua New Guinea.

The general consensus in the literature is that the domestic exchange rate depreciation will increase both the supply and the demand for the exports. However, the effect of the variability of the domestic exchange rate is uncertain. If the exporters are risk averse, generally the increase in the variability of the exchange rate will discourage the exporters and will decrease the exporters. But, if the exporters are risk lovers, increase in the variability of the exchange rates may increase the exports. The 'export led growth' hypothesis points out that the exports will lead to the GDP growth. However, a higher GDP can as well increase the exports due to a bigger domestic market and the creation of the external economies of scale. Similarly, increasing the domestic consumer prices can increase the real exchange value of the domestic currency and can reduce the exports. Also, how the increase of imports will affect the exports is an interesting issue. All the foregoing research issues are investigated with long -term time series annual data, and by employing the recent Time series research techniques of Cointegration and Vector Error-Correction models, in this paper.

2. METHODOLOGY

We have implemented the Unit Root methods (Dickey, 979.) for the study.

2.1 Cointegration and Vector Error Correction models **(**Johansen, 1988.) and (Bhaskara, 1994). The unit root processes $\{q_t\}$ and $\{f_t\}$ will be cointegrated if there exist a linear combination of the two-time series that is stationary.

2.2 Modelling of the variability or the volatility of the exchange rates through GARCH methods:(Results are given in Supplementary Table no.1)

Among the most common specifications are: the standard deviation, moving average of the standard deviation, and the conditional variance specified by the squared residuals of ARIMA (Autoregressive Conditional Heteroskedasticity processes, ARCH, Engle, R., 1982; Generalized ARCH, GARCH, Bollerslev, 1986 or some variant GARCH) represented as follows:

$$yt = \delta 0 + \sum \delta i \; . \; yt{-}i \; k \; i{=}1 + \varepsilon t \; ; \quad \varepsilon t{\sim}N(0, \sigma t \; 2) \tag{1}$$

$$GARCH(p, q){:}\; \sigma t \; 2 = \alpha 0 + \sum \alpha i \; . \; \varepsilon t{-}i \; 2 \; q \; i{=}1 + \sum \beta i \; . \; \sigma t{-}i \tag{2}$$

3. EXCHANGE RATES AND MONETARY POLICY DEVELOPMENTS IN PAPUA NEW GUINEA

The PGK was introduced in 1975 when it replaced Australian dollar (AUD) the national official currency. The PGK has been until very recently mostly a free-floating currency whose value fluctuated on demand and supply.

In the past decade, the PGK has depreciated against the US dollar (USD) from roughly 2.50PGK per USD in 2009 to about 3.50PGK per USD in the year 2020. Papua New Guinea's inflation has averaged about 5.50% between 2009 and 2019, while per capita gross domestic product has only just grown under 3 % during the

same period. The exports mainly consist of commodities such as gold, copper, coffee, oil, and the liquified natural gas (LNG).

There have been three major natural resource booms since 1970s. The first took place between 1971 and 1977. PNG's economy expanded rapidly during this boom and nominal exchange rate depreciated by about 10 %. The second boom ended by 1995 and followed by financial crisis and increased fiscal deficits. Kina was devalued by 12% against the US dollar in September 1994, and the Kina floated thereafter.

3.1 Floating exchange rate regime of Papua New Guinea (1994-2013)

The floating of the kina exchange rate resulted in a significant depreciation in the nominal exchange rate, averaging 14.0 per cent annually in two years from mid-1994 to mid-1996, and significantly dropped to an annual depreciation rate of 2.8 per cent in the second half of 1996. (Tumsok, 2019)).The floating of the kina coupled with the liberalisation of wage indexation policy in 1992 meant that the economy became more flexible than it had been since independence. This provided the scope for real wages to fall, stimulating a positive response from employment levels. Although real exchange rate initially declined by around 25 per cent up to mid-1995, subsequent depreciations in the real exchange rate were largely offset by rising domestic inflation fuelled by imported prices. As a result, real exchange rate remained fairly elevated afterwards. The managed floating exchange rate regime generally assisted growth in the export sector, supported by a broad-based increase in the international commodity prices. This was the period of marked growth in the overall economy which was largely export-driven. Overall level of imports over this period which typically follows aggregate domestic demand conditions also increased. As a result, the country recorded positive trade balances over the large part of the period.

It was not until the Global Financial Crisis (GFC) of 2008 and 2009 that PNG's export sector was adversely impacted as foreign demand and price for PNG's export commodities fell. In addition, with the transmission of higher imported inflation to domestic economy, real exchange rate remained appreciated. Subsequent to GFC, international export commodity prices recovered, contributing to increased export earnings. This combined with the increased capital inflows associated with the construction of the multi-billion-dollar LNG gas project led to a further appreciation of the exchange rate both in nominal and real terms. Over the same period, the trade balance turned negative mainly reflecting the significant increase in imports emanating from the LNG project which more than offset the increase in exports. At the end of 2012, the general decline in the international commodity prices had an adverse impact on export revenue, resulting in an increase in the trade deficit. This led to the shortage of international reserves in the foreign exchange market. Meanwhile, the nominal exchange rate also declined thereafter following the imbalance in the foreign exchange market, although the real exchange rate remained broadly elevated as the nominal kina depreciation pressure was partly offset by exchange rate pass-through effect on domestic inflation. There was a turnaround in the trade balance in the second half of 2014 due to the start of LNG exports. However, the earnings from the project was held offshore to meet project liabilities in accordance to the Project Development Agreements (PDAs), resulting in the overall balance of payments to be in deficit thereafter

The third major natural resource boom occurred during 2002 to 2012 period, during which the commodity prices boomed and the kina appreciated. A lot of liquified natural resources (LNG) was planned to boost the export revenues. However, after 2012 the commodity prices declined and the government fiscal deficits increased much. Papua New Guinea has neither a purely fixed currency nor a purely floating currency. Before 2013the interbank rate was set by trades between PNG's banks, whereas after 2013 it has been set by fiat by the Central Bank. This is also consistent with the reduction of volatility in the exchange rates after 2013, and the increase in excess demand for foreign exchange. The recent regime of exchange rate is also known as 'crawling peg'. In June 2014, Bank of Papua New Guinea (BPNG) imposed a narrow FX trading band to bring the markets rates closer to official rates, leading to immediate appreciation in the USD/Kina market rate. The trading band is linked to official rate so that the rates are not allowed to change by more than 75% of the official band. Thus, the floating exchange regime is said to be changed to 'crawling peg'. Generally, the real exchange rate appreciated in PNG after 2012 due to increased inflation rates compared to trading partners.

3.2 Crawl-like exchange rate regime of Papua New Guinea (2014-2017)

The accelerated depreciation of kina due to the imbalance in the foreign exchange market after 2012 prompted the Bank to increase its intervention in the foreign exchange market to stabilise the exchange rate, thus, running down on its foreign exchange reserve holdings. This persistent foreign exchange market shortage distorted the relationship between the official interbank foreign exchange rate and the market exchange rates5. This distortion of the price setting mechanism of the foreign exchange market implied that exchange rate was not set by market forces but was instead dictated from the supply-side of the market. Consequently, the margins of the market exchange rates also increased significantly reflecting immense downward pressure exerted on exchange rate and rate of depletion of the foreign exchange reserves. This posed a major threat to inflation and overall macroeconomic stability. As part of the correction to the price setting mechanism and additional support to the stabilisation of exchange rate, the central bank introduced an exchange rate trading margin in the foreign exchange market on the 4th of June 2014. The exchange rate trading margin restricted the authorised foreign exchange dealers to transact with each other within a width of 150 basis points around the official interbank exchange rate.

The exchange rate policy caused an immediate de facto appreciation of 17.0 per cent in the kina exchange rate, and hence, realigned the market exchange rates with the official interbank exchange rate. The magnitude of the spread was immediately reduced and the pace of depreciation in the nominal exchange rate was largely slowed thereafter. Exchange rate volatility, consequently, was highly reduced reflecting very high stability and rigidity in the kina exchange rate.

The imposition of the exchange rate trading margin policy reduced high exchange rate volatility and effectively shifted the exchange rate regime from the managed float to 'crawllike' arrangement (IMF, 2015). The IMF argued that this exchange rate policy restricted much needed flexibility for exchange rate to adjust according to market fundamentals to correct the imbalance in the foreign exchange market (IMF, 2015). On the other hand, the BPNG views this as a market correction and a precautionary measure. Hence, removing the trading margin would otherwise lead to high inflationary pressure and the depletion of foreign exchange reserves which would be drastic for the economy. It would definitely lead to more exchange rate variability which may not be even good for exports

3.3 Very Recent changes in the exchange rate policy of Papua New Guinea in consultation with the IMF

The IMF approved PNG Government's request for US$918 million loan under the Extended Credit Facility and the Extended Fund Facility program on 22 March 2023. The program aims to protect the domestic economy against shocks and promote inclusive growth over a period of 38 months. Specifically, the program focuses on three policy reforms: (i) strengthen debt sustainability through sustained fiscal consolidation; (ii) improve operational framework of the Central Bank to reduce excess liquidity, remove exchange rate restriction and alleviate foreign exchange shortage; and (iii) enhance governance and operationalise the anti-corruption framework. Under the loan arrangement, the IMF has proposed to relevant government agencies to implement these policy reforms starting at the end of June 2023. (Wangi, 2023)

IMF (2023) stated that the Kina is overvalued in real terms under the current foreign exchange rate regime. Particularly, the Kina exchange rate exceeds the price the open market is willing to pay. The overvaluation has led to foreign exchange shortage and consequent rationing. In order to address the backlog of foreign exchange orders, the IMF has proposed to the Central Bank to remove the trading band of the Kina and adopt a flexible exchange rate regime. This proposed policy intervention is expected to cause an exchange rate depreciation due to weak demand for Kina in the foreign exchange market. The depreciation may address foreign exchange shortage through increased exports and foreign investments but can also generate high prices for imported goods and services. This period may result in the more volatility of the exchange rates. However, very recent period is not in our sample frame as our research was completed two years ago. But we study the effects of the exchange rate depreciation and the variability of the exchange rates separately in our following research.

4. PREVIOUS STUDIES ON THE ESTIMATION OF THE EXPORT DEMAND FUNCTIONS

Tumsok et al., (2019) have estimated the import and export demand functions for Papua New Guinea with the quarterly data from 1995 Q1 to 2017 Q 4. They have used the Autoregressive Distributed lag model (ARDL), also known as the bounds test approach. They have used a moving average standard deviation method of 4 to 10 quarters to model the volatility of the PGK/USD exchange rate. Their main finding regarding the exchange rate volatility and the export is that in the long-run exchange rate volatility, although the sign of the coefficient is as expected negative, is not statistically significant. But their short-run coefficients (variable in difference form) tell us that the exchange rate volatility is positive and therefore increasing the exports. However, with a lag one the difference in exchange rate volatility is negatively and significantly affecting the exports. As a whole, their conclusion about the effect of the exchange rate volatility on the exports in Papua New Guinea is inconclusive.

This is in our view due to the method that they have used to model the exchange rate volatility as a moving standard deviation, and also because they have used the real exchange rate volatility rather than the nominal exchange rate volatility of the exchange rate. However, their other findings are interesting and substantial: the export demand is influenced mainly by other fundamental factors including foreign income, relative export price level and the real exchange rate level. A one per cent increase in foreign income would result in a 3,38 per cent increase in export demand, whereas a 1 per cent increase relative export price level and real exchange rate would result in a 1.29 per cent 0.95 decline in export demand respectively and they are both important determinants of the exports from Papua New Guinea.

Miranda et al., (2017) have estimated the impact of real exchange rate volatility (RER) on exports, for a set of countries: Uruguay, Brazil, Chile and New Zealand, selected as commodity exporting countries. RER volatility was modelled as GARCH process (Generalized ARCH, GARCH, Bollerslev, 1986 or some variant GARCH). In the case of Brazil, Chile and New Zealand, they did not find evidence of RER volatility on imports and exports. In the case of Uruguay, the impact of RER volatility was significant on exports.

Miranda et al., (2017) analysed of how the RER volatility affects both negatively and sometimes positively the exports is really illuminating: “The main argument is as follows: greater exchange rate volatility leads to higher costs for riskaverse traders which implies less foreign trade. This is because the exchange rate is agreed at the time of the commercial contract, but payment is not made until delivery actually takes place. If changes in exchange rates become unpredictable, this creates uncertainty about the benefits and, therefore, reduces international benefits from trade. Even if hedging in the forward markets was possible, there are limitations and costs. On the other hand, other theoretical developments suggest that there are situations where you could expect volatility in the exchange rate has both negative and positive effects on trade volumes. De Grauwe, (1988) emphasized that if the impact of income effect is greater than substitution effect, this may lead to a positive relationship between trade and exchange rate volatility, which depends on the degree of exporters risk aversion.

This is because, if exporters are enough risk takers, increased exchange rate volatility raises expected marginal utility of increased export earnings and thus induces them to increase exports.”

Narayan et al., (2007) have investigated the ‘export the ‘export led growth hypothesis ‘for Fiji and Papua New Guinea. For Fiji the annual data are from1960 to 2001, and for Papua New Guinea, the annual data are from 1961 to 1999. They found the variables are non-stationary and therefore used the ARDL or bounds test of cointegration and found that there is cointegration between the exports, the imports, and the GDP for both Fiji and Papua New Guinea. However, they found cointegration for Fiji, they found significant F statistics for cointegration when GDP is taken as the dependent variable, and for PNG when the import is taken as dependent variable only.

Then they have used the Granger causality test with the error correction factor as a variable, which is a correct method. Beginning with the long run results, in the export and import VECMs the coefficient on the lagged error correction term is significant in the GDP equation at the 1 percent level with the correct sign. This implies that in the exports and imports VECMs, changes in income are a function of disequilibrium in the cointegrating relationship, but this is not the case for changes in exports and imports. For instance, when exports and imports are in turn dependent variables, we do not find any evidence for cointegration; hence, ruling out the possibility of any long-run causation. In the case of PNG, long run causal relationship exists between imports, exports and GDP.

In the VECM where import is the dependent variable, the coefficient on the lagged error correction term is significant at the 1 percent level with the correct sign. This implies that that in the long run exports and GDP Granger cause imports with causality running interactively through the error correction term. In the short-run, in the case of Fiji there is no evidence of any causal relationship among exports, imports and GDP. However, in the case of PNG, there is evidence of bi-directional causality between exports and GDP, and unidirectional causality running from imports to exports. So, their conclusion is that in the case of both Fiji and Papua New Guinea, the export led growth hypothesis is supported and hence the important role of the exports and imports in those small island's economies.

Jones et al., (2010) have used a single-equation export demand function is used to estimate the disaggregated export price and income elasticities, which are compared with the estimated aggregated elasticities. We use quarterly trade data from 1994 to 2006 and apply the Engle and Granger (1987) twostep co-integration procedure to estimate the export demand elasticities. The coefficient for the relative price variable indicates that a 1 per cent increase (decrease) in the relative price of mineral and petroleum exports would result in an approximately 0.3 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, 1999). The low-price elasticity of demand is plausible for a number of reasons. First, as goods such as copper, gold and crude oil are likely to have few or no substitutes, cross-price elasticities are likely to be low.

Own-price elasticities are likely to be low due to 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 contracts (DFAT 2004). Such arrangements would result in a low responsiveness to price, particularly if importers hedged against foreign exchange risk. The insignificance of the income variable could be a result of several factors. First, Australia's real GDP might not be an adequate proxy for the income movements of Papua New Guinea's mineral and petroleum importers. The statistically significant error-correction term reaffirms the validity of the co-integration results. The highly significant income variable suggests that export volumes exhibit a high level of income elasticity with a 1 per cent increase (decrease) in world GDP resulting in a more than 3 per cent increase (decrease) in export volumes. In the long-term, export volumes are explained predominantly by movements in world real income and relative prices. It was found that divergence from this long-run equilibrium path for farming, forestry and fishery exports and mineral and petroleum exports is corrected at a rate of approximately 80 per cent per quarter. It was also found that total exports were determined in the longterm by world income, with any departure from the long-term path being corrected at approximately 54 per cent per quarter. For the non-mineral sector, the positive price elasticity suggests that exporters will react strongly to price signals. The income inelasticity suggests that world demand for Papua New Guinea's non-mineral exports has grown more slowly than world real income growth and that the sector can serve as a viable long-term driver of economic growth only while exporters can sustain price competition.

5. DATA AND VARIABLES

The annual data cover a long-time span from 1977 to 2020 collected from the World Bank Economic Outlook, and the Bank of Papua New Guinea Quarterly Economic bulletins.

- 1 ln Money supply: The natural log of the broad money supply data
- 2 ln Kina-USD exchange rate: The natural log of the Kina /USD rate from 1977 to 2020. The rate is for one USD; how many Kinas are exchanged. This means if this exchange rate increases, kina value depreciates. It is interesting to note that until 1985 Kina was more valuable than US dollar: for one US dollar less than one kina was offered. After 2016 Kina depreciated much though real exchange rates are still higher.
- 3 ln CPI: The natural log of the Consumer Price Index. This is considered as a proxy for inflation. The Consumer Price Index represents the purchasing power of Kina.
- 4 ln GDP: The natural log of the Gross Domestic Product of Papua New Guinea in real terms RGDP.
- 5 ln Exports: The exports from Papua New Guinea annually in PGK currency
- 6 ln Imports: The imports from Papua New Guinea annually in PGK currency

GARCH 03: The series of the variability of the PGK/USD exchange rates which models the variability or the volatility of the exchange rate from ARCH -GARCH Time series modelling which are reported in the Table.

6. DISCUSSION OF RESULTS

6.1 Unit root results

All the variables are found to be non-stationary at the level form and found to be stationary at the first difference form. They are found to be significant at 1% level with first difference and unit root hypothesis is rejected (Table 1).

6.2 Cointegration Analysis

Testing of the cointegration between non stationary variables is in order. Johansen-Julius (1988) multi-variate cointegration procedure was used by us and the results are reported in Table 2. The Eigen value and Trace Statistics clearly show that there is at least one cointegrating vector. There is a linear combination of the random variables or a long run relationship exists among the non-stationary variables.

PGK/USD exchange rate when read in an equation form is having the positive sign and statistically significant at 5 per cent level. This implies as expected in theory when the kina depreciates in value the exports from Papua New Guinea increases (the number of Kina for a US dollar increase is the depreciation of PNG Kina. Similarly, when the imports of Papua New Guinea increases, the exports also increases and the coefficient is statistically significant at 1 per cent. This supports the trade liberalization argument that the imports of raw materials and machines will promote exports.

But the variable GARCH03, the proxy for the variability of the PGK-USD exchange rates has a very significant negative sign. This implies as expected in theory, the exchange rate volatility discourages the exports. The uncertainty of the exchange rate is bad for the exports.

Finally, as expected the real GDP growth in Papua New Guinea is very positive to export growth and the sign is positive when transformed and read in an equation and is statistically significant at 1 per cent level.
But the adjustment matrices between the variability of exchange rate (GARCH03) and the exports from the PNG is significant and it implies a definite causal relationship between the exports and the variability of exchange rates; The variability of exports negatively affect the exports from PNG.

Table 2 also provides the cointegrating vector and their signs of the variables and the adjustment matrices of the cointegrating vector from the short-run to the long-run equilibrium. The adjustment matrices show that the exports from short-run too long-run adjustment takes time and adjusts slowly and is significant only at 10 per cent. The adjustment matrices between kina- USD dollar is significant at 1 per cent level, and therefore they have definitely Granger causality between the PGK Kina / USD exchange rate, and the long-run exports from Papua New Guinea.

The adjustment matrices between the imports of PNG and the exports of PNG are not statistically significant and the long-run adjustment may take long-time. The adjustment matrices between the real GDP and the exports from Papua New Guinea are highly significant at 1 Per cent level, and therefore the exports reach its long-run equilibrium and there is definite causal relationship between real GDP and exports of PNG. Similarly, the adjustment matrices between the consumer price index and the exports are highly significant at 1 per cent level. The exports reach a long-run equilibrium from shocks in the consumer price. The consumer price increase will negatively affect exports. The adjustment matrices between the money supply and the exports are significant at 10 per cent. There is also causal relationship as higher inflation discourages the exports.

6.3 Vector Error Correction model

As the variables are cointegrated, and are integrated of the order one, the Granger causality is tested in the VECM model in a different way. When variables are cointegrated, the past level of a variable, say, Y, may influence the current changes in another variable, say, X. When variables are not cointegrated Granger causality tests the influence of past changes in Y on current changes in X. A consequence of the error-correction model (VECM) is that either Δ X or Δ Y or both must be caused by the Error-correcting term Z_{t-1} which itself is a function of $X_{t-1,}$ $Y_{t-1.}$ Thus, either X_{t-1} is caused by Y_t or Y_{t+1} is caused by X_t. More specifically, this alternative to Granger causality test considers the possibility that the lagged level of a variable y, may help explain the current changes in another variable x, even if past changes in y do not, when two variables have a common trend or when they are cointegrated. Therefore, we have gone for the Error correction modelling and the results reported in Table 4.

In the error-correction model where the change in natural log of the export is taken as the dependent variable , the sign of the error correcting factor negative and lies between zero and minus one ,though it is not statistically significant .The foregoing results corroborate that the changes in the export from Papua new Guinea are Granger caused by other variables in the cointegrating vector , namely the natural log of the money supply , the natural log of the kina-dollar exchange rates , and the natural log of the GDP , the variability of the PGK Kina-US dollar exchange rates , and the natural log of the consumer price index .

The signs of the variables, after conversion into an equation, are as predicted by the theory: the money supply has the expected negative sign, the kina -dollar exchange rate has the expected positive sign, and the real GDP has the expected positive sign, and the variability of the kina – USD exchange rate has the negative sign on exports. This is also a test of Granger -causality using the error-correction model through which it is established that the change in natural log of the exports from Papua New Guinea are Granger-caused by the other variables in the system, namely the money supply, kina-dollar exchange rates depreciation, and the real GDP., the consumer prices and the variability of the exchange rate

These results broadly corroborate the hypothesis that the changes in the long-run of the exports of the Papua New Guinea are caused by the real GDP positively, and also positively by the exchange rate depreciation; but negatively by the variability of the exchange rates, and the also negatively by domestic consumer price increase and increase in the money supply by the excess money supply. Even the short-term coefficients point out that increase in consumer prices and the money supply reduce exports.

6.4 Variance decomposition analysis

As shown in Table no.5 the variance decomposition results show that one standard deviation shock in ln export produces shocks of only 2 percent in real GDP in 2nd and third year, and around 4 percent in consumer prices in near 2 to 3 years. But it is interesting to note that one standard deviation shock in PGK / USD exchange rate produce around 53 to 57 per cent variation in exports from 2nd year 10th year. This establishes the importance of exchange rates on the exports of Papua New Guinea. However, the effect of the shock of exchange rate on the imports of Papua New Guinea are of less magnitude of around 5 per cent until 10th year.

One standard deviation shock in imports produce around 30 per cent shocks on exports and 20 per cent shocks on the exchange rate on an average from period 1 to period 10. This shows that imports are closely associated with exports and exchange rates in Papua New Guinea. One standard deviation shock in the variability of the PGK/USD exchange rate causes around 20 to 60 per cent variance in the exports, and cause 30 per cent shocks in the imports for only first 3 periods. One standard deviation shock in real GDP causes considerable variations in the exports and the exchange rates and even the imports for various periods. One standard deviation shock in the consumer prices cause considerable variations in the exports. It shows that the inflation of consumer prices will negatively affect exports magnitude in ln kina-dollar exchange rates .It corroborates the purchasing power parity theory that increases in consumer prices cause the depreciation of the domestic currency .

One standard deviation in the money supply produces significant shocks in the ln consumer price ,and ln kina -dollar exchange rates .This also corroborates the monetarist hypothesis that the money supply is really important variable in the Papua New Guinea in causing inflation , and exchange rate depreciation .Similarly ,one standard deviation in ln exchange rate has significant effect on consumer price and the money supply .

GDP shocks also significant effect on ln consumer prices. ln exchange rates. The shocks on exports are around 40 per cent, and on the exchange rate around 20 per cen. Therefore, in Papua New Guinea negative GDP shocks also cause price shocks.

Similarly, it is interesting to note that one standard deviation shock in the money supply produces considerable shocks in the exports, real GDP, and the variability of the PGK-USD exchange rates. The money supply is an important variable affecting shocks in the exports.

6.5 Impulse response function

As shown in Table no 6 the impulse response function results show that the positive shocks in the exports produce negative shocks on the exchange rates. The negative shock on exchange rate is an appreciation of the PNG Kina currency. However, positive shocks in the PNG/USD exchange rates produces negative shocks on both exports and imports. This may be mostly due to the fact that shocks in exchange rate may be the increase in the volatility of the exchange rates rather than the positive increase of the exchange rate or the depreciation of the PGK/ USD exchange rate .The one standard deviation shock in the variability of the exchange(GARCH 03) rate produces negative shocks in the exports .One standard deviation in real GDP has positive shocks on the exports and the positive shocks on the exchange rates . But a positive shock on the exchange rate is the depreciation of the PGK/USD (Kina) rate. One standard deviation shock has negative impulses continuously on exports , and it has positive impulse on the imports .The foregoing impulses from the consumer prices which is positive on the exports and negative on imports is as expected from a theoretical perspective.

Interestingly, one standard deviation shock in consumer prices has negative impulses on the money supply for the subsequent periods. . Though apparently the foregoing impulse on the money supply seems strange, it can be explained by the fact that the consumer price inflation may produce restrictive monetary and money supply policy for the subsequent periods. But one standard deviation shock in money supply produces the positive shocks on the consumer prices for the subsequent periods.

7. CONCLUSIONS

For the sample period annual data between 1977 to 2020 for Papua new Guinea, there is a long-run relationship (cointegration) between the exports, the real GDP, the PGK/USD exchange rate, the variability of the exchange rate, the consumer prices, the imports, and the money supply. Most of the aforesaid relationships or the signs of the coefficients of the variables in the cointegrating vector, after transformation into equation form are as expected from the theory. For example, the depreciation of the exchange rate of PGK /USD increases the exports; but the increase in the variability or the volatility of the PGK/USD rate decreases the exports by discouraging the exporters due to the heightened uncertainty. The increase in the consumer prices and inflation decreases the exports. The same is the effect of the increase in money supply which produces more inflation and decreases the exports. In our earlier study Paul, et al., (2023) it was established that the money supply and consumer prices are cointegrated and the money supply causes consumer price increase for Papua New Guinea for the same sample period 1977 to 2020. Here we establish that an anti-inflationary monetary policy will increase exports from Papua New Guinea as inflation will reduce the export demands from Papua New Guinea. The increase in GDP has of course a positive favourable effect on the exports. The increase in the size of the economy is favourable to the exports. The increase in imports will not reduce the exports and in most cases the increase in imports is associated with increase in exports. Granger -causality using the Error-correction model has established that the change in natural log of the exports from Papua New Guinea are Granger-caused by the past level or the past trend of other variables in the system, namely the money supply, kina-dollar exchange rates depreciation, and the real GDP., the consumer prices and the variability of the exchange rate .In simple words , it means the exports are caused by the other variables described in the system .

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Supplementary Tables Models the variability/ volatility of the PGK/USD exchange rate

Dependent Variable: LN_EXCHANGE_RATES
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 08/12/21 Time: 07:55
Sample (adjusted): 1976 2020
Included observations: 45 after adjustments
Convergence achieved after 18 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: back cast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.029069	0.022746	1.277978	0.2013
LN_EXCHANGE_ RATES(-1)	0.987105	0.032231	30.62618	0.0000
	Variance Equation			
C	0.002705	0.006586	0.410684	0.6813
RESID(-1)^2	0.069737	0.167255	0.416948	0.6767
GARCH(-1)	0.666678	0.754339	0.883790	0.3768

R-squared	0.972579	Mean dependent var	0.490207
Adjusted R-squared	0.971941	S.D. dependent var	0.613129
S.E. of regression	0.102703	Akaike info criterion	-1.575733
Sum squared resid	0.453563	Schwarz criterion	-1.374993
Log likelihood	40.45400	Hannan-Quinn criter.	-1.500899
Durbin-Watson stat	1.020402		

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Table No.1 Unit Roots Test Results

Note:
Null hypothesis: unit root (assume common root process). Asterisk *** and ** indicate significant at 1% and 5% level respectively. The p- values are estimated from one-sided standardized normal distribution. The common lag length is chosen based on SIC and is in bracket ( ). Mackinnon probability (1999) is on

variables	Level	1st difference	Decision	Integration
Nominal exchange rate Ln Exchange Rates	-2.650804 (0.2613)	***-3.737897 [0.0300] (03)	Not stationary at level but stationary at 1st difference	I(1)
Domestic price inflation , Ln(CPI)	-1.268995 [0.8826]	-4.214862***- [0.0092]	Not stationary at level but stationary at 1st difference	I(1)

		(0)		
Ln Money Supply	-1.021907 (0.7373)	-5.265153 (0.0005)	Not stationary at level and stationary at 1st difference	I (1)
Ln GDP	0.265430 [0.9738]	-6.251953 [0.0000] (0)	Not stationary at level but stationary first difference	I(1)
D(GARCH03)	-2. 140085 (0.5089)	-11.09425 (0.0000)	Non-Stationary at level and stationary in difference	1(1)
ln Exports	-1.094344 (-1.094344) 0.7096	-5.513802 (0.0000)	Non-Stationary in level form and stationery in difference	1(1)
ln Imports	-0.997974 (0.7462	-5.376359 (0.0001	Non stationary in level form and stationary in difference form	1(1)

Table 2

				Cointegration	**Tests**
Null hypothesis	Alternative hypothesis	Eigen-values	Maximum Eigen statistics λ_{max}	0.05 Critical Value	Probabilities
$r = 0$	$r \geq 1$	0.741838	54.16664**	42.77219	0.0019
$r \leq 1$	$r \geq 2$	0.597122	102.8088	83.93712	0.0011
$r \leq 2$	$r \geq 3$	0.471963	66.44396	60.06141	0.0131
			Trace statistics λ_{trace}		
$r = 0$	$r = 1$	0.741838	54.16664	42.77219	0.0019
$r \leq 1$	$r = 2$	0.597122	36.36485	36.63019	0.0537
$r \leq 2$	$r = 3$	0.471963	25.54357	30.43961	0.1804

Note: Cointegration Table

Asterisk ** and *** rejection of null hypothesis by 5% and 1% respectively. *Probabilities are calculated using MacKinnon-Haug-Michelis (1999) p- values

Date: 08/12/21 Time: 08:44

Sample (adjusted): 1978 2020

Included observations: 40 after adjustments

Trend assumption: No deterministic trend

Series: LN_EXPORTS EXCHANGE_RATES_PGK_USD LN_IMPORTS GARCH03 LN_REAL_GDP LN_CONSUMERPRICE LN_MONEY_SUPPLY
Lags interval (in first differences): 1 to 1

Table 3

1 Cointegrating Equation(s):		Log likelihood	478.6067	
Normalized cointegrating coefficients (standard error in parentheses)				
LN_EXPORTS	EXCHANGE_RATES_PGK_USD	LN_IMPORTS	GARCH03	LN_REAL_GDP
1.000000	-0.362983	-0.718156	10.23183	-2.179724
	(0.19934)	(0.33970)	(1.73514)	(0.81402)
Adjustment coefficients (standard error in parentheses)				
D(LN_EXPORTS)	0.077443			
	(0.07073)			
D(EXCHANGE_RATES_PGK_USD)	0.218590			
	(0.09194)			
D(LN_IMPORTS)	-0.016949			
	(0.08300)			
D(GARCH03)	-0.016270			
	(0.01109)			
D(LN_REAL_GDP)	0.038586			
	(0.00882)			
D(LN_CONSUMERPRICE)	0.061930			
	(0.01321)			
D(LN_MONEY_SUPPLY)	0.024627			
	(0.01628)			

Table No.4 Vector Error correction model

Vector Error Correction Estimates						
Date: 08/12/21 Time: 09:11						
Sample (adjusted): 1979 2016						
Included observations: 38 after adjustments						
Standard errors in ( ) & t-statistics in [ ]						
Cointegrating Eq:	CointEq1					
LN_EXPORTS (-1)	1.000000					

EXCHANGE_RATES_PGK_USD (-1)	-0.448213						
	(0.07460)						
	[-6.00782]						
LN_IMPORTS (-1)	-0.575274						
	(0.08440)						
	[-6.81644]						
GARCH03(-1)	9.628660						
	(0.80090)						
	[12.0223]						
LN_REAL_GDP (-1)	-6.424870						
	(0.36566)						
	[-17.5705]						
LN_CONSUMERPRICE (-1)	0.446052						
	(0.12348)						
	[3.61230]						
LN_MONEY_SUPPLY(-1)	3.760008						
	(0.31815)						
	[11.8185]						
C	24.22962						
Error Correction:	D(LN_EXPORTS)	D(EXCHANGE_RATES_PGK_USD)	D(LN_IMPORTS)	D(GARCH03)	D(LN_REAL_GDP)	D(LN_CONSUMERPRICE)	D(LN_MONEY_SUPPLY)
CointEq1	-0.141135	0.228071	0.002949	-0.183607	0.036389	0.065173	-0.165504
	(0.48054)	(0.53115)	(0.48349)	(0.05813)	(0.05713)	(0.08481)	(0.10705)
	[-0.29370]	[0.42939]	[0.00610]	[-3.15871]	[0.63699]	[0.76850]	[-1.54602]
D(LN_EXPORTS(-1))	-0.036467	-0.318662	-0.365774	0.139937	-0.115030	-0.191871	0.192755
	(0.57665)	(0.63738)	(0.58019)	(0.06975)	(0.06855)	(0.10177)	(0.12846)
	[-0.06324]	[-0.49996]	[-0.63044]	[2.00618]	[-1.67800]	[-1.88539]	[1.50048]
D(LN_EXPORTS(-2))	0.328361	-0.470784	1.045921	0.169372	0.004067	-0.068271	0.298344
	(0.67413)	(0.74511)	(0.67826)	(0.08154)	(0.08014)	(0.11897)	(0.15018)
	[0.48709]	[-0.63183]	[1.54206]	[2.07708]	[0.05075]	[-0.57385]	[1.98663]

D(EXCHANGE_RATES_PGK_USD(-1))	0.002308	0.620606	-0.392641	0.062136	0.009861	0.094447	-0.051192
	(0.21517)	(0.23783)	(0.21649)	(0.02603)	(0.02558)	(0.03797)	(0.04793)
	[0.01073]	[2.60944]	[-1.81364]	[2.38730]	[0.38552]	[2.48717]	[-1.06795]
D(EXCHANGE_RATES_PGK_USD(-2))	-0.023705	-0.636627	0.346111	-0.015135	-0.038048	0.028038	-0.022366
	(0.26812)	(0.29636)	(0.26977)	(0.03243)	(0.03187)	(0.04732)	(0.05973)
	[-0.08841]	[-2.14817]	[1.28299]	[-0.46666]	[-1.19370]	[0.59254]	[-0.37445]
D(LN_IMPORTS(-1))	0.060503	-0.341530	0.151411	0.018446	-0.025829	0.057766	-0.038040
	(0.21615)	(0.23891)	(0.21748)	(0.02615)	(0.02570)	(0.03815)	(0.04815)
	[0.27991]	[-1.42952]	[0.69622]	[0.70552]	[-1.00519]	[1.51435]	[-0.79000]
D(LN_IMPORTS(-2))	0.083094	-0.264620	0.026771	-0.003455	-0.022932	0.049626	-0.004633
	(0.24615)	(0.27207)	(0.24766)	(0.02977)	(0.02926)	(0.04344)	(0.05484)
	[0.33758]	[-0.97262]	[0.10810]	[-0.11603]	[-0.78367]	[1.14239]	[-0.08448]
D(GARCH03(-1))	2.907233	-0.906187	0.207612	0.768543	-0.057099	-0.176892	0.593356
	(2.93590)	(3.24505)	(2.95391)	(0.35513)	(0.34902)	(0.51812)	(0.65404)
	[0.99024]	[-0.27925]	[0.07028]	[2.16412]	[-0.16360]	[-0.34141]	[0.90722]
D(GARCH03(-2))	1.096989	3.240116	-0.012843	0.245922	0.036527	-0.277622	0.483363
	(2.14558)	(2.37151)	(2.15874)	(0.25953)	(0.25506)	(0.37865)	(0.47797)
	[0.51128]	[1.36627]	[-0.00595]	[0.94756]	[0.14321]	[-0.73319]	[1.01128]
D(LN_REAL_GDP(-1))	3.300010	-0.426129	4.008203	-0.660207	0.780677	0.982945	-0.401705
	(3.15622)	(3.48858)	(3.17558)	(0.38178)	(0.37521)	(0.55701)	(0.70312)
	[1.04556]	[-0.12215]	[1.26219]	[-1.72929]	[2.08065]	[1.76469]	[-0.57132]
D(LN_REAL_GDP(-2))	-3.936767	4.883317	-6.843018	-0.779483	-0.155047	0.832071	-2.094287
	(4.10348)	(4.53558)	(4.12865)	(0.49636)	(0.48782)	(0.72418)	(0.91414)
	[-0.95937]	[1.07667]	[-1.65745]	[-1.57039]	[-0.31784]	[1.14899]	[-2.29099]
D(LN_CONSUMERPRICE(-1))	-2.093438	-0.104415	1.777113	0.243729	-0.189614	-0.229681	0.580873
	(1.21184)	(1.33944)	(1.21927)	(0.14658)	(0.14406)	(0.21386)	(0.26996)
	[-1.72749]	[-0.07795]	[1.45752]	[1.66271]	[-1.31620]	[-1.07396]	[2.15168]
D(LN_CONSUMERPRICE(-2))	0.231076	0.051089	-0.148352	0.049188	0.132720	-0.159285	0.226513
	(1.23132)	(1.36098)	(1.23887)	(0.14894)	(0.14638)	(0.21730)	(0.27430)
	[0.18767]	[0.03754]	[-0.11975]	[0.33025]	[0.90670]	[-0.73301]	[0.82578]

D(LN_MONEY_SUPPLY(-1))	0.969893	-1.147796	1.340441	0.295595	-0.066089	-0.503328	0.695287
	(1.81175)	(2.00253)	(1.82286)	(0.21915)	(0.21538)	(0.31974)	(0.40361)
	[0.53534]	[-0.57317]	[0.73535]	[1.34882]	[-0.30685]	[-1.57420]	[1.72269]
D(LN_MONEY_SUPPLY(-2))	-0.173550	1.057464	0.009447	0.116350	0.095844	-0.097860	0.325910
	(0.93043)	(1.02841)	(0.93614)	(0.11255)	(0.11061)	(0.16420)	(0.20727)
	[-0.18653]	[1.02826]	[0.01009]	[1.03380]	[0.86652]	[-0.59597]	[1.57237]
C	0.148070	-0.030896	-0.086811	-0.007969	0.027120	0.059607	0.008247
	(0.14099)	(0.15583)	(0.14185)	(0.01705)	(0.01676)	(0.02488)	(0.03141)
	[1.05024]	[-0.19826]	[-0.61198]	[-0.46730]	[1.61810]	[2.39566]	[0.26258]
R-squared	0.433777	0.664724	0.493149	0.728340	0.561894	0.665765	0.440555
Adj. R-squared	0.047715	0.436126	0.147569	0.543117	0.263186	0.437878	0.059116
Sum sq. resids	0.584678	0.714297	0.591874	0.008555	0.008263	0.018210	0.029016
S.E. equation	0.163022	0.180189	0.164022	0.019719	0.019380	0.028770	0.036317
F-statistic	1.123595	2.907833	1.427017	3.932232	1.881081	2.921467	1.154980
Log likelihood	25.39165	21.58715	25.15924	105.6585	106.3184	91.30468	82.45273
Akaike AIC	-0.494297	-0.294060	-0.482065	-4.718869	-4.753601	-3.963404	-3.497512
Schwarz SC	0.195213	0.395449	0.207445	-4.029359	-4.064091	-3.273894	-2.808002
Mean dependent	0.064149	0.063792	0.026460	0.001937	0.037860	0.068101	0.044692
S.D. dependent	0.167057	0.239959	0.177653	0.029174	0.022577	0.038373	0.037440
Determinant resid covariance (dof adj.)		2.83E-20					
Determinant resid covariance		6.17E-22					
Log likelihood		550.4587					
Akaike information criterion		-22.70835					
Schwarz criterion		-17.58012					
Number of coefficients		119					

The Tables for Impose response functions and the Variance decomposition are not presented in the article. However, it will be supplied to any interested reader on request