Papua New Guinea Global Trade Potential: Evidence from the Gravity Model Analysis.

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Abstract

Papua New Guinea (PNG) is the largest country and economy in the Pacific, representing 80% of the Pacific economy and population. They are starting to recover from the effects of COVID 19, but their growth outlook remains fragile due to rising uncertainties. According to the National Budget, delivered last December, PNG's economy is expected to grow by 4.0 per cent in 2023, with non-resources and resources growth at 4.6 per cent and 2.0 per cent, respectively. With the expansion of their mineral and energy exports from the last decade, they are expected to experience significant growth in total export values throughout the years to come. Apparently, there is a long historical background on the theories supporting the connections between trade and economic growth. (Romer, 1986; Lucas, 1988; Solow, 1994) all demonstrated the economic theory that openness to trade propelled economic growth. The question that we attempt to answer is whether PNG can take advantage of their trade potential as they propel into post-COVID with a promising mineral and energy sector. Using an augmented Gravity Model with Ordinary Least Squares (OLS) we attempted to investigate PNG's trade potential between 31 countries and 5 regional bodies using cross section data. OLS will be employed as an estimation technique for 1990 to 2020 data. The estimated coefficients from the gravity models are then used to predict PNG's trade potential.

1. Introduction

Improving growth and tackling high unemployment rates are among the greatest challenges for any country (Baldwin & PORTES, 1994; Söderling, 2007). While different countries use different macroeconomic approaches, this paper studies an element of arresting these – the scope of enhancing their ability to trade internationally through their trade potential initiatives. This is consistent with the notion that foreign trade plays a vital role in the process of economic development in any country.

Trade potential could refer to the maximum amount of trade that can be conducted between two countries or more countries or regions given their respective capabilities, resources, and trade policies (Baldwin & PORTES, 1994). They then measure how far above or below potential trade actual trade is. (Egger, 2002) and the others measure how far above, or below potential trade actual trade is. Egger corrects for serial correlation, uses different panel data methods to find the best specification, and then performs the simple exercise of finding the ratio of actual to potential trade. This gives a measure of how well a bilateral trade flow performs relative to the mean as predicted by the model.

PNG is the largest country by population, land mass, and economics in the Pacific. Given its size and location, foreign trade constitutes an important part of the economy of PNG. Since it is a resource rich country that exports a significant amount of natural resources such as minerals and petroleum, our intention is to find out whether they have trade potential in other areas and with other trading partners.

The PNG government has taken some very serious corrective measures by introducing policy interventions and reforms to re-establish themselves laying the foundation for a robust, competent, and sustainable economy. Since independence, their economy had been driven primarily by the extractive sector without adequate attention given to the non-extractive industries and services sector. Their overreliance on the extractive sector has left them exposed to commodity price fluctuations and global financial shocks and has led them to a situation whereby they continue to face economic and fiscal imbalances (Government Source). This led to the development of a National Trade Policy 2017-2032 and the establishment of a National Trade Office.

This paper aims to estimate trade potential for PNG using the gravity model. The gravity model is one of the most popular empirical tools for modeling bilateral trade flows. First, it will be used to analyze the world trade flows for the year 2010 to 2020. The coefficients thus obtained from the gravity model estimation are then used to predict trade potential for PNG.

The main contribution of this study is that this would be the first attempt to estimate PNG‟s global trade potential using gravity model extensively against her trading partners. Since it covers 94% of PNG global trade, it should provide a contributory role for the policy makers in particular and for the economies of PNG and its trading partners in general.

The remainder of the study is organized as follows. The next section briefly reviews PNG trade overview including the sectoral composition in trade and PNG trade to the world, analysis of the top 10 trading partners. The third section discusses the gravity model, its origin, the theoretical interface and the rationale behind the choice of the model. The fourth section discusses the survey of selected literature that have created the pathway of research in the area of trade potential. The fifth section discusses the methodology and the regression results. The sixth section outlays the trade potential for PNG via trade simulation from the coefficient and selected dependent variables and finally the conclusion with some findings and policy implications.

2. Papua New Guinea Trade Overview

The World Bank estimated that the PNG economy contracted by 3.5 percent in 2020 (refer Table 1) before returning to positive economic growth of 1 percent in 2021. Extractive sector growth was projected to be the main driver of GDP growth in 2022 at 4 percent. High commodity prices amplified this bounce-back, supporting the external accounts and providing (potentially) higher dividends to the state-owned companies that hold shares in joint projects in the resource sector.

Table 1: Key Macro-Fiscal Indicators, 2017-2014

	2017	2018	2019	2020	2021	2022	2023	2024
						est.	Projections	
GDP Growth	3.5	-0.3	4.5	-3.5	1.0	4.0	3.0	3.0
Extractive Sector	8.1	-9.2	11.3	-8.4	-6.2	6.8	2.9	3.2
Extractive Sector	0.5	4.1	1.4	-1.1	4.2	2.9	3.1	2.9
Overall Fiscal Deficit (% of GDP)	-2.5	-2.6	-5.0	-8.9	-7.6	-6.1	-4.5	-3.4
Public Debt, Net (% of GDP)	32.55	36.7	39.7	48.9	48.9	53.8	54.5	54.1
Current Account Balance (% of GDP)	28.4	24.4	22.9	21.7	21.7	23.8	22.9	22.7

Source: Author's calculation based on PNG National Statistics Office.

As stipulated in Table 1, PNG's economic performance in 2021 was constrained by falling gold and liquefied natural gas (LNG) production that resulted in a decline in extractive sector output for a second consecutive year. Despite reversing the trajectory of the widening fiscal deficit, it remained large at over 7 percent GDP. However, the projected high commodity prices amplified a bounce-back looking at the extractive sector as the main driver of GDP growth in 2022 of 4 percent.

In Table 2, the international trade has been growing from 2002 to 2012 then it started to decline. Trade picked up again 2017 but must have been affected by the dropping in global price for gold and LPG and the incoming of COVID 19 in 2020. However, the major boost in trade happened in 2011 and 2012. PNG's economy grew by 3.5% in 2012 and a whopping 9.7% in 2014. During the

same period, total trade (exports plus imports) also grew from US$6416.84 million to US$8110.53 million. The same data indicates that PNG trade to Australia also increased by 23%.

Table 2: PNG's Trade to the World

Year	PNG Trade to the World	Growth
2000	1092.21	-3.81%
2001	989.24	-9.43%
2002	1055.76	6.72%
2003	1200.71	13.73%
2004	1425.82	18.75%
2005	1800.49	26.28%
2006	2098.09	16.53%
2007	2640.20	25.84%
2008	3112.58	17.89%
2009	3457.91	11.09%
2010	4568.47	32.12%
2011	6416.84	40.46%
2012	8110.53	26.39%
2013	6253.27	-22.90%
2014	5585.54	-10.68%
2015	4988.73	-10.69%
2016	4419.46	-11.41%
2017	4544.15	2.82%
2018	4793.11	5.48%
2019	4760.34	-0.68%
2020	4144.20	-12.94%

Source: IMF DoT and Author's Calculation

Table 3: PNG's top 10 trading partners (2010-2020, cumulated)

		2010-2020 (USD million)	2010-2020 (%)	2011	2015	2020
1	Australia	20,528.86	-26.63	27.15	-34.39	-22.34
2	China	7,589.86	161.77	28.4	55.45	15.12
3	Singapore	7,322.22	-29.87	55.49	-25.64	-30.73
4	Malaysia	4,565.50	11.97	167.05	-17.82	-30.16
5	Japan	2,536.24	-46.55	10.47	-4.7	8.01
6	Indonesia	2,027.27	-9.56	98.95	27.14	-9.11
7	United States	1,881.70	-67.40	58.6	44.86	-34.4
8	Thailand	1,767.96	-9.85	44.14	8.8	-17.27
9	New Zealand	1,626.15	-17.61	21.48	-15.86	-13.27
10	Italy	681.38	40.79	447.08	-24.18	-46.87
	The World	*58,584.64*	*-9.29*	*40.46*	*-10.69*	*-12.94*

Source: Author's calculation based on IMF DoT.

Table 3 shows PNG's top 10 trading partners from the period 2010 to 2020. Here, we see that Australia has accounted for more than one third of PNG cumulative trade for the period. Despite the magnitude of trade to Australia, the PNG cumulative trade of this period declines by 26.63% (refer Table 3). Majority of her trading partners also declined in terms of volume of trade except China and Japan. China is becoming a dominant trading partner with the signing of their China - Papua New Guinea Economic and Trade Cooperation Agreement signed in 2018 during the Asia Pacific Economic Cooperation (APEC) Summit held in Port Moresby, Papua New Guinea. China's trade to PNG grew by 161% for this period, the fastest growing trading partner.

3. The Gravity Model

This model originates from the Newtonian physics notion. Newton's gravity law in mechanics states that two bodies attract each other proportionally to the product of each body's mass (in kilograms) divided by the square of the distance between their respective centers of gravity (in meters). Then (Tinbergen, 1962) formulated an empirical analysis that captured the movement of goods through bilateral trade in the area of economics. Since then, the gravity model has been reengineered in so many ways to continue to produce analytical results that trade economists need.

Now the gravity equation is a widely used empirical model in international trade that seeks to explain the bilateral trade flows between two economies. The gravity model of trade is based on the idea that gross trade volumes between two countries depend on the sizes of the two countries and the distance they are apart. This simple model has been used extensively in analyzing trade and has been successful to a high degree in explaining trade. It has enjoyed many different applications, some to test standard trade theories, others to explain trade and the effect of certain policy measures on trade volumes (Anderson & Van Wincoop, 2003).

The theoretical foundations of the gravity model as described by (Anderson, 1979), (Bergstrand, 1985), and (Helpman, 1987) started with the assumption of frictionless trade or iceberg transport costs and then, with the exception of Bergstrand, derive a model where trade volumes between country pairs are proportions of the product of incomes or total world trade. Then over the years the model has gone through significant improvement to overcome the complexities of trade and to suit individual needs. (Linnerman 1966) include other trade explanators such as population, and more importantly, complementarity. A complementarity index would reflect how the commodity compositions of two trading partners would complement each other or not. (Helpman, 1987) highlighted the value of trade loss when it comes to international border cross. There has been quite a lot discussion in the body of literature to solve the border puzzle in the gravity model. (Frankel, Stein, & Wei, 1997) further developed the model with inclusions of dummy variables to capture trade agreements and the like. Whereas, (Rose, 2005) was the first to include a common currency to explain trade.

The gravity model for trade is consistent to the classical law described by Newton. The trade flow between two countries is proportional to the product of each country's economic mass, generally measured by GDP (national income) and inversely proportional to the distance between the countries' respective economic centers of gravity, generally their capitals. This formulation can be generalized to

$$X_{ij} = \alpha Y_i Y_j / D_{ij} \quad (1)$$

where X_{ij} is the export of country i to country j , Y_i and Y_j are country i's and country j's GDPs, D_{ij} is the geographical distance between the countries' capitals and α is a constant of proportionality.

Taking the logarithm of equation (1), we get the following linear form of the model[1]:

$$ln(X_{ij}) = \alpha + \beta \ln(Y_i Y_j) + \delta \ln\ (D_{ij}) \quad (2)$$

Where α, β and δ are coefficients to be estimated. Equation (2) is the baseline model where bilateral trade flows are expected to be a positive function of income and negative function of distance. When estimated, the model gives relatively good results. However, we know that there are other factors that influence trade levels as we have discussed above.

The gravity model reflects the notion of partial equilibrium model of export supply and import demand as discussed by (Linnerman 1966). In addition to that, the model can also postulate Walrasian's general equilibrium model, with each country having its own supply and demand functions for all goods. Aggregate income determines the level of demand in the importing country and the level of supply in the exporting country as projected by (Oguledo & MacPhee, 1994).

[1] In the original version by Tinbergen (1962), the model is expressed in a log-log form, so that the parameters are elasticity of the trade flow with respect to the explanatory variables.

4. Survey of Literature

There are wide ranges of applied research where the gravity model is used to examine the bilateral trade patterns and trade relationships among two countries via bilateral or among countries through multilateral. Whatever the pattern maybe, countries are increasingly interested in their trade potentials as a step from just acknowledging their comparative advantage to trade.

Trade potential between two economies can be estimated by matching the total export supply for a given commodity (or group of commodities/products) of a country with the total import demand for that commodity of a trading partner. This has been the essence of past research as well when it comes to trade potential in the literature. In addition to this, focus has also shifted to trade barriers, regional trade agreements, types of goods and services and the like as the determinants of trade potentials in an economy. Within the model, dummy variables such as polity, distance and language were also discussed.

Majority of the work in the literature focuses on predicting the potential for trade.

(Masudur Rahman & Arjuman Ara, 2010) has estimated trade potential for Bangladesh using panel data approach on forty-nine countries with economic factors like openness, exchange rates, and so forth rather than natural factors. They found that liberalization of non-policy barriers will spur Bangladesh's trade, particularly in time of ongoing global economic and financial crisis. Improvement in infrastructure that leads to reduce trade transportation costs should be a necessary step in order to unleash Bangladesh's trade potential. One of their major findings is that a large part of Bangladesh's potential trade has remained unrealized. The estimated results indicate that Bangladesh tends to trade more with larger economies in general and with import developing economies in particular. The rising trade transaction cost is one of the major trading barriers causing high unrealization of trade potential in Bangladesh.

(Batra, 2006) developed a model to predict India's global trade potential. Using a sample of 146 countries; found that the magnitude of India's trade potential is at its highest level in the Asia-Pacific region followed by Western Europe and North America. The potential for expansion of

trade is highest with countries like China, United Kingdom, Italy, and France. The estimates indicate that India can potentially attain ten times or more the level of the actual trade with countries like Georgia, Turkmenistan, and Uzbekistan. In fact, most of the countries in the Commonwealth of Independent States (CIS) region reveal possibilities of expanding trade with India. For the region, however, the estimates show that India has exceeded its trade potential. This may be explained by the large magnitude of trade that India has with the Russian Federation.

(Söderling, 2007) attempted to quantify the scope of trade potential in The Middle East and North Africa (MENA) countries in the medium term. Employing the Gravity model with a panel data set covering 90 countries and about 90 percent of total world trade. With some of the world's most significant regional agreements within the MENA, the integration effects were also discussed, and revealed some interesting facts about the subject. This including the Mediterranean countries' total export to the EU surpassing model predictions. The US figures prominently as a major untapped export market for Jordan, Morocco, Syria, and Tunisia, while Algeria and Egypt over-export to the United States. This was also discussed earlier by (Péridy, 2004).

(Gul, 2011) attempts to estimate Pakistan's trade potential, using the gravity model of trade for the period between 1981 to 2005 across 42 countries. The results revealed that Pakistan's trade potential is highest with countries in the Asia-Pacific region (the Association of Southeast Asian Nations [ASEAN]), the European Union (EU), the Middle East, Latin America, and North America. Specifically, the maximum potential exists with Japan, Sri Lanka, Bangladesh, Malaysia, the Philippines, New Zealand, Norway, Sweden, Italy, and Denmark. The volume of trade between Pakistan and other members of the South Asian Association for Regional Cooperation (SAARC) and Economic Cooperation Organization (ECO) is very low, despite the existence of significant potential. Apart from the conventional variables of the gravity model, they also include common border, common language, and common socio-economic region as their dummy variables.

5. Data, Methodology and Model Selection, Estimation and Econometric Issues.

A. Data And Sample Size

This study has conducted a panel data analysis based on bilateral trade flows between PNG and some 31 trading partners 4 regional member countries with a time-period from 1990 to 2020. The use of panel data has several advantages over cross-sectional analysis. First, panel makes it possible to capture the relevant relationships about variables over time. Second, a major advantage is the ability to monitor the possible unobserved trading-pair individual effects. The gravity model is estimated using both fixed effects and random effects. The countries are chosen on the basis of importance of trading partnership with PNG and availability of required data. All observations are annual. Data on GDP, GDP per capita, total exports and total imports are obtained from the *World Development Indicators (WDI*) database of the World Bank, PNG National Statistics Office and the Bank of Papua New Guinea.

B. The Methodology and Model

The real-world situation is too complex to be represented by a simple equation as equation (2). The geographical size, population, trade policies, and trade transaction cost of the country are also important factors affecting exports of any country. Especially, with country like PNG, given its location, geographical size and transaction costs, there need to be more consideration given to the model so that it can produce a well-respected output. Therefore, such factors are captured by a vector of variables Z which indicate a number of dummies like regional trading arrangements, connectivity, language affinities, historical relationships, etc. ε_{ij} represents error term. Thus, the gravity equation (2) can be written as follows:

$$ln(X_{ij}) = \alpha + \beta \ln(Y_i) + \gamma lnY_j + \delta lnD_{ij} + \lambda Z_{ij} + \varepsilon_{ij} \quad (3)$$

For this model we have replicated (Frankel et al., 1997) and (Rahman, 2009) and (Batra, 2006). Given the rationale behind the trade theory, we have taken the approach of including variables such as the ratio of GDP, Per Capita GDP Differential Trade as a percentage of GDP and independent variables. We have also included dummy variables such as Remoteness of PNG from trading partners, Common Language, Regional Trade Agreements and Population.

Therefore, the specific model will then be:

$$ln(X_{ij}) = \beta_0 + \beta_1 \ln GDP_{ijt} + \beta_2 \ln PCGDP_{ijt} + \beta_3 \ln TRGDP_{ijt} + \beta_4 \ln REMOTE_{ij} + \beta_5 LANG + \beta_6 lnPOP_{ijt} + \beta_7 RTA + \varepsilon_{ijt} \quad (4)$$

The variables are explained as follow:

$ln(X_{ij})$ denoted natural log of total trade it includes net exports and imports of country i to country j in the US $. Independent variables are:

- GDP_{ijt} the log of GDP of *i* country and *j* in US$.
- $PCGDP_{ijt}$ is the log of the Per Capita GDP Differential between *i* country and *j* in US$.
- $\ln TRGDP_{ijt}$ is the log of Trade as a percentage of GDP between country *i* and *j*
- $REMOTE_{ijt}$ is the assessment of the remoteness between country i and j[2].
- $LANG_{ijt}$ is common language between country i to country j (dummy variable).
- RTA is regional trading agreement (dummy variable)
- $lnPOP_{ijt}$ is the log of Population of country *i* and country *j*

And "ε" is the error term and "*t*" denotes time duration whereas' β s are the parameters.

[2] A method frequently used to control for the multilateral resistance terms for exporting and importing countries is to include a proxy for these indexes called "remoteness". This is often calculated as:

$$REMOTE_i = \sum_j \frac{dist_{ij}}{\frac{GDP_j}{GDP_W}}$$

a formula that measures a country's average weighted distance from its trading partners (Head, 2003), where weights are the partner countries' shares of world GDP (denoted by GDPW).

C. Regression

In the first stage the gravity model equation (4) has been estimated using the OLS technique with cross-section data for the year 1990 to 2000 using Stata. The dependent variable is total merchandise trade (exports plus imports in thousands of US dollars), in log form, between pairs of countries. Stationary of series is a prerequisite before conducting any econometric work is a must for any econometric analysis. Granger and Newbold (1974) discussed in detailed the topic of non-stationarity of time series and when not handled properly, its impact on the spuriousness of regressions. Generally, the discussions are technically driven showing how different types of non-stationary data effect regression results. However, from the practical point of view, the conclusions are comparable. When all (dependent and independent) time series are non-stationary, the regression results are simply misleading.

All estimates are checked for heteroskedasticity. As suspected on the first stage of regression, the null was rejected after the first Breusch-Pagan/Cook-Weisberg test for heteroskedasticity. Even the variance of the weighted error below (assuming $LNGDP_i$ was the driving force) did not solve the issue of heteroskedasticity. However, in using the robust standard error, we were able to overcome the issue of heteroskedasticity.

Once variables have been classified as integrated of order I(0), I(1), I(2) etc. it is possible to set up models that lead to stationary relations among the variables, and where standard inference is possible. The necessary criteria for stationarity among non-stationary variables is called cointegration. Testing for cointegration is a necessary step to check if the model has an empirical meaningful relationship.

The Johansen's (1988, 1991) approach was chosen then to determine the presence of cointegrating vectors[3]. The Cointegration approach produces test statistics of trace test (λ trace) and maximum

[3]There are approached that can be used. See these reference for further readings:

- Granger C. and Newbold P. (1974). Spurious regressions in econometrics. Journal of econometrics, 2(2), pp.111-120.
- Johansen S. (1995). Likelihood based inference in cointegrated vector autoregressive models. OUP catalogue.
- MacKinnon, J. G., Haug, A. A., &Michelis, L. (1998). Numerical distribution functions of likelihood ratio tests for cointegration (No. 9803). Department of Economics, University of Canterbury.
- Dickey-Fuller test of co-integration ADF(0), from Engle and Yoo (1987). Table 2, p. 157.

Eigen-value (λ max). The distribution of both test statistics follow chi-square distribution, the main objective of using the Johansen's cointegration test is to determine the number of cointegrated vector(r), if ($0 \leq r \geq n$) is zero, it would suggest that there is no long- run equilibrium relationship among the variables. On the other hand if r is ($1<r< n$), it suggests that there are (n-r) common stochastic trends among the variables that link them together.

Table 4: Descriptive Statistics

Table 4 shows the descriptive statistics of the chosen variables from equation.

Variable	Obs	Mean	Std. Dev.	Min	Max
LNGDP	1116	49.236	2.927	40.837	55.549
LNPCGDP	1071	9.731	1.430	3.884	11.542
LNTRGDP	1116	4.266	.6432	2.741	6.092
LNPOP	1116	32.784	2.343	27.091	37.448
LNREMOTE	1116	-22.842	.8022	-25.304	-21.362
LANG	1116	.4166	.4932	0	1
RTA	1116	.2222	.4159	0	1

D. Estimates

When we selected the concerning dependent and independent variables and run the gravity regression simulating Equation 4; the results are depicted in Table 5 where all the independent variables show significant results. Table 5 reported the outcomes of regression results, which showed the impact of independent variables on the dependent variable.

- Augmented Dickey-Fuller test of co-integration ADF(4), from Engle and Yoo (1987), Table 3, p. 158..
- CRDW, ADF(1) and ADF(4), from Banerjee et al (1993), Table 7.1 p. 209.

Table 5: Regression Results

Variable	Model 4
LNGDP	0.3475***
	(0.0092)
LNPCGDP	-0.2427***
	(0.11)
LNTRGDP	0.1213**
	(0.0144)
LNREMOTE	-0.3998***
	(0.0136)
LNPOP	-0.2817***
	(0.1048)
RTA	-0.2205***
	(0.0262)
LANG	-0.1136
	(0.0176)
R^2	0.83

Source: Author's calculation based on STATA.

Table 5 also shows that if the partner countries' GDP increases by 1%, it brings a significant positive impact on PNG's total trade which will increase by 0.34%. This is in line with the notion that as income increases in partner countries, it will consequently increase the demand for imported goods. LNREMOTE is the assessment of the remoteness between partner countries; states that the further away a partner country is to PNG, trade will decrease by .39%. It means that those countries with which PNG has a close border have a high potential for trade as compared to those countries with which PNG has a large distance. The coefficient value of the Per Capita GDP Differential is negative. This reinforces other work in the body of literature that support the Linder hypothesis (Linder, 1961) that similar countries with similar Per Capita GDP seems to trade more in relative to dissimilar ones. The coefficient of this variable is -.2427. The implication is that 1 percent increase of Per Capita GDP differential between pair of countries results in .24 percent decrease in their bilateral trade. Surprisingly, the coefficient for Language is negative, and inversely impacts PNG's trade by .11%. Similar to the Per Capita GDP, bigger countries tend to trade more within themselves rather than with small countries. However, it is important to note that PNG's population is about 10 million. The trade proportion gives a positive coefficient. This goes to show that PNG has no issue of trade openness and is readily available to trade with her current partners and of course potential newer ones. As the coefficient of RTA is depicted at –.2205 any new RTA will not be beneficial to PNG because it will reduce trade by .22% This could be justified since PNG out of all the PICs has probably more RTAs membership now.

The variance, the spread of the data points around the standard error is also portrayed in Table 3. For the variables, the GDP between the two countries is .0092, Per Capita GDP is .1100, the trade proportion is .0144 and RTA is .0262. Assessing the significance of the coefficients, the p-value shows significance at 1% for all variables.

6. Papua New Guinea's Trade Potential

After the first stage of regression and analysis, we proceed to estimate trade potential for PNG. Trade potential is defined as the maximum level of trade given the current level of determinants of trade and the lowest level of economic system constraints, or it is the maximum level of trade given the current level of determinants of trade and the least level of institutional technologies. Earlier research such as (Baldwin & PORTES, 1994) ; and (Nilsson, 2000)) have calculated the discrepancies between observed values and the expected predicted values by applying the gravity equation through OLS estimates as prospective commerce between two countries. It is therefore the ratio of estimated trade and actual trade between reporting PNG and her partner countries. This simulation can display the improvement needed and the potential growth not only in trade but also opportunities in new trade partners. The equation that formulates this simulation is as follows:

$$TP_i = \frac{Estimated\ Trade_{ij}}{Actual\ Trade_i} \tag{5}$$

where TP denotes Trade potential between PNG (*i*) and her global trade partners (*j*) $TP_{ij} > 1$ shows potential for trade expansion. $TP_{ij} < 1$ shows exceeding trade potential.

The gravity model was employed to predict future trade flows and capacity of PNG. In other words, it is used to compute trade potentials i.e. the difference between predicted value (as computed by gravity model estimates) and actual bilateral trade flows. The study has estimated the total trade potentials of PNG with 31 partner countries for the period 1990 to 2020 from equation 4. However, for the Table 3, we used t data from 2010 to 2020. The foreign trade sector of PNG constitutes an important part of its economy. Around 86% of exports from the country are generated by extractive industries, principally liquefied natural gas (LNG) and gold. The 2023 national budget stated that 75% of PNG LNG sales are on long term contracts linked to crude oil price[4]. LNG prices in 2022YTD have risen sharply as a result of the peaks in crude oil prices. The overall mining sector especially the Porgera Mines are set to boost the economy to 24% growth in 2023 when it reopens.

[4] National Budget 2023

However, the overall predetermined growth of 4.6% will be reduced to 4% according to the National Budget. All of these are setting the scene for PNG's trade potential globally. Surprisingly, PNG seems to have a lot of potential than her Pacific neighbors, especially her wantok Melanesians. Table 5 show a lot of potential to Fiji and Vanuatu so as New Zealand.

Table 5: Trade Simulation and Trade Potential between PNG and selected Economies

	Actual value of ln_TRADE_ij	Predicted value of ln_TRADE_ij	Estimated to actual trade ratio
Fiji	14.062	15.697	1.116
New Zealand	15.999	17.484	1.093
Vanuatu	13.127	14.688	1.119
Sweden	14.668	15.282	1.042
Malaysia	17.889	18.437	1.031
Thailand	17.117	17.535	1.024
Bulgaria	13.549	14.165	1.045
Finland	12.521	15.225	1.216
France	15.531	15.882	1.023
Vietnam	15.996	16.09	1.006
Indonesia	17.461	17.866	1.023
Hong Kong SAR, China	16.578	16.827	1.015
Russian Federation	15.524	16.663	1.073

Source: Author's calculation based on STATA.

Apart from her Pacific neighbors, PNG also has trade potentials with certain Asian economies. PNG is already an observer to the ASEAN which Vietnam and Malaysia are part of. This could generate more trade within these countries. However, it is to be noted that the trade potential calculations presented in Table 4 indicate the maximum levels of trade which would have been possible between PNG and each of these trading partners. More work is needed to be done to isolate product and service to determine additional potential between these trading partners.

Table 6: Trade Exhausted

	Actual value of ln_TRADE_ij	Predicted value of ln_TRADE_ij	Estimated to actual trade ratio
Australia	21.206	20.082	.947
Singapore	19.474	19.352	.993
China	19.526	17.960	.920
Japan	20.085	19.062	.949
United Kingdom	18.806	18.322	.974
Switzerland	16.915	16.062	.950
India	19.134	15.346	.802
Sri Lanka	13.975	12.67	.907

Source: Author's calculation based on STATA.

Table 6, shows some trading partners that PNG has exhausted her trade potential with. They are also found in her top 10 trading partners. Australia, Singapore, China and the United Kingdom have some kind of FTA with PNG which explains the potential trade reaching its maximum capacity. From the simulation, we can also conclude that most of the Pacific Island countries have the highest potential growth in trade volume. This includes Fiji 1.142, Marshall Islands 1.149, New Zealand 1.148 and Vanuatu at 1.121. Solomon Islands and Samoa for some reasons are at .994 and .980 respectively though other Pacific Island Countries are not included in this study.

The PNG 2020 national budget projected total exports valued at PGK38bn ($11.2bn) in 2019, up from PGK33.7bn ($9.9bn) in 2018 and PGK31.4bn ($9.3bn) in 2017. In 2020 the budget forecast a record total of PGK42.1bn ($12.4bn), but that projection was released prior to the Covid-19 pandemic which disrupted commodity markets around the world.

7. Conclusion and Discussions.

This research considers the trade potential of PNG with the rest of the world using the gravity model. Our findings show that PNG's trade has been decreasing for the last 12 years. This is prior to the dropping in the global commodity prices and the pandemic in 2020. Despite this and other effort such as the Medium-Term Development Plan III (2018-2022), a Trade Policy Review and Investment Competition Policy; growth is only found in two of her top 10 trading partners from 2010-2020. This relationship with her top 10 trading partners was not merely based on how close or how remote PNG is from them but on some other determining factors.

Our first conclusion would be that since the coefficient of GDP is positive and highly significant as expected, this implies PNG tends to trade more with larger economies irrespective of distance. Since the coefficient for RTA is negative, we are of the view that PNG's involvement in her current RTA membership is creating a trade diversion. However, there is always room for further growth and deepening of this trade relationship with partners given that PNG is still a developing economy. Given their growth trajectory and abundant resource potential, they provide a strong platform for greater economic engagement with Asia and beyond (World Bank). It is important to note that PNG's economy remains dominated by two broad sectors: (1) the agricultural, forestry, and fishing sector that engages most of PNG's labor force (the majority informally); and (2) the minerals and energy extraction sector that accounts for most export earnings and GDP. Due to time constraint, this paper did not establish a trade potential based on these sectors but on maximum level of trade possible regardless of sectors.

Answering to our earlier question whether PNG can take advantage of their potential; we are of the view that this could be possible given that they have not fully exhausted their natural resources and most of the trade potential are with countries close by like the Asian countries, the Pacific and Europe. Their agricultural products have a lot of potential in relative to their Mineral fuels and precious metals. In 2021, fish, meat, coffee, and cocoa accounted for $711.2 million while Mineral fuels and precious metal accounted for $7.7 billion representing 65% of total export[5].

[5] WTO 2021

This study explores that PNG has definite potential for trade expansion with Hong Kong, Vietnam, Indonesia, Thailand, Malaysia, Vanuatu, New Zealand, Fiji and a couple of European countries. This research also confirms that PNG has exceeded its trade potential with Australia, China, Singapore, Japan, Sri Lanka, India, and United Kingdom.

The policy implication is that the PNG government should take correct measures to increase trade volume of other products especially agriculture with the countries where full potential of trade expansion is yet to be exploited. Also attempts should be continued to maintain its high level of trade participation with the Pacific Island Countries (PIC).

Based on the findings, this study recommends that:

- PNG is to embark on the expansion of their mineral energy exports to new potential markets. This export revenue should help them in developing and diversifying their industries especially Agriculture. In terms of trade facilitation, PNG has a few non-tariff measures (NTMs) and those NTMs can have a negative impact on the free flow of trade. NTMs can increase the cost of trade and reduce the competitiveness of producers, possibly leading to an unpredictable environment in the new export market that they will be pursuing. However, the removal of the NTMs should be according to the relevant provisions in the WTO and other multilateral and bilateral agreements.
- Apart from the NTMs the government in 2019 also raised the provision of higher tariff for domestic import-competing industry. This may have an adverse effect on their exports if their trading partners responded negatively.
- Table 5 stipulated about six (6) Asian countries that PNG has the potential to increase trade with. The PNG government should strategically position herself in the northern segment of the South Pacific to bring these Asian countries closer in terms of trade and making them a gateway for the Pacific to these Asian economies.
- On the positive side, due to PNG's non reliance on tourism like most of the PICs and their positive trade balance, there is hope that they will achieve the revised economic growth

from 3% (table 1) to 3.7% as projected by IMF[6]. This can be attributed to the late opening of some of their mines and an expected growth from their non-resources sectors.

- Finally, PNG should push for economic transformation in the industries that have the potential to increase their international trade; this will have to be backed up with good governance, good environmental practices, international labor standards and a resilience policy that will sustain them during natural disasters.

[6] IMF Papua New Guinea, Country Report No. 23/126

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Appendix

A.1 Countries included in the data set.

Australia, China, Fiji, Singapore, Solomon Islands, Malaysia, Indonesia, Japan, New Zealand, Vanuatu, Vietnam, United States, United Kingdom, France, India, Germany, Netherlands, Italy, Belgium, Spain, Bulgaria, Sweden, Greece, Finland, Switzerland, Hong Kong, Brunei, Sri Lanka, United Arabs Emirates, Thailand, and Russia Federation.

Region: Pacific Islands Small States, OECD, South Asia, Northen America, and European Union.

A.2 Variables

Dependent variable: $\ln X_{ij}$ — Nominal Export (fob) flows from country i to country j of manufactured products measured in thousands of US dollars, current prices and Nominal Import (fob) flows from country j to country i of manufactured products measured in thousands of US dollars, current prices. Source: World Bank database.

Dependent variable:

- GDP_{ijt} the log of GDP of *i* country and *j* in US$. Source IMF Outlook and World Bank
- $PCGDP_{ijt}$ is the log of the Per Capita GDP Differential between *i* country and *j* in US$.
- $\ln TRGDP_{ijt}$ is the log of Trade as a percentage of GDP between country *i* and *j*. Source IMF Outlook and World Bank
- $REMOTE_{ijt}$ is the assessment of the remoteness between country i and j[7]. Source World Bank

[7] A method frequently used to control for the multilateral resistance terms for exporting and importing countries is to include a proxy for these indexes called "remoteness". This is often calculated as:

$$REMOTE_i = \sum_j \frac{dist_{ij}}{\frac{GDP_j}{GDP_W}}$$

a formula that measures a country's average weighted distance from its trading partners (Head, 2003), where weights are the partner countries' shares of world GDP (denoted by GDPW).

- $LANG_{ijt}$ is common language between country i to country j (dummy variable). presented by CEPII GeoDist database.
- RTA is Regional trading agreement (dummy variable). Source WTO.
- $lnPOP_{ijt}$ is the log of Population of country i and country j. Source World Bank database

And "ε" is the error term and "t" denotes time duration whereas' β s are the parameters.