A Study of Inflation, Exchange Rates, Money Supply, and Real GDP, Employing the Cointegration, and Error Correction Models for Annual Data between 1977 to 2020 for Papua New Guinea- a Pacific Island Country

Thomas Muthucattu Paul[1,*], Ishmael Inore[2] and James Kimata[3]

[1]*Professor and Dean Faculty of Business and Tourism Studies, Solomon Island National University, Kukum Campus, Honiara, Solomon Islands.*

[2]*Lecturer and MPhil. Student under supervision of first author at Papua New Guinea University of Technology, Lae-411, Morobe Province, Papua new Guinea.*

[3]*Lecturer at Faculty of Science and Technology, Solomon Islands National University, Honiara, Solomon Islands.*

Abstract: For Long term annual data between 1977 and 2020 for Papua New Guinea, there is long term cointegrating relation between the consumer price inflation, the money supply, the Kina -US dollar exchange rates, and real GDP. The error-correcting model establishes that the consumer price inflation is Granger caused by the money supply, the kina-dollar exchange rates, and the real GDP. The signs of the variables are as predicted by the theory: the money supply has the expected positive sign, the Kina-U.S.Dollar depreciation has the expected positive sign, and the real GDP has the expected negative sign .The variance decomposition results shows that one standard deviation shocks in ln consumer price produces shocks of high magnitude in ln exchange rates. This corroborates the Purchasing Power Parity theory that increases in consumer prices produces the depreciation of currency. One standard deviation shock in the money supply produces significant shocks in ln consumer price index and ln exchange rates. This corroborates the monetarist hypothesis that the money supply is really important policy variable causing inflation and exchange rate depreciation. The nominal exchange rate depreciation is also an important variable to explain inflation in an open economy such as Papua New Guinea.

Keywords: Exchange rates regimes, inflation, small open economy, demand and supply shocks, Money Supply and Money Demand, devaluation, cointegration, Vector Error Correction (VEC) model.
JEL classification: E2, E24, E31, C01, C58, C32, F10.

INTRODUCTION

The relationship between the money supply, and the prices, especially the consumer prices and inflation, and the foreign exchange rate value of domestic currency ,and the GDP , is a topic which has attracted the attention of macroeconomists' s for centuries. The causes for inflation have been hotly debated by economists and the policy prescriptions, varied between wages and price and costs control on the one side, and the money supply and fiscal policy controls on the other side. Inflation has been discussed from the demand pull or aggregate demand caused, and the cost push or the aggregate supply shift caused inflation. The monetarists, in general hold the view that inflation is caused in the long run by the money supply increase. Interestingly, both Keynesians and the New-classical economists, and the structuralist economists argue that inflation is caused by supply side factors. Any case, an examination of the long-run variations in the inflation rate, relationship between the money supply and the consumer prices, controlling for the GDP or real income, is the main objective of this paper.

Though the motivation of this paper is not to test the purchasing power parity theory (PPP) for Papua New Guinea, the implications of the PPP theory are relevant in the sense that when the kina exchange rate depreciates the domestic consumer prices increase in the Papua New Guinea. Therefore, kina-dollar exchange rate is also an important variable in this times series study.

Muthucattu Thomas Paul and G.R.Motlaleng (2006(a)) have tested the purchasing power parity theory (PPP) in both its absolute and relative version of it for the Republic of South Africa for the sample period from 1993 second quarter to 2003 second quarter. The cointegration and error correction methodologies are employed in this paper as the data are found to be non-stationary. It is clearly established that the changes in RSA rand /USA dollar are influenced by the long term trends in the price differential between the RSA and the USA. It is also interesting to note that the effect of short term interest rate differential is in the direction of appreciation of

*Address correspondence to this author at the Faculty of Business and Tourism Studies, Solomon Island National University, Kukum Campus, Honiara, Solomon Islands. Tel: +677 7234134; E-mail: tommypaul50@gmail.com

the South African rand. The proportionality and symmetry hypothesis of the strong version of the PPP is also supported.

Muthucattu Thomas Paul and G.R.Motlaleng (2006(b)) have examined empirically two important economic relationships, the Purchasing Power Parity (PPP) and the money demand relationship, among the consumer prices, money, output, interest rates, and the nominal rand/dollar exchange rate of the Republic of South Africa (RSA) for the sample period from 1993 second quarter to 2003 second quarter within the frameworks of co-integration and Error Correction Model (ECM). It is established that the strong version of the PPP including the proportionality and the symmetry hypothesis, is supported. The changes in the rand/dollar exchange rates are influenced by the long term trends in the consumer prices of the RSA and the USA. There exists also a well-defined money demand function for this period. The broad money demand is influenced by the consumer prices, the GDP and the interest rates. The short-term interest rates are found to be the own rate of return for broad money and the long-term bond yield is the opportunity cost of holding money. The monetary policy works through the short term interest rates

Muthucattu Thomas Paul and G.R.Motlaleng (2008) have found that for the small open economy of Botswana, the PPP theory is validated in both the absolute and relative version for the Pula-Dollar exchange rate during the sample period 1992 third quarter to 2002 fourth quarter. The Pula-Dollar exchange rate is determined by the long-term trends in Botswana's Consumer Price Index (CPI) and the USA's CPI. The influence of the USA CPI is considerable. In the long-run there is no trade-off between export competitiveness through devaluation and inflation. But as the speed of adjustment in the short-term towards long-term is slow, there is some flexibility for the exchange rate policy. The monetary policy can be used in the short-run to counter the inflation. The money markets of Botswana are not fully integrated with the world economy as interest rate differential is found to be relatively exogenous. As the real exchange rate is found to be stationary and follows the PPP theory, there is no real appreciation of the Pula in the long run, contradicting the portfolio balance theory which advocates that for a trade account surplus economy like Botswana the real exchange rate will appreciates through the limited demand for foreign assets.

Muthucattu Thomas Paul, Yih Pin Tang, and Markand Bhatt (2014) have found for Fiji Islands for the period 1975 to 2010 annual data, a long term trend relationship-cointegration-between inflation rate and the exchange rate, and the consumer price inflation is Granger caused by the exchange rates, and the demand shocks, which were established in an error-correction model.

Other studies about Fiji Islands on inflation, output, and money are Paresh Kumar Narayan et al (2012) Rao B, and Singh R(2005), and Resina Katfono (2000)

Muthucattu Thomas Paul, James D Kimata, and M.G.M .Khan (2017) have tested the purchasing power parity hypothesis using the consumer price index of USA and UK against Solomon Islands for the sample monthly period from January 1993 to December 2013. Their result shows that the changes in Solomon dollars (SBD) per USD are influenced by the long term trends in the price differential of Solomon Islands and the USA. They have found that there is a long-run relationship between Solomon Islands nominal exchange rates and the price differential against USA and UK prices.

We may also refer to the role of expectations (Laidler, David, 1983), especially, rational expectations in macroeconomics, and in our modelling work. If the money supply itself is an endogenous variable, rational agents could use information about the time path of money supply to form expectations about the money supply in order to generate information about inflation. Thus, interestingly the actual rate of monetary expansion is conceived of two elements: one, the expected monetary expansion, and two, the unexpected monetary expansion. The expected variation in the monetary expansion, via a rational expectation mechanism should lead to variation in inflation rates; but unanticipated variations in money supply on output, employment, as well as on inflation rate. Barro (1978) shows that forecast changes in current monetary expansion are highly correlated with inflation rate. But in our empirical study we have not differentiated between the expected monetary expansion and unexpected monetary expansion and their effects on inflation rate.

How the monetary expansion impinges on inflation rate in an open economy depends also on the exchange rate regime. The traditional view of the operation of the fixed exchange rate system always recognized the balance of payments as source of monetary expansion or contraction unless reserves flows are sterilized, and sterilization often does not successfully work. The traditional view of the balance of payments mechanism under fixed exchange rates assume that when the rest of the world monetary expansion occurs, and in the particular country if the monetary expansion does not immediately happen, the balance of payments would become surplus and this in turn ultimately leads to the monetary expansion, and catching up with the rest of the world inflation. This is in a way similar to the monetary expansion and inflation in a closed economy. But the rational expectation notion undermines this traditional view of the balance of payments surplus and the monetary expansion in an open economy. If an increase in the world inflation rate is going to lead to a monetary expansion via the balance of payments surplus, then the rational agents would expect the world prices directly lead to domestic prices and inflation without the balance of payments surplus occurring first. So the prices may lead and the monetary expansion lags creating the reverse–causation between money supply and prices. Here, the effects of exchange rate depreciation on prices can as well be important. In our study, we are finding the relation of exchange depreciation on prices for Papua New Guinea.

Having discussed in detail the conceptual frame work of how the monetary expansion and the exchange rate depreciation can lead to the higher prices and inflation, it is interesting and challenging to note some recent developments in the monetary economics, called 'Modern Monetary Theory (MMT) by such authors as Warren Mosler (2020) argue that the Fed's rate hikes could be undermining its effort to bring down inflation. While Mosler is a leading proponent of Modern Monetary Theory (MMT), the notion that "monetary tightening" (conventionally defined as central banks raising interest rates) might cause inflation to run hotter isn't unique to MMT. Mosler emphasizes the "interest-income channel," but it's not the only possible pathway from higher rates ==> higher inflation. And while mainstream economists like Paul Krugman and Olivier Blanchard acknowledge the interest-income channel, they don't assign it much potency. Mosler does. He points to the fact that that the rate hikes are feeding hundreds of billions of dollars of additional income to bond-holders. However, in this paper our views are in line with the traditional economics of a positive relationship between monetary expansion and prices and inflation. Moreover, for a developing economy such as Papua New Guinea even the bond markets are not developed, and the bond holders become rich because of a hike in the central bank interest rates is too farfetched and nowhere near reality .

The rest of the paper is organized as follows: The section 1 deals with methodology. Section 2.1 deals with the theory of exchange rates and inflation and section 2.2 deals with the monetary policy and the exchange rates policy developments in Papua New Guinea and section 2.3 deals with the studies on inflation in Papua New Guinea. The section 3.1 deals with data and the variables. In section 4 the tables of results are given. We discuss the results in section 5. The conclusions are given in section 6.

SECTION 1: METHODOLOGY

Unit Roots: Unit-root analysis figure is very important in exchange rate studies. The presences of a unit root indicate that a time series is not stationary. To test the stationarity of a time series, we utilize the cointegration analysis. Since this study use multivariate cointegration it is appropriate to employ the Augmented Dick-Fuller (ADF)(Dickey and Fuller, 1979) test based on *t*-ratio of the parameter as given in equation (1)

$$\Delta q_t = \beta_0 + \beta_1 t + \Pi_i q_{t-i} + \sum_{i=1}^{p} \Gamma_i \Delta q_{t-i} + \varepsilon_t \quad ...(1)$$

Where q is the dependent variable in this case is the exchange rate Δ is the first difference operator, t is the time trend and ε is the random error and p is the maximum lag length. The optimal lag length is chosen so that lag length is $\varepsilon_t \sim N(0,\sigma^2_{\varepsilon_t})$ is independent and identical distribution (i.i.d) with mean zero and constant standard deviation. While $\beta_0, \beta_1, \Pi \text{ and } \Gamma$ are parameters to be estimated. Under the null hypothesis, Δq_t is in level form or $I(0)$ which implies that $\Pi = 0$ and then we conclude that the series under consideration has a unit root and is therefore non-stationary. To achieve stationarity further differencing is required so that $0 < \Pi < 1$ or is inside the unit circle.

1.1. Akaike Information Criteria (*AIC*) and Schwarz Information Criteria (*SIC*)

Determining optimal lag length is crucial in multiple linear regressions because they are sensitive to lag length (p). To maximize normal likelihood, we choose p to minimize $\hat{p}_p^2$ which is the estimated error covariance in sample N as given in (2).

$$\hat{p}_p^2 = SSE_p / N \quad ...(2)$$

Where;

$$N = Sample\ size\,(Number\ of\ usuable\ observations)$$
$$p = lag\ length$$

Akaike Information Criteria (AIC)(Akaike, 1974) is the most popular information criteria used to determine the value of p. AIC modify the likelihood. $\ln\left(\frac{SSE_p}{N}\right)$ by adding penalty on each additional lags as in equation (3).

$$AIC_p = \ln(\hat{p}_p^2) + \frac{2r}{N} \quad ....(3)$$

Another model selection criterion is Schwarz Information Criteria (SIC)(Schwarz, 1978), it is an extension of Bayesian Information Criteria. SIC suggests that p values are too large by adding greater penalty on the parameters (r) as given in equation (4) below

$$SIC_p = \ln(\hat{p}_p^2) + \frac{r\ln(N)}{N} \quad ....(4)$$

Where;

$r = p+1$, number of parameters (regression coefficient) in the model

The preferred model is one with the minimum value of *AIC* and *SIC* from their corresponding i^{th} and j^{th} candidate models. Let

$$AIC_{i\min} = AIC_1, AIC_2, ..., AIC_L \quad ...(5)$$

$$SIC_{j\min} = SIC_1, SIC_2, ..., SIC_K \quad ...(6)$$

L and K are length of candidate models, thus the optimal lag length p is obtained by evaluating equation (7).

$$p = \min(AIC_{i\min}, SIC_{j\min}) \quad ...(7)$$

$\ln N > 2;\ for N \geq 8 :\Longrightarrow AIC > SIC$; from equation (3 and 4) which means that SIC will always select h as the optimal lag length than *AIC* (Mukhtar and Rasheed, 2010). The fit of the model improves as $\{AIC, SIC\} \to -\infty$ [*AIC* and *SIC* can be both either negative or positive].

1.2. Cointegration

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. To understand the implications of cointegration, let's first look at what happens when the observations are not cointegrated.

1.2.1. No Cointegration

Let $\xi_t = \xi_{q_{t-1}} + \mu_{q_t}$ and $\xi_t = \xi_{f_{t-1}} + \mu_{f_t}$ be two independent random walk processes, where $\mu_{q_t} \sim N(0,\sigma_q^2)$ and $\mu_{f_t} \sim N(0,\sigma_f^2)$ and are independent and identical distribution (i.i.d). Let $\underline{z_t} = (z_{q_t}, z_{f_t})'$ follow a stationary bivariate process such as vector autoregressive (VAR). The next process for $\underline{z_t}$ does not need to be explicitly modeled at this point. Now consider the two unit root series built up from these components:

$$q_t = \xi_{q_t} + z_{q_t} \qquad ...(8)$$

$$f_t = \xi_{f_t} + z_{f_t} \qquad ...(9)$$

Since q_t and f_t are driven by independent random walks, they will drift arbitrarily far apart from each other over time. If we try to find a value of β to form a stationary linear combination of q_t f_t, we will fail, because

$$q_t - \beta f_t = (\xi_{q_t} - \beta\xi_{f_t}) + (z_{q_t} - \beta z_{f_t}) \qquad ...(10)$$

For any value of β, $(\xi_{q_{t-1}} - \beta\xi_{f_t}) = (u_1 + u_2 + ... + u_t)$, where $u_t = u_{q_t} - \beta\mu_{f_t}$ so the linear combination itself is random walk $\{q_t\}$ and $\{f_t\}$ clearly do not share a long-run relationship. There may, however, be short-run interactions between their first differences:

$$\begin{pmatrix} \Delta q_t \\ \Delta f_t \end{pmatrix} = \begin{pmatrix} \Delta z_{q_t} \\ \Delta z_{ft} \end{pmatrix} + \begin{pmatrix} \varepsilon_{q_t} \\ \varepsilon_{ft} \end{pmatrix} \qquad ...(11)$$

If $\underline{z_t}$ follows a first-order VAR, we can show that equation (3.11) follows a vector ARMA process. Thus, when both $\{q_t\}$ and $\{f_t\}$ be first order differenced to induce stationarity and then their first differences modeled as a stationary vector process.

1.2.2. Cointegration

$\{q_t\}$ and $\{f_t\}$ will be cointegrated if they are driven by the same random walk, $\xi_t = \xi_{t-1} + \varepsilon_t$, where ε_t $N(0,\sigma^2)$ and is i.i.d. For example $q_t = \xi_t + z_{q_t}$

$$f_t = \phi(\xi_t + z_{f_t}) \qquad ...(12)$$

And we look for a value of β in equation (13) that renders stationary

$$q_t - \beta f_t = (1 - \phi\beta)\xi_t + z_{q_t} - \phi\beta z_{f_t} \qquad ...(13)$$

we will succeed by choosing $\beta = \frac{1}{\phi}$, since $q_t - \frac{f_t}{\phi} = z_{q_t} - z_{f_t}$ is the difference between two stationary processes , so it will itself be stationary. $\{q_t\}$ and $\{f_t\}$ will share a long-run relationship. We say that they are cointegrated, with cointegrating vector $(1, -\frac{1}{\phi})$. Since the random walks are sometimes referred to as stochastic trend processes, when two series are cointegrated we sometimes say they share a common trend.

1.3. Vector Error-Correction Representation (VECM)

For the univariate AR (2) process, we can write $q_t = \rho_1 q_{t-1} + \rho_2 q_{t-2} + \mu_t$ in Augmented Dick-Fuller test equation as

$$\Delta q_t = (\rho_1 + \rho_2 - 1)q_t - \rho_2 \Delta q_{t-1} + \mu_t \qquad ...(14)$$

Where $u_t \sim N(0, u_u^2)$ and is iid. If q_t is a unit root process, then $(\rho_1 + \rho_2 - 1) = 0$ and $(\rho_1 + \rho_2 - 1)^{-1}$ clearly does not exist. There is a sense a singularity in q_{t-1} because q_t is stationary and this can be true only if q_{t-1} drops out from the right-hand side of equation (14).

By analogy, suppose that in bivariate case the vector (q_t, f_t) is generated according to

$$\begin{bmatrix} q_t \\ f_t \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}\begin{bmatrix} q_{t-1} \\ f_{t-1} \end{bmatrix} + \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}\begin{bmatrix} q_{t-2} \\ f_{t-2} \end{bmatrix} + \begin{bmatrix} \mu_{q_t} \\ \mu_{f_t} \end{bmatrix} \qquad ...(15)$$

Where $(\mu_{q_t}, \mu_{f_t}) \sim N(0, \Sigma_u)$ and is iid. Rewrite equation (15) as a vector analog of the augmented Dick-Fuller test equation,

$$\begin{bmatrix} \Delta q_t \\ \Delta f_t \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \end{bmatrix}\begin{bmatrix} q_{t-1} \\ f_{t-1} \end{bmatrix} - \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}\begin{bmatrix} \Delta q_{t-1} \\ \Delta f_{t-1} \end{bmatrix} + \begin{bmatrix} \mu_{q_t} \\ \mu_{f_t} \end{bmatrix} \qquad ...(16)$$

Where

$$\begin{bmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \end{bmatrix} = \begin{bmatrix} a_{11} + b_{11} - 1 & b_{12} + b_{12} \\ a_{21} + b_{22} & a_{22} + b_{22} - 1 \end{bmatrix} \equiv R$$

If $\{q_t\}$ and $\{f_t\}$ have unit-root processes, their first difference are stationary. This means that the terms on the right hand side of equation (16) are stationary. Linear combinations of levels of the variables appear in the system $r_{11}q_{t-1} + r_{12}f_{t-1}$ appears in the equation for Δq_t and $r_{21}q_{t-1} + r_{22}f_{t-1}$ appears in the equation for Δf_t.

If $\{q_t\}$ and $\{f_t\}$ do not cointegrate, there are no values of the r_{ij} coefficients that can be found to form stationary linear combination of $\{q_t\}$ and $\{f_t\}$. The level terms must drop out. *R* is the null matrix, and $(\{q_t\},\{f_t\})$ follows a vector autoregression.

If $\{q_t\}$ and $\{f_t\}$ do cointegrate, then there is a unique combination of the two variables that is stationary. The levels enter on the right-hand side, but do so in the same combination in both equations. This means that the column of *R*, which is singular, and can written as

$$R = \begin{bmatrix} r_{11} & -\beta r_{11} \\ r_{21} & -\beta r_{21} \end{bmatrix}$$

Equation (3.11) can be written as

$$\begin{bmatrix} \Delta q_t \\ \Delta f_t \end{bmatrix} = \begin{bmatrix} r_{11} \\ r_{21} \end{bmatrix}(q_{t-1} - \beta f_{t-1}) - \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}\begin{bmatrix} \Delta q_{t-1} \\ \Delta f_{t-1} \end{bmatrix} + \begin{bmatrix} \mu_{q_t} \\ \mu_{f_t} \end{bmatrix}$$

$$= \begin{bmatrix} r_{11} \\ r_{21} \end{bmatrix} z_{t-1} - \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}\begin{bmatrix} \Delta q_{t-1} \\ \Delta f_{t-1} \end{bmatrix} + \begin{bmatrix} \mu_{q_t} \\ \mu_{f_t} \end{bmatrix} \quad \text{...(17)}$$

Where $z_{t-1} \equiv q_{t-1} - \beta f_{t-1}$ is called the error-correcting term, and equation (17) is the vector error-correction representation (VECM).

A VAR in first difference would be misspecified, because it omits the error-correction term. To express the dynamics governing z_t, multiply the equation by Δf_t by β and subtract the result from the equation for Δq_t, to give

$$z_t = (1 + r_{11} - \beta r_{21}) z_{t-1} q_{t-1} - (b_{11} - \beta b_{21}) \Delta q_{t-1} - (b_{12} + \beta b_{22}) \Delta f_{t-1} + \mu_{q_t} - \beta \mu_{f_t} \quad \text{...(18)}$$

The entire system is given by

$$\begin{bmatrix} \Delta q_t \\ \Delta f_t \\ z_t \end{bmatrix} = \begin{bmatrix} b_{11} & b_{12} & r_{11} \\ b_{21} & b_{22} & r_{12} \\ -(b_{11} + \beta b_{21}) & -(b_{12} + \beta b_{22}) & 1 + r_{11} - \beta r_{21} \end{bmatrix}\begin{bmatrix} \Delta q_{t-1} \\ \Delta f_{t-1} \\ z_{t-1} \end{bmatrix} + \begin{bmatrix} \mu_{q_t} \\ \mu_{f_t} \\ \mu_{q_t} - \beta \mu_{f_t} \end{bmatrix} \quad \text{...(19)}$$

$(\Delta q_t, \Delta f_t, z_t)'$ is stationary vector, and (19) looks like a *VAR(1)* in these three variables, except that the columns of the coefficient matrix are linearly dependent. In many applications, the cointegration vector $(1, -\beta)$ is given a priori by economic theory and does not need to be estimated. In these situations, the linear dependence of the *VAR* in (19) tells us the information contained in the *VECM* is preserved in bivariate *VAR* form z_t and either Δq_t, or Δf_t.

Suppose that we know this strategy. To obtain the *VAR* for $(\Delta q_t, \Delta f_t)$ substitute $f_{t-1} = (q_{t-1} - z_{t-1}) / \beta$ into the equation (14) for Δq_t, to get

$$\Delta q_t = b_{11} \Delta q_{t-1} + b_{12} \Delta f_{t-1} + r_{11} z_{t-1} + \mu_{q_t}$$

$$= a_{11} \Delta q_{t-1} + a_{12} z_{t-1} + a_{13} z_{t-2} + \mu_{q_t}$$

Where $a_{11} = b_{11} + b_{12} / \beta$, $a_{12} = r_{11} - b_{12} / \beta$, and $a_{13} = b_{12} / \beta$.

Similarly, substitute f_{t-1} out of the equation for z_t, to give

$$z_t = a_{21} \Delta q_{t-1} + a_{22} z_{t-1} + a_{23} z_{t-2} + (\mu_{q_t} + \mu_{f_t})$$

Where $a_{21} = -(b_{11} + \beta b_{21} + \frac{b_{12}}{\beta} + b_{22})$, $a_{22} = 1 + r_{11} - \beta r_{21} + b_{22} + \frac{b_{12}}{\beta}$,

and $a_{23} = -(b_{22} + \frac{b_{12}}{\beta})$

Together, we have the VAR (2)

$$\begin{bmatrix} \Delta q_t \\ z_t \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}\begin{bmatrix} \Delta q_{t-1} \\ \Delta f_{t-1} \end{bmatrix} + \begin{bmatrix} 0 & a_{13} \\ 0 & a_{23} \end{bmatrix}\begin{bmatrix} \Delta q_{t-2} \\ \Delta f_{t-2} \end{bmatrix} + \begin{bmatrix} \mu_{q_t} \\ \mu_{q_t} - \beta \mu_{f_t} \end{bmatrix} \quad \text{...(20)}$$

Equation (20) is easier to estimate than the VECM and the standard forecasting formulae for VARs can be employed without modification.

2.1. The Theory of Exchange rates and Inflation

The transmission mechanism of the effects of the exchange rates on the domestic consumer prices is described through import prices and export prices, and the domestic aggregate demand. Thus, changes in exchange rates imply changes in export and import prices, volume of exports and imports, investment decisions, and last but not the least in consumer prices. The main factors influencing the degree of pass-through are openness and size of economy, besides relative elasticities of demand and supply for traded goods and macroeconomic conditions and microeconomic environment (MacFarlane 2006). They (McFarlane 2006) further gives a flow chart in which exchange rate depreciation has the direct effect through imported inputs becoming more expensive and production costs rising and thus leading to higher consumer prices, and similarly imports of finish goods become more expensive and leading to higher consumer prices. The Exchange depreciation has indirect effects also of the domestic demand for import substitutes rising, and the demand for substitutes and exports raising their prices, and demand for labour increases and wages increase, and they all also lead to higher consumer prices. However, the 'rational expectation hypothesis' can 'short circuit ' all those intermediate transmission mechanism between exchange rates and domestic consumer prices, and the exchange rates changes or even expected changes in exchange rates can move the domestic consumer prices before occurring those intermediate effects on import prices and export prices.

There is another direct channel due in operation of law of one price based on the purchasing power parity theory (*PPP*). It is argued that the exchange rate between two monies/ currencies is determined by the relative movements in the prices levels in two countries. The intellectual origins of *PPP* began in the early 1800s, with the writing of Wheatly and Ricardo. These ideas were subsequently revived by Cassel (1921). The Casselian approach begins with the observation that the exchange rate '*E*' is the relative price of two currencies. Since the purchasing power of the home currency is *1/P* and the purchasing power of the foreign currency is $1/P^*$, in equilibrium the relative value of two currencies should reflect their relative purchasing powers, $E = P/P^*$. The Casselian view suggests the consumer price index (the *CPI*) is typically used in empirical implementation of the theory. However, this theory implies that the long run real exchange rate, $q = E + P^* - P$ is constant over time which assumption may not be realistic though mean reversion to the long run Q is a good possibility.

The commodity-arbitrage view of *PPP*, articulated by Samuelson (1964) says that the law of "one price" is applicable only for all internationally tradable goods. Therefore this theory is more applicable to tradable goods only which can be expressed in the following way:

$$P = P^* E$$

Where P = domestic currency price of imported goods E is the exchange rate expressed as units of domestic currency per unit of foreign currency P^* is the foreign price index .

Expressing in log form:

$$\log P = \beta \log P^* + \lambda \log E$$

The law of one price implies that $\beta = \lambda = 1$ in which case changes in exchange rates completely 'pass through' to the domestic price of the traded goods.

The transmission mechanism of the effects of the exchange rates on the domestic consumer prices is described through import prices and export prices, and the domestic aggregate demand. Thus, changes in exchange rates imply changes in export and import prices, volume of exports and imports, investment decisions, and last but not the least in consumer prices. The main factors influencing the degree of pass-through are openness and size of economy, besides relative elasticity of demand and supply for traded goods and macro-economic conditions and microeconomic environment (MacFarlane 2006). They (McFarlane 2006) further gives a flow chart in which exchange rate depreciation has the direct effect through imported inputs becoming more expensive and production costs rising and thus leading to higher consumer prices, and similarly imports of finish goods become more expensive and leading to higher consumer prices. The Exchange depreciation has indirect effects also of the domestic demand for import substitutes rising, and the demand for substitutes and exports raising their prices, and demand for labour increases and wages increase, and they all also lead to higher consumer prices. However, the 'rational expectation hypothesis' can 'short circuit ' all those intermediate transmission mechanism between exchange rates and domestic consumer prices, and the exchange rates changes or even expected changes in exchange rates can move the domestic consumer prices before occurring those intermediate effects on import prices and export prices .

There is another direct channel due in operation of law of one price based on the purchasing power parity theory (*PPP*). It is argued that the exchange rate between two monies/ currencies is determined by the relative movements in the prices levels in two countries. The intellectual origins of *PPP* began in the early 1800s, with the writing of Wheatly and Ricardo. These ideas were subsequently revived by Cassel (1921). The Casselian approach begins with the observation that the exchange rate 'E' is the relative price of two currencies. Since the purchasing power of the home currency is $1/P$ and the purchasing power of the foreign currency is $1/P^*$, in equilibrium the relative value of two currencies should reflect their relative purchasing powers, $E= P/ P^*$. The Casselian view suggests the consumer price index (the *CPI*) is typically used in empirical implementation of the theory. However, this theory implies that the long run real exchange rate, $q = E + P^* - P$ is constant over time which assumption may not be realistic though mean reversion to the long run Q is a good possibility.

The commodity-arbitrage view of *PPP*, articulated by Samuelson (1964) says that the law of "one price" is applicable only for all internationally tradable goods. Therefore this theory is more applicable to tradable goods only which can be expressed in the following way:

$$P = P^* E$$

Where P = domestic currency price of imported goods

E is the exchange rate expressed as units of domestic currency per unit of foreign currency

P^* is the foreign price index .

Expressing in log form:

$$\log P = \beta \log P^* + \lambda \log E$$

The law of one price implies that $\beta = \lambda = 1$ in which case changes in exchange rates completely 'pass through' to the domestic price of the traded goods.

2.2 The Exchange Rates and the Monetary Policy Developments in Papua New Guinea

The Kina (PGK) is the national currency of Papua New Guinea. The PGK was introduced in 1975 when it replaced Australian dollar (AUD) as 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 boom 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.

The third major natural resource boom occurred during 2002 to 2012 period, during which the commodity prices boomed and the kina appreciated. The production of a lot of liquefied 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 2013 the 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.

2.3. Studies on Inflation in Papua New Guinea

The Bank of Papua New Guinea (BPNG) under the author Eli Direye (2019) has done an important study on inflation in PNG using the VAR econometric methodology. They have used the variables, oil prices, food prices, exchange rates, output gap, government spending, and money supply to explain inflation. The study uses quarterly data covering the period 1996 Quarter 1 to 2017 Quarter 4, data sourced from BPNG's Quarterly Economic Bulletins. The Unit root tests for stationarity showed the exchange rate is stationary (I(0))at 5 % level of significance ,while Head line inflation, and exclusion based core inflation are also stationary (I(0)) at 5 % level, of significance. But the variables, global oil prices, food prices, and the money supply are found to be non-stationary (I(1)) variables. Now the BPNG authors have transformed non stationary variables (I(1)) in to stationary variables (I(0)) by first differences and put all variables in the VAR system. According to us, such a procedure, the methodology employed by the BPNG is not correct as the non-stationary variables should have been tested for long term cointegration relations. In our present study we try to address this lacuna by checking for cointegration relation among the non-stationary variables, and after finding the long term cointegration relation, to examine the Granger causality through the error-correction model.

The conclusions of the BPNG (2019) study are the following: (1) the fluctuations in oil and food prices produce both the first round and second round effects on domestic inflation in PNG. (2) However, according to BPNG model, with an oil and commodity price shock produce exchange rate appreciation and the reduction in money supply through the monetary policy reaction function, and finally moderate the effects of second and third round shocks of oil and food prices. Therefore, they are not finding any independent effects of exchange rates and money supply on inflation in PNG, (3) the output gap effects also contribute to inflation. (4) Their major conclusion is that the exchange rate stability and monetary policy response are important in curbing inflation in PNG.

3.1. 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. $\ln \text{Money Supply}$: The natural log of the broad money supply data.
2. $\ln \text{Kina-USD}$ 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. $\ln \text{CPI}$: 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. $\ln \text{GPD}$: The natural log of the Gross Domestic Product of Papua New Guinea.

SECTION 4: TABLES OF RESULTS

Table 1. ADF Unit Root Test.

Variables	Level	1st difference	Decision	Integration
Nominal exchange rate In 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, In (CPI)	-1.268995 [0.8826]	-4.214862*** [0.0092] (0)	Not stationary at level but stationary at 1st difference	I(1)
In Money Supply	-1.021907 (0.7373)	-5.265153 (0.0005)	Not stationary at level and stationary at 1st difference	I(1)
In GDP	0.265430 [0.9738]	-6.251953 [0.0000] (0)	Not stationary at level but stationary at 1st difference	I(1)

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 parenthesis.

Table 2. Johansen Multi-Variate Cointegration Test.

Null hypothesis	Alternative Hypothesis	Eigen- values	Maximum Eigen Statistics λ_{max}	0.05 Critical Value	Probabilities
$r = 0$	$r \leq 1$	0.573538	60.58398***	40.17493	0.0002
$r \leq 1$	$r \geq 2$	0.228546	23.08576	24.27596	0.0701
$r \leq 2$	$r \leq 3$	0.193910	11.66870	12.32090	0.0641

			Trace statistics λ_{trace}		
$r = 0$	$r = 1$	0.573538	37.49822**	24.15921	0.0005
$r \leq 1$	$r = 1$	0.228546	11.41705*	17.79730	0.3480
$r \leq 2$	$r = 1$	0.193910	9.484607	11.22480	0.996

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

Table 3. Cointegration and Error Correction Estimates.

(a) Cointegration Equations

Cointegrating Equation:	**Cointegration Equation1**
LN_CONSUMERPRICE(-1)	1.000000
LN_EXCHANGE_RATES(-1)	-0.522278
	(0.05465)
	[-9.55647]
LN_MONEY_SUPPLY(-1)	-1.169151
	(0.22459)
	[-5.20562]
LN_REAL_GDP(-1)	0.173189
	(0.30932)
	[0.55991]
C	5.875831

Standard errors in ( ) & t statistics in [ ].

(b) Vector Error Corrections Estimates.

Error Correction:	**D(LN_CONPRICE)**	**D(LN_EXRATES)**	**D(LN_MONEY_SUPPLY)**	**D(LN_REAL_GDP)**
CointEq1	-0.205655	0.476267	0.353029	0.041133
	(0.07850)	(0.21739)	(0.09066)	(0.05302)
	[-2.61980]	[2.19088]	[3.89412]	[0.77583]
D(LN_CONPRICE(-1))	0.109690	-0.398472	0.278304	-0.181673
	(0.15805)	(0.43767)	(0.18252)	(0.10674)
	[0.69403]	[-0.91044]	[1.52476]	[-1.70194]
D(LN_CONPRICE(-2))	0.174004	0.798990	-0.020093	0.213433
	(0.15567)	(0.43108)	(0.17977)	(0.10514)
	[1.11779]	[1.85346]	[-0.11177]	[2.03004]
D(LN_EX_RATES(-1))	0.196855	0.887016	0.102741	0.128059
	(0.06135)	(0.16989)	(0.07085)	(0.04144)
	[3.20869]	[5.22100]	[1.45009]	[3.09054]
D(LN_EX_RATES(-2))	-0.102487	-0.143630	-0.083679	-0.053636
	(0.06442)	(0.17839)	(0.07440)	(0.04351)
	[-1.59092]	[-0.80513]	[-1.12478]	[-1.23275]

D(LN_MONEY_SUPPLY(-1))	-0.312072	-0.401365	0.468765	0.073189
	(0.12628)	(0.34969)	(0.14583)	(0.08529)
	[-2.47134]	[-1.14778]	[3.21443]	[0.85816]
D(LN_MONEY_SUPPLY(-2))	0.104534	1.194554	0.473167	0.209043
	(0.13658)	(0.37823)	(0.15773)	(0.09225)
	[0.76536]	[3.15831]	[2.99982]	[2.26614]
D(LN_REAL_GDP(-1))	0.160206	-0.833525	0.092195	0.121105
	(0.24143)	(0.66858)	(0.27882)	(0.16306)
	[0.66357]	[-1.24671]	[0.33066]	[0.74269]
D(LN_REAL_GDP(-2))	0.196377	0.843418	-0.215196	-0.288367
	(0.22114)	(0.61238)	(0.25538)	(0.14936)
	[0.88803]	[1.37728]	[-0.84264]	[-1.93075]
C	0.038356	-0.056329	-0.014710	0.026219
	(0.02103)	(0.05822)	(0.02428)	(0.01420)
	[1.82430]	[-0.96746]	[-0.60581]	[1.84638]
R-squared	0.569606	0.566064	0.425728	0.411001
Adj. R-squared	0.452226	0.447718	0.269108	0.250365
Sum sq. resids	0.025626	0.196519	0.034178	0.011690
S.E. equation	0.027867	0.077169	0.032182	0.018821
F-statistic	4.852663	4.783120	2.718224	2.558588
Log likelihood	98.63033	54.83184	92.43931	115.5059
Akaike AIC	-4.122341	-2.085202	-3.834386	-4.907253
Schwarz SC	-3.712760	-1.675620	-3.424805	-4.497672
Mean dependent	0.064809	0.032635	0.040195	0.037188
S.D. dependent	0.037652	0.103840	0.037643	0.021738

Determinant resid covariance (dof adj.)	1.33E-12
Determinant resid covariance	4.62E-13
Log likelihood	366.5900
Akaike information criterion	-15.00419
Schwarz criterion	-13.20203
Number of coefficients	44

Table 4. Variance Decompositions of Each Variables.

(a) Variance Decomposition of LN_CONSUMER_PRICE.

Period	S.E.	LN_consumerprice	LN_Money_Supply	LN_Exchange_Rates	LN_real_GDP
1	0.027867	100.0000	0.000000	0.000000	0.000000
2	0.048744	79.07404	1.756783	18.95570	0.213475
3	0.070472	64.18285	2.021015	33.67764	0.118494
4	0.093436	60.39260	1.160802	38.33680	0.109798

5	0.118155	60.43724	0.733628	38.57060	0.258530
6	0.142205	61.95097	0.522349	37.10769	0.418999
7	0.164824	64.42416	0.411329	34.55811	0.606397
8	0.185767	66.62006	0.338022	32.20841	0.833507
9	0.204857	68.17639	0.283943	30.51810	1.021569
10	0.222372	69.26440	0.247144	29.34455	1.143912

(b) Variance decompositions of LN_MONEY_SUPPLY

Period	S.E.	LN_Consumerprice	LN_Money_Supply	LN_Exchange_Rates	LN_real_GDP
1	0.032182	0.021739	99.97826	0.000000	0.000000
2	0.050929	8.965724	89.17355	1.564524	0.296202
3	0.069882	12.98574	81.40957	5.259633	0.345061
4	0.088852	15.74785	70.68008	12.87389	0.698189
5	0.105283	15.35953	64.21151	19.28605	1.142922
6	0.118525	14.00593	60.65818	24.04782	1.288070
7	0.129945	12.46809	59.11805	27.19107	1.222786
8	0.140054	11.15583	58.61577	29.10269	1.125707
9	0.149236	10.07905	58.68967	30.19829	1.032988
10	0.157971	9.215793	58.88769	30.94643	0.950083

C) Variance decomposition of LN_EXCHANGE_RATES

Period	S.E.	LN_Consumerprice	LN_Money_Supply	LN_Exchange_Rates	LN_Real_GDP
1	0.077169	10.98036	3.815925	85.20371	0.000000
2	0.160180	9.873017	14.05427	75.35434	0.718373
3	0.220368	14.58346	14.74468	70.09751	0.574345
4	0.278206	19.64334	15.59125	64.25289	0.512519
5	0.335518	21.62494	16.54552	61.26131	0.568230
6	0.388224	23.50190	16.90882	59.06140	0.527878
7	0.437737	25.31422	16.84821	57.30007	0.537502
8	0.485374	26.47046	16.74905	56.19934	0.581145
9	0.530354	27.33858	16.54024	55.51691	0.604272
10	0.572891	28.23291	16.23988	54.90439	0.622816

d) Variance Decomposition of LN_REAL_GDP.

Period	S.E.	LN_Consumerprice	LN_Money_Supply	LN_Exchange_Rates	LN_Real_GDP
1	0.018821	0.678903	3.376281	3.698526	92.24629
2	0.028150	0.341202	2.724259	3.206292	93.72825
3	0.032515	4.398646	4.225895	2.813072	88.56239
4	0.038829	14.52166	5.531710	2.509827	77.43680
5	0.045428	18.65392	4.727218	2.316610	74.30225
6	0.050443	19.55744	4.183597	2.108965	74.15000

7	0.054700	20.54610	4.095806	2.034369	73.32373
8	0.058713	21.44025	4.091003	1.891543	72.57721
9	0.062406	21.99536	4.073913	1.713888	72.21684
10	0.065915	22.51900	4.130898	1.567856	71.78224

Cholesky Ordering: LN_Consumerprice Ln_Money_Supply.
LN_Exchange_Rates LN_Real_GDP.

Table 5. Responses of Each Variables.

(a) Response of LN_Consumer_Price.

Period	LN_Consumerprice	LN_Exchange_Rates	LN_Money_Supply	LN_real_GDP
1	0.027867	0.000000	0.000000	0.000000
2	0.033200	0.022100	-0.001927	0.002252
3	0.036177	0.035787	-0.000253	0.000901
4	0.045660	0.040236	0.007508	0.001924
5	0.056258	0.043949	0.010362	0.005148
6	0.063957	0.044668	0.011285	0.006974
7	0.070528	0.041956	0.011407	0.008945
8	0.074082	0.040193	0.010769	0.011086
9	0.074973	0.039919	0.010068	0.011878
10	0.075098	0.040016	0.010254	0.011702

(b) Response of LN_Exchange_Rates.

Period	LN_Consumerprice	LN_Exchange_Rates	LN_Money_Supply	LN_Real_GDP
1	0.025571	0.072810	0.000000	0.000000
2	0.043351	0.128863	-0.032143	-0.013576
3	0.067445	0.130987	-0.033218	-0.009726
4	0.090120	0.137049	-0.042599	0.010852
5	0.095603	0.152442	-0.050515	0.015588
6	0.105252	0.155688	-0.051706	0.012488
7	0.114384	0.158095	-0.050824	0.015307
8	0.117710	0.164627	-0.051744	0.018417
9	0.120563	0.168194	-0.050320	0.018181
10	0.125558	0.168742	-0.048431	0.018559

(c) Response of LN_Money_Supply.

Period	LN_Consumerprice	ln_Exchange_Rates	LN_Money_Supply	LN_Real_GDP
1	-0.000475	-0.006662	0.031481	0.000000
2	0.015242	-0.013632	0.033649	0.002772
3	0.020040	-0.022830	0.036847	0.003028
4	0.024680	-0.035255	0.033480	0.006186
5	0.021431	-0.040881	0.031429	0.008460

6	0.016280	-0.042215	0.029363	0.007366
7	0.011736	-0.041989	0.030185	0.005052
8	0.009107	-0.040759	0.031162	0.003786
9	0.007517	-0.039413	0.032204	0.003042
10	0.007419	-0.039236	0.032892	0.002651

(d) Response of LN_Real_GDP.

Period	LN_Consumerprice	LN_Exchange_Rates	LN_Money_Supply	LN_real_GDP
1	0.001551	-0.004257	0.002634	0.018077
2	0.000547	0.002790	0.003762	0.020395
3	0.006618	0.001042	0.005132	0.013914
4	0.013132	-0.004073	0.005499	0.015206
5	0.012885	-0.003868	0.003027	0.019127
6	0.010615	-0.002985	0.002417	0.018798
7	0.010822	-0.003457	0.003369	0.017526
8	0.011150	-0.002927	0.003774	0.017549
9	0.010841	-0.002084	0.003851	0.017624
10	0.011036	-0.002091	0.004221	0.017501

Cholesky Ordering: LN_Consumerprice LN_Exchange_RAT

ES LN_Money_Supply LN_Real_GDP.

SECTION 5: DISCUSSIONS

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.

Then the testing of the cointegration between non stationary variables is in order.

We have used Johansen –Julius (1998) procedure for it 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.

Therefore, we have gone for the Error correction modelling and the results reported in Table 3. In the error-correction model where the change in natural log of the consumer price is taken as the dependent variable, the sign of the error correcting factor is negative and lies between zero and minus one and is statistically significant. The foregoing results corroborate that the consumer price inflation which is represented by the natural log of the consumer price index ($\ln$ CPI) is 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. This has tested the causality between inflation, and other explanatory variables, mainly the money supply, and the nominal kina-US dollar exchange rates.

The signs of the variables, after conversion into an equation, are as predicted by the theory: the money supply has the expected positive sign, the kina-dollar exchange rate has the expected positive sign, and the real GDP has the expected negative sign. This is also a test of Granger-causality using the error-correction model through which it is established that the natural log of the consumer price index, a proxy for inflation, is Granger-caused by the other variables in the system, namely the money supply, kina-dollar exchange rates depreciation, and the real GDP.

These results broadly corroborate the monetarist hypothesis of inflation that inflation is primarily caused in the long-run by the excess money supply. The kina-dollar depreciation is also transmitting in to inflation. The negative GDP shocks also cause the increase in consumer prices and inflation.

As shown in Table **4** the variance decomposition results show that one standard deviation shock in $\ln$ consumer price produces shocks of high 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 shock 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 shock in $\ln$ exchange rate has significant effect on consumer price and the money supply.

GDP shocks also significant effect on in consumer prices and ln exchange rates. Therefore, in Papua New Guinea negative GDP shocks also cause price shocks.

As shown in Table **5** the impulse response function results show that the positive shocks in ln consumer price produces positive shocks in ln consumer price, and ln real GDP, but negative shocks in money supply for two years. Negative shocks in the money supply may be due to monetary policy reaction function. Similarly positive shocks in ln exchange rate causes positive shocks in ln consumer prices. Also, the positive shocks in ln money supply causes positive shocks in ln consumer prices for all years ahead. The traditional theoretical relationships of the money supply and the consumer prices is being fully corroborated for Papua New Guinea.

SECTION 6: CONCLUSIONS

Long term time series annual data for the years 1977-2020 of the developing country of Papua New Guinea, relating to the money supply, kina-dollar exchange rate, and the real GDP are examined with time-series techniques of testing for stationarity, cointegration, and error-correction models. There is a long-term cointegrating relationship between those variables corroborating the traditional monetary theory though these time series are non-stationary. Further, the error-correction model establishes that the money supply changes are causing changes in consumer prices, and exchange rate depreciation of kina. And, the change in consumer prices–inflation– is caused in the long-run by the increase in money supply, and the depreciation of kina-dollar exchange rates. In a small open economy such as Papua New Guinea, the money supply, though very important cannot alone explain consumer inflation but the nominal exchange rate of kina-U.S. dollar is also very important variable to explain inflation.

REFERENCES

Armstrong, P. and Mosler, W. B. 2020.'Weimar Republic Hyperinflation through a Modern Monetary Theory Lens', Weimar-Republic-Hyperinflation-through-a-Modern-Monetary-Theory-Lens.pdf (moslereconomics.com) accessed 25/10/202

Barro, R.J. 1978. 'Unanticipated money, output, and the price level in the United States. "Journal of Political Economy', 86,(August)549-81.

Dornbusch, R. 1976. 'Expectations of Exchange Rate Dynamics', *Journal of Political Economy 84(6): 1161-1176*.

Dornbusch, R. 1980. 'Exchange Rate Economics. Where do we stand?', *Brookings Papers on Economic Activity (1): 143-1176.*

Eli Direye, 2019. 'Dynamic Impacts of Global and food price shocks on inflation in Papua New Guinea', in www.bankpng.gov.png 2019 chapter 7-PNG-Inflation.pdf

Frenkel, J.A and H. G Johnson. 1978. '*The Economics of Exchange Rates*', Reading, Mass: Addison Wesley.

Frenkel, J.A. 1981. 'The Collapse of Project on Purchasing Power parity During the 1970s,' *European Economic Review 6(1): 637-654.*

Frankel, J.A and A. K. Rose 1996.'A Panel Project on Purchasing Power Parity: Mean Reversion Within and Between Countries', *Journal of International Economics 40(1/2): 209-224.*

Granger, C. W. J. 1969. 'Investigating Causal Relations by Econometric Models and Cross Spectral Methods, *Econometrica 37: 424-438*

Granger, C. W. J. 1988. 'Some Recent Developments in a Concept of Causality', *Journal of Econometrics, 39: 199-211*

Granger, C.W.J, Huang, B.N and Yang, C. W 2000. "A Bivariate Causality between Stock Prices and Exchange Rates: Evidence from Recent Asian flu", The Quarterly Review of Economics and Finance, Vol. 40, Pp. 337-54.

Gunnar, J. 2001. 'Inflation, Money Demand, and Purchasing Power Parity in South Africa', *IMF Staff Papers 48(2): 243-265*.

Gustav Cassel 1921. *The World Monetary Problems*. London: Constable

Johansen. S and K. Juselius 1990."Maximum Likelihood Estimation and Inference on Cointegration: With Applications to the Demand for Money", *Oxford Bulletin of Economics and Statistics* 52(2): pp 169-210.

Johnson H.G. 1972. "The Monetary Approach to the Balance of Payments", *in Further Essays in Monetary Economics*, London, Allen and Unwin;

Kannapiram, Arjunan 2000. "Inflation Targeting policy in Papua New Guinea .An Econometric Model Analysis." Pacific Economic Bulletin , volume, 15,2

Laidler, David 1982. Monetarist Perspectives, published by Phillip Allan.

Lothian. J and M. Taylor 1996. 'Real Exchange Rate Behavior: The Recent Float from the Perspective of the Past Two Centuries', *Journal of Political Economy 104(3): 488-509*.

Lothian, J. 1997. 'Multi-Country Evidence on the Behaviour Purchasing Power Parity Under the Current Float', *Journal of International Money and Finance, 16: 19-35*

Masale, S. M. 1993. *Inflation and Exchange Rate Policy in Botswana (1976-1992): an Exploratory Study,* unpublished M.A dissertation, University of Sussex.

McFarlane,L.2006." Consumer price Inflation and Exchange Rate Pass-Through in Jamaica in D.Seerattan,(eds.) *Finance and Real Development* , St.Augustine Trinidad: Caribbean Centre for Monetary Studies ,pp370-399

Mkenda. B. K. 2001. 'An Empirical Test of Purchasing Power Parity in Selected African Countries '' Working Papers in Economics .No.39. University of West Indies

Muthucattu Thomas Paul and G.R.Motlaleng 2008. "Pula- Dollar Exchange Rate and Purchasing- Power Parity in Botswana " Journal of Developing Areas, International Journal from Tennessee University, University College of Business, TN 37203, USA., volume:41. Issue 2: spring. 2008 pp.205-231.

Muthucattu Thomas Paul and G.R.Motlaleng 2006(a). 'Purchasing Power Parity for South Africa: Recent Empirical Evidence" in ICFAI Journal of Applied Economics, Volume 6, Issue 6, 2006

*Muthucattu Thomas Paul and G.R.Motlaleng 2006(b). '*Money Demand and Purchasing Power Parity (PPP), in the Republic of South Africa' Journal of Quantitative Economics,

Muthucattu Thomas Paul, James D Kimata, and M.G.M .Khan 2017.'Purchasing Power Parity Theory and application for Solomon Island'. The Journal of Economics and Public Finance , Scholink .org , Los Angeles, USA , Volume 3, No.4 , 2017 .(Indexes :Google Scholar, Directory of Research Journals Indexing , EconBid , Scientific Indexing Service (SIS**)**

Mundell R. 1971. *Monetary Theory*, Pacific Palisades, Goodyear.

Nelson C.Mark 2001. International Macroeconomics and Finance, Blackwell Publishing.

Paresh Kumar Narayan, Seema Narayan, Sagarika Mishra, Russell Smyth, (2012),"An analysis of Fiji's monetary policy transmission", *Studies in Economics and Finance*, Vol. 29 pp 52 – 70

Rao, B. and Singh, R., 2005. 'A cointegration and error correction approach to demand for money in Fiji: 1971 – 2002.' *Pacific Economic Bulletin,* 20(2) pp72-86

Resina Katfono 2000. 'The Relationship between Monetary aggregates, Inflation, and Output in Fiji.' 2000 *RBF working Paper series.*

Samuelson, Paul A 1964. 'Theoretical notes on trade problems'. *Review of Economics and Statistics* 46: pp145-54

Received: May 02, 2023 Revised: May 10, 2023 Accepted: Aug 09, 2023