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How much is too much? Estimating Inflation-Economic Growth Threshold for Papua New Guinea

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Abstract

This study employs annual PNG's data for the period 1980-2020 to estimate the inflation threshold level for PNG. Adopting the threshold regression approach of Khan and Senhadji(2001), the study estimates that the inflation threshold for PNG is 12.0 percent. The inflation levels above this threshold have been found to have adverse effects on long-run economic growth. In contrast, the paper finds a statistically insignificant impact of inflation on growth for inflation levels lower than the threshold, implying an ambiguous relationship. The results have important policy implications for monetary policy management as it provides a guide to set inflation targets to ensure a low inflation outcome is achieved as well as assist policy makers prioritise policy objectives given the level of inflation and multiple monetary policy objectives including economic growth and employment, and price stability.

1 Introduction

A considerable amount of theoretical and empirical work has been dedicated to examining the relationship between inflation and economic growth due to its importance to monetary policy as well as broader macroeconomic policies. In particular, low inflation has widely been accepted as a vital condition for fostering economic growth. On the contrary, high inflation is viewed to be detrimental to the economy as it weighs on society's welfare, distorts the efficiency of resource allocation, increases intermediation costs, and thus restraints financial development. Furthermore, it adversely impacts on export competitiveness of a country, thus balance of payments and eventually economic growth in the longer term (Feldstein,1982; Ocran,2007; Khan and Senhadji,2001). In addition, inflation could raise the cost of capital, impact borrowing and lending behaviour, affect investment and consumption decisions and hence, restrain economic growth (Feldstein,1982).

Condition on this notion that low inflation is conducive for stimulating economic growth whilst higher inflation is harmful for growth, it is then natural to pose the question, what is the level of inflation that is tolerable for an economy? Alternatively, what is the optimal level of inflation that is consistent with promoting growth and not growth-hindering? What is the level of inflation where it starts to inhibit economic growth? Many recent empirical studies have attempted to answer these critical questions which trickles down to this specific question, does economic growth and inflation have a long-run non-linear relationship. The existence of a non-linear relationship between the inflation and economic growth would mean that there exist an inflexion point or threshold whereby at levels lower than the threshold, inflation could have a positive (or no effect) on growth but levels higher than the threshold point, inflation could have adverse effects on economic growth. Fisher (1993) was the first to establish this non-linear relationship between inflation and economic growth where low inflation periods was associated with high economic growth but higher inflation periods was linked to lower growth outcomes. Sarel (1996) tested for this inflexion point, deemed as a structural break in the relationship between inflation and economic growth. He found the threshold point to be at 8.0 percent, which implied that at levels lower than 8.0 percent, the relationship between inflation and growth was positive but at levels higher than 8.0 percent, the relationship turned negative.

This study re-examines the nature of this relationship between inflation and economic growth in the case of Papua New Guinea. In particular, the paper attempts to answer the following questions:

(1) Is there a threshold level of inflation that exists in PNG where inflation affects growth differently at lower and higher levels?

(2) Is the established threshold level statistically significant and different from other threshold levels?

Although related literature is vast for both developed and developing countries, the study of this important relationship is non-existent in the case of Papua New Guinea (PNG) and limited for the Pacific Island Countries (PICs). To the author's best knowledge, this study is the first for PNG and second for the Pacific Island Countries (PICs) after Jayaraman et al (2013) estimated the inflation threshold rate for Fiji. Hence, this paper aims to fill the literature gap in PNG and the Pacific Islands region.

The answers to the research questions posed would have important implications for various players in the economy. For the Central Bank of PNG (BPNG), relevant policy-related questions could be: what is the comfortable or tolerable inflation at which the Bank can afford to accommodate without restraining the real GDP growth? What guide can be used to set an implicit inflation target or an explicit target for the Bank if the Bank decides to pursue an inflation targeting monetary policy regime?[1] The policy relevance of this question as far as the BPNG is concerned is reinforced by the recent amendments to the PNG's Central Banking Act 2000 to include promotion of employment and economic growth as part of the monetary objectives of the BPNG and the current high inflationary environment mainly induced by high global inflation.[2] Given such developments, the Bank could be faced with a policy dilemma of having to pursue the twin objectives of stabilizing prices as well as stimulating growth since the trade-off between the policy objectives is inevitable. Hence, it is critical to establish this inflation threshold level as it would be a guide to inform monetary policy of its confines, particularly, when choosing which monetary policy goals to pursue given the level of inflation.

The paper, following Khan and Senhadji(2001), employs the threshold regression model with annual PNG data from 1980 to 2020 to test if a threshold effect exists in the relationship between inflation and real GDP growth for PNG. In so doing, the paper applied the Ordinary Least Squares (OLS) with heteroscedasticity robust standard errors as the base econometric technique with robustness checks using the Two Stage Least Squares (2SLS) to conduct the empirical analysis. Further, the paper tested the sensitivity of the model results to different data frequencies and additional explanatory variables. The estimation results from the baseline model established a threshold level of inflation at 12.0 percent for PNG. At inflation levels lower than the threshold point, the relationship between growth and inflation is unclear as it is statistically insignifi-

[1]The BPNG currently does not have an explicit target for its inflation objective , nor does it have an endorsed implicit target, rather it broadly pursues low and stable inflation as part of its monetary framework. The exploration of the question, should BPNG have an explicit target for inflation has been explored by Kannapiran (2000) who recommended against PNG adopting the Inflation Targeting framework. Perhaps, this study can stimulate discussion surrounding the theme 20 years on. However, that is reserved for future studies.

[2]The PNG's Central Banking Act 2000 was amended in December 2021 in Phase 1 of the Review of the Central Bank with a series of amendments which among others included the widening of Bank's monetary policy objectives to include promotion of employment and economic growth alongside price stability. See link `https://www.bankpng.gov.pg/about-us/our-legislation`

cant. However, at levels higher than the threshold point, inflation has a negative impact on economic growth, consistent with prior expectations. Furthermore, the paper shows that the inflation threshold is imprecise with the estimation of the confidence interval to be in the range of 4.0-16.0 percent. The robustness test of sensitivity to different econometric approach and inclusion of the additional variable support the findings of the location of inflation threshold and the results related to the parameter estimations. On the contrary, the quarterly model produces an inflation threshold estimate of 7.0 percent, an untrustworthy estimate as both the parameter estimates associated with inflation and the inflation threshold dummy were statistically insignificant.

The findings provide important guide for the management of monetary policy in PNG. In particular, it would encourage the BPNG to strive to keep inflation levels below the threshold point as levels above it would have a negative effect on long-term economic growth. In addition, the BPNG can use the estimated inflation threshold as a guide when choosing an optimal or target level of inflation especially if the Bank decides to adopt an inflation-targeting monetary policy regime. Ideally, the Bank could take the inflation threshold as the target level. However, with the imprecision of the inflation threshold level, a single digit would be more appropriate. In addition, the Bank could use this as a yardstick to decide which policy goals to pursue or prioritise conditioned on the level of inflation. For example, at inflation levels lower than the inflation threshold point, both the employment and economic growth, and price stability objectives can be pursued concurrently. However, at inflation levels higher than the threshold point, policy priority should be geared towards controlling inflation as supposed to encouraging growth and employment, as the latter could have an adverse impact on long term economic growth.

The paper is structured as follows: Section 2 discusses the stylised facts of the overall trend of inflation and economic growth in PNG over the 40 year period. Section 3 discusses key theoretical and empirical literature with main emphasis on the literature in the developing countries. Section 4 presents the empirical section of the paper which includes data description, the underlying model and the methodology adopted. Section 5 outlines the main results and discusses the outcome of the robustness tests, Section 6 presents the main discussion of the results and highlights key policy implications and Section 7 concludes the paper.

2 Stylised Facts

Prior to conducting empirical analysis, it is imperative that we establish a qualitative account of inflation and economic growth for PNG. This serves the purpose of forming an economic narrative on the relationship between inflation and economic growth from which we can benchmark our econometric results against. The discussion does not claim to be comprehensive in nature, however, aims to bring clarity and flow to the events surrounding inflation and economic growth in PNG since 1975, and to substan-

tiate the statistical inferences that will be derived in the empirical section.

(1975-1993): Hard Kina Policy

Over this period, inflation was relatively stable and low with an average of 6.0 percent. The low inflation was largely due to the "hard kina" policy adopted by the government which entailed a mix of exchange rate (fixed exchange rate), fiscal and monetary policies framed amid an environment of high government spending with high import propensity, increased global inflationary pressures, full indexation of minimum wages to inflation and a relatively low public debt (Tumsok,2019). High inflation emanating mainly from the global economy was counteracted through a series of revaluations of the kina exchange rate against the Australian dollar and later a basket of key currencies (Money and Banking in Papua New Guinea,2007). Although the hard kina policy attained its macroeconomic objective of stabilising inflation, it was achieved at the cost of restraining potential growth of the economy with policies such as exchange rate appreciations which impede the competitiveness of PNG's dominant export sector. Consequently, the real economic growth also remained subdued during the period with exceptions in 1984, where growth jumped to about 11.0 percent backed by the start of production and export of copper and gold from the Ok Tedi mine, one of the large mines in PNG. Following this one off spike, growth surged again in the early 1990's, driven by a boom in the mineral and the agriculture/forest/fisheries sector (Yabom,2011). In particular, between 1991 and 1994, the economy grew by an average of 13.9 percent, an unprecedented and historically high growth in PNG. This growth outcome,unsurprisingly, did not translate to high inflation.

(1994-1997): Exchange Rate Devaluation, Asian Financial Crisis and El Niño

In September 1994, the kina exchange rate was devalued by about 12.0 percent against the US dollars with the hard kina policy scraped in October as the exchange rate was floated. This outcome was realised following years of government deficits and the deterioration of the foreign exchange reserves as the government was unable to defend the fixed exchange rate regime. This resulted in a substantial reduction in the value of kina which led to higher imported inflation. With a lagged effect of exchange rate devaluation, inflation climbed to an average of 14.5 percent between 1995 and 1996, the highest being in 1995 with an inflation level of 17.3 percent. This was the start of the historically high inflation period.

In addition, the balance of payments crisis of 1994 exerted a break on consecutive favorable economic growth in the preceding years. In fact, an average negative growth of 1.0 percent was recorded for the period between 1995 and 1997, where 1995 saw growth collapsed into negative territory, recovered in 1996 supported by the construction of Lihir gold mine and then largely regressed again in 1997, caused by the Asian Financial Crisis (AFC) and the El Niño drought which had an adverse impact on the country.

(1998-2003): Fiscal Mismanagement and Resource Projects Maturity

Inflation remained elevated, at about an average of 13.2 percent during this period mainly attributed to a combination of factors including the lagged effects of the AFC, the El Niño drought and further depreciation of the exchange rate. The economic growth remained subdued with an average growth of 1.7 percent over the period mainly attributed to the above factors including imprudent government spending and the end of construction for some major mining and petroleum projects such as the Lihir mine and Gobe petroleum fields. It was also noted that these events brought the economy to near collapse especially during the period 1997 to 1999, whereby, growth recorded an average marginal increase of 0.06 percent (Money and Banking in Papua New Guinea,2007).

(2004-2009): High Commodity Prices

In the earlier part of this period, particularly from 2004 to 2007, inflation was low with an average of about 1.8 percent mainly reflecting the strengthening of the kina exchange rate on the back of high commodity prices. However, inflation shot up in 2008 to about 10.8 percent as the effect of high global fuel and food prices intensified and fed through to the domestic economy. However, in 2009, with the onset of the Global Financial Crisis (GFC) and resulting global recession, global demand dampened and foreign inflation dipped, resulting in a turnaround of inflation to about 6.9 percent. The rapid increase in the global commodity prices resulted in favorable terms of trade outcome, hence, an increase in the export revenue which stimulated growth during this period. In nominal terms, annual GDP growth over this period increased, on average, by about 12.8 percent. However, accounting for inflation, the real GDP grew at an annual average of about 3.5 percent over the period.

(2010-2020): PNG LNG and Fiscal Deficits

In the recent decade, 2010 to 2020, inflation broadly stabilized around an average of 5.0 percent amidst several episodes of large macroeconomic shocks which include notably the construction of the US$19 PNG LNG project from 2011 to 2013. Although the project is the largest foreign direct investment in as far as PNG macroeconomy is concerned, surprisingly, it did not have much anticipated impact on inflation in PNG. In fact, during the construction period, inflation only averaged 4.7 percent as majority of the project construction materials as well as a large proportion of skilled labour were imported from overseas compared to the domestic share of construction inputs.[4] Economic growth over the decade averaged 4.5 percent, a somewhat similar magnitude as

[4]At the peak of the PNG LNG construction in 2012, foreign skilled labour constitute about 60.0 percent of the labour force. See link `https://devpolicy.org/png-lng-and-skills-development-20190327/`

inflation. Nonetheless, in 2014, the project exported its first LNG cargo, boosting the total exports double times the size at end of December 2013, that is, exports increased from about K3559.9 million to about K6826.0 million. Consequently, real GDP grew by 14.5 percent in 2014, after which growth remained subdued. This period broadly depicted a stable macroeconomic environment whereby inflation and economic growth somewhat trended together.

The trend of real GDP growth and inflation over the period 1980 to 2020 is depicted in Figure 1. Although the anticipated negative relationship between inflation and growth over the period is unclear from Figure 1, it can be noticed that from 1994-2003, inflation and economic growth moved in opposite directions. This is the period of historically high inflation growth in PNG. A more clear relationship can be seen from the scatter plots generated from non-linear functions including loess [5], quadratic and cubic fit. In all the three non-linear curve fitting, there is a tendency for real GDP growth rate to decline as inflation increases over certain threshold level, notably in the quadratic and cubic fits. In particular, for both the quadratic and cubic fit, the relationship seem to turn negative at around 7.5 percent level of inflation. It is too early to conclude the inflation threshold for PNG from mere inspection of the scatter plots. Instead, a scientific approach is required to establish such critical relationship between inflation and economic growth. This is undertaken in the empirical section of the paper.

3 Literature Review

This section conducts a brief review on both the theoretical and empirical literature surrounding the relationship between inflation and economic growth.

Theoretical literature

Standard economic theories established various predictions on the relationship between inflation and economic growth. The classical theory, also referred to as the quantity theory of money, predicts inflation to be a phenomenon attributed to an increase in the growth of money supply relative to its demand. The theory advocates for money neutrality in that money only affects the aggregate price level, but does not have any effect on real GDP growth in the long-run.The Keynesians, however, advocate a positive relationship between output and inflation under the Aggregate Demand (AD)-Aggregate Supply (AS) framework. In the short run, a shift in the aggregate demand

[5] loess is a locally weighted linear polynomial regression that fits data according to a set regression function. The polynomial is fit using weighted least squares, giving more weight to points near the point whose response is being estimated and less weight to points further away. For further information on the method, see the link `https://www.itl.nist.gov/div898/handbook/pmd/section1/pmd144.htm`

Figure 1: Inflation vs Real GDP Growth

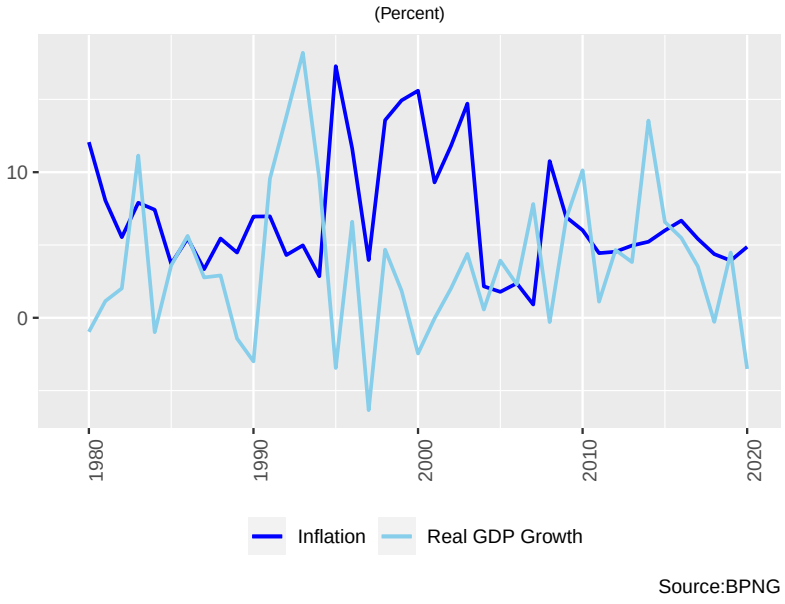
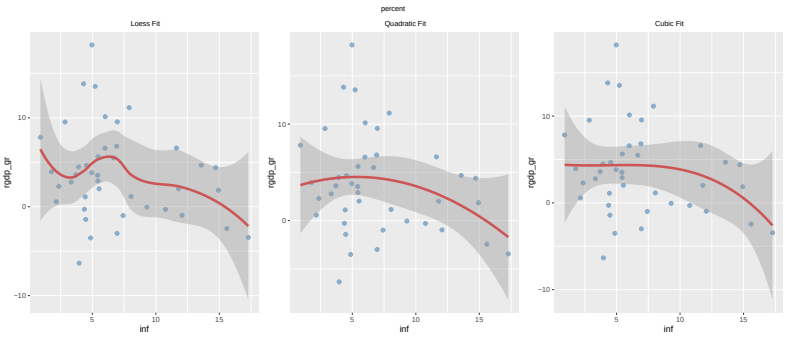


Figure 2: Scatter Plots of Inflation & Real GDP Growth



of the economy impacts on both the prices and output given an upward sloping AS curve (Fabayo and Ajilore,2006). However, in the long-run, efforts in stimulating the demand side of the economy only affects the price level rather than the output level as AS curve becomes vertical.

The neo-classicals predict a positive association of inflation and economic growth. Based on their portfolio management theory, they argue that agents take account

of their wealth by substituting the future consumption with current consumption. In fact, Tobin (1965) outlined the link between the variables suggesting that inflation induces economic growth when economic agents substitute money holdings for interest bearing assets which leads to high capital accumulation and economic growth. The neo-Keynesian economists propose that inflation is a result of the dynamics between the actual levels of output and unemployment. An upward pressure on inflation eventuates when actual output level exceeds its potential level and unemployment is below its natural rate. This shifts the Phillips curve outward indicating a higher inflation with higher unemployment (Gordon,1997). For the monetarist, inflation persists when money supply increases faster than the economic growth. They argue against the Phillips's curve trade-off between inflation and growth with the proposition of wage adjustments in anticipation of future interest rate adjustments.

Finally, the endogenous growth theory which emphasises the long-run growth to be emanating from endogenous factors of production including improvement to technology, innovation and human capital, predicts inflation to have a negative impact on economic growth. Since higher rate of return of capital is crucial to support growth, inflation shifts demand from goods to leisure, thus driving down the return of human capital which then reduces the return to all capital and, thus, economic growth (Gillman et al,2001)
Drukker et al(2005) discusses some of these theoretical predictions and asserts that a sizeable amount of theoretical models in the literature relating to money and growth are focused on assessing the relationship between inflation and long-run economic growth. The authors briefly discussed the theoretical predictions of the relationship between inflation and growth which includes: (1) super-neutrality of money, that is, inflation does not have any effect on growth. This was first established by Sidrauski (1967) who showed that in an optimal control framework with money in the utility function, money is neutral and super-neutral.(2) Money is a substitute for capital, according to Tobin (1965). Hence, it has a positive effect on economic growth, especially in the long run.(3) The cash in advance model posited by Stockman (1981) advocates that since money is complementary to capital, it predicts a negative relationship of inflation and long-run growth. (4) The recent class of models support the hypothesis of a non-linear relationship between inflation and growth. That is, inflation only turns negative when it falls above a threshold level of inflation. In such models, the efficiency of the financial market is distorted by various information asymmetries. In this case, high inflation could induce frictions in the financial markets, causing inefficiencies in the financial system and thus, restrain overall economic growth.

Empirical literature

The empirical literature on the relationship between inflation and economic growth is abundant across both the developed and developing countries. Some of the earlier work mainly concentrated on cross-country panel studies which were mainly supported by their ability to generalize empirical findings and their strong appeal for policy im-

plication. In contrast, recent studies particularly in the developing countries focus on single country to capture heterogeneous factors pertaining to different countries.

One of the first to explore the potential non-linearities in the relationship between inflation and economic growth is by Fisher(1993). In his landmark work, Fisher(1993) used both cross-section and panel data from a sample which included both the developed and developing countries and found evidence of non-linearities in relationship between inflation and growth. He arbitrarily chose break points of 15.0 percent and 40.0 percent in his spline regression and established not only the non-linear relationship of the variables, but also show that the strength of the relationship softens as inflation exceed 40.0 percent level. Sarel (1996) undertook a panel data study on 87 countries during the period from 1970-1990 and found evidence of a structural break in the relationship when inflation level was at 8.0 percent. Inflation levels above 8.0 percent had an adverse and significant impact on growth while levels below 8.0 percent had none or slight positive impact. Gosh and Phillips (1998) employed panel data covering all IMF member countries over the period 1960-1996 and found evidence of a positive association between inflation and growth at very low inflation rates of less than 2.0-3.0 percent. However, at higher level of inflation, a negative relationship was found. Khan and Senhadji(2001) used an unbalanced panel dataset from 140 industrialized and developing countries for the period 1960-1998 to examine the issue of the existence of threshold effects of inflation and growth. The study revealed the existence of inflation threshold beyond which inflation-growth relationship turns negative. These threshold levels were found to be 1.0-3.0 percent and 7.0-11.0 percent, respectively, for industrialized and developing countries. Gillman et al (2002) investigated the inflation-growth relationship under the framework of the endogenous growth model with a panel data for the Organization for Economic Cooperation and Development(OECD) and Asia-Pacific Economic Cooperation (APEC) countries over the period 1961-1997. They found evidence of negative relationship between inflation and growth for both the OPEC and APEC countries and further established that single-digit inflation levels can have positive effect on economic growth. In a more recent study, Kremer et al (2009) employed panel data for 124 industrial and non-industrialised countries with a new dynamic panel threshold model during the period from 1950-2004 to shed new light on the impact of inflation on long-term economic growth. The study established the inflation threshold to be about 2.0 percent for industrialised countries and 17.0 percent for non-industrialized countries. For the non-industrialised countries, the impact of inflation on growth remains insignificant,thus,contradicting the notion of growth-enhancing effects of inflation in developing countries.

In their concluding remarks, Kremer et.al (2009) emphasised that the findings for the developing countries may be attributed to the restrictive assumption of whether a country is industrialised or not, and that it lacks accounting for country specific factors especially for the non-industrialized countries which are heterogeneous by structure. This view is supported by Lin and Ye (2009) who noted that effectiveness of inflation targeting in developing can be affected by country-specific characteristics. Many

empirical literature in the recent years have embarked on addressing this gap by undertaking single country empirical studies, some of which are discussed here.

Hodge(2005) explored two critical issues on the inflation-growth relationship for South Africa, that is, whether the country data support the negative relationship between inflation and economic growth in long term that has been widely established by prior cross-sectional studies, and whether there is a trade-off between inflation and growth, especially at higher levels of inflation in the short term. The study finds that inflation impedes growth in the long-term, consistent with prior view while economic growth above its trend is associated with higher inflation. In other words, Hodge(2005) suggests that if above trend growth is to be pursued as an objective, inflation targeting in South Africa should be abandoned, although this would be counterproductive over the longer term as negative relationship between inflation and growth emerges.Fabayo and Ajilore (2006), adopted the inflation threshold model employed by Khan and Senhadji (2001) and the data from the period 1970-2003 to examine the existence of the threshold relationship between inflation and economic growth for Nigeria. They established an inflation threshold of 6.0 percent below which inflation has significant and positive effect on growth while above the threshold, inflation restraints growth. Frimpong and Oteng-Abayie(2010) also deployed the threshold regression model to test the existence of inflation threshold for Ghana using the data from the period 1960-2008. The authors used growth rate of gross domestic investment as a proportion of GDP, terms of trade, aggregate labour force and money supply as control variables together with inflation and economic growth to conduct the empirical tests. They find the inflation threshold to be 11.0 percent with implications that inflation levels above it largely impacts negatively on growth while the levels below it have mild effect on growth. The authors concluded with the support of the current medium term inflation target of Ghana 6.0-9.0 percent annual average set by the Bank of Ghana as it is below the inflation threshold estimate.

Hussain(2005) and Mubarik(2005) both examined inflation and growth for Pakistan for the periods 1973-2005 and 1973-2000, respectively, and found inflation threshold estimates to be 4.0-6.0 percent and 9.0 percent, respectively. In the same vein, Singh and Kalirajan (2003) uncovered the inflation threshold range of 4.0-7.0 percent for India. In Bangladesh, Ahmed and Mortaza(2005) finds a statistically significant long-run negative relationship between inflation and economic growth using the data covering the period 1980-2005. They employed the cointegration and error correction models and estimated the inflation threshold level to be 6.0 percent, beyond which inflation hurts economic growth.

Literature on the relationship between inflation and economic growth, in particular, the estimation of inflation threshold in the Pacific Island Countries (PIC's) is sparse. From the authors best knowledge, the only study which examined the existence of inflation threshold was done for Fiji by Jayaraman et al (2013). This is despite other studies such as Gokal and Hanif(2004) who undertook a simple correlation estimation

between inflation and growth for the period 1970-2003, and established a weak linear and negative relationship between inflation and economic growth for Fiji. Although the authors highlighted the possibility of the existence of a threshold level of inflation for the case of Fiji, they did not explore it further. Jayaraman et al (2013) filled the gap for Fiji by extending the bivariate relationship with the inclusion of additional explanatory variables to determine the threshold level of inflation for Fiji. With the employment of annual data from 1970-2008 and the nonlinear least squares econometric technique, the authors, in following the estimation approach by Sarel(1996) and Khan and Senhadji(2001), established 3.6 percent as the inflation threshold for Fiji. Above this threshold level, inflation has negative impact on growth whilst inflation levels below the threshold were found to have positive effect on economic growth.
For PNG, although the study on the inflation-growth threshold is presently none existent, there are other past studies on the relationship between inflation and economic growth. For instance, Gani(1997) analysed a simple economic growth model for PNG for the period 1970-1992 with the inclusion of physical investment, human capital, exports , exchange rate, inflation and government consumption among others to establish determinants of economic growth for PNG. In summary, the results show that exports and stable exchange rate affect growth positively while high inflation and government consumption reduces economic growth. In addition, factors such as investment in physical and human capital were insignificant in influencing growth whilst there is weak evidence of external economic conditions and social and political instability of the having adverse effects on economic growth. Aba and Vellodi (2013) estimated a Philips curve to examine the impact of domestic demand on inflation in PNG. Using quarterly data for the period 1996-2011, they adopt a basic Auto Distributed lag (ADL) model to estimate the Philips curve for PNG which depicts the relationship between inflation and growth. The study confirmed a positive relationship of domestic demand represented by a constructed output gap and inflation, although inflation is dominantly influenced by external factors such as the exchange rate and foreign inflation. The long-run pass-through of the output gap to inflation approximates to around 30.0 to 60.0 percent. Further, output gap featured prominently in certain period such as 2007-2009 underpinned by fiscal expansion. Direye (2019) extended the work of Aba and Vellodi (2013) by testing the impact of food and oil price shock on domestic inflation. Among other key insights, Direye (2019) found output gap shock to explain some variation in inflation, hence, as part of his conclusion he stated that weak demand conditions could contribute to disinflation in PNG. Given non-existence of an estimation of a threshold inflation level for PNG and very limited studies within the PICs, this paper attempts to fill the literature gap.

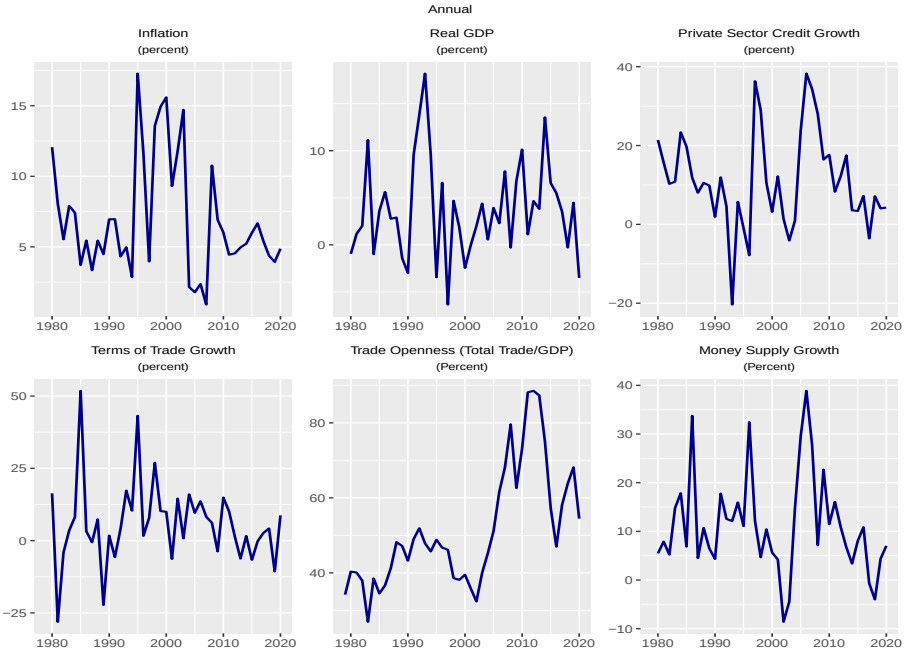
4 Data and Methodology

4.1 Data

The data used in the study are all in annual frequency and are sourced mainly from the Bank of PNG's Quarterly Economic Bulletin (QEB) tables. Other data sources

the include the National Statistics Office(NSO), World Development Indicators (WDI) database of the World Bank and the IMF's International Financial Statistics (IFS) database. The period of study is from 1980 to 2020 and depend largely on the availability of data. The variables employed for the analysis includes inflation, real GDP growth, private sector credit growth, growth in the terms of trade, trade openness and money supply growth. Inflation is the annual growth rate of Consumer Price Index (CPI) supplied by the NSO. Real GDP growth is the growth rate of nominal GDP deflated by CPI with a base period of 2016 and is provided by NSO. Private sector credit growth is the total loans extended by the commercial banks to the private sector firms and individuals.Terms of trade growth is the growth rate of the ratio of export price index over import price index. Whilst the export price index is sourced from BPNG QEB tables, the lack of import price index data mean that we construct the import price index as the import-weighted export price index of PNG's major importing countries which includes Australia, the United States and Singapore among others. Trade openness is computed as the ratio of total trade (total imports and exports) to nominal GDP. The trend of the variables are displayed in Figure 3.

Figure 3: Trend of variables



4.2 Model

A threshold regression model developed by Khan and Senhadji(2001) is employed for the analysis of the threshold level of inflation for PNG. The model is based on the theoretical underpinnings of the GDP growth model. The model is specified as follows:

$$rgdp_t = \alpha_0 + \alpha_1\pi_t + \alpha_2 D_t * (\pi_t - \overline{\pi}) + \alpha_{1i} X_{i,t} + \varepsilon_t \tag{4.1}$$

Where, $rgdp_t$ is the real GDP growth rate, π_t is the inflation level, $\overline{\pi}$ is the threshold level of inflation, $X_{i,t}$ are other control variables, $\varepsilon_{i,t}$ is the i.i.d error term and $\alpha_0....\alpha_{1i}$ are coefficients of the model.
D_t is the dummy variable where:

$$D_t = \begin{cases} 1, & \text{if } \pi_t > \overline{\pi} \\ 0, & \text{otherwise} \end{cases} \tag{4.2}$$

The selection of the control variables $X_{i,t}$ is based on the growth theory and empirical literature as well the structural underpinnings of PNG economy. Although growth literature have identified numerous potential growth factors, the paper has selected limited factors as control variables as adding extra factors in the model could lead to over-fitting of the model given a small sample size for estimation. Further, inclusion of additional variables could potentially result in the problem of multicollinearity which may render results to be unreliable and distort correct statistical inferences from the results. These variables include trade openness, growth rate of terms of trade, investment growth and financial development. Prior to estimation of the model using econometric techniques, we discuss the theoretical expectations of the signs of model coefficients especially for the controlled variables.

The trade openness is expected to positively influence growth for a small open economy such as PNG, who largely depend on foreign goods and services for its domestic economic activities. In particular, the inflow of capital goods and technology can enhance productivity and growth in the domestic economy. Barro and Sala-i-Martin (1997) and, Rivera-Batiz and Romer (1991) have shown that positive economic growth can be achieved in the long-run through trade openness as it provides access to goods and services, promote efficient resource allocation and improve productivity through diffusion of much needed technology, skills and knowledge. Although general consensus on the relationship between trade openness and economic growth is a positive one, a negative relationship can be possible especially for countries who have competitive advantage in the production and export of low-quality goods (Haussman et al,2007). This could apply to PNG as a large proportion of its exports constitute of primary products, particularly, commodity exports, hence, it is vulnerable to an adverse terms

of trade shock, which could translate to a regression of economic growth. Movements in terms of trade, that is, prices of imports and exports, is critical to trade, hence, long-run economic growth of PNG due to the fact that PNG is a commodity-exporting as well as an import-dependent economy. Consequently, higher terms of trade ratio would imply either an increase in relative export price or a decline in the import price or a combination of both. Aipi (2012) observed that the overall increasing trend of terms of trade for PNG has largely been due to high export prices relative to the import prices, underpinned by the increasing mineral commodity prices. Higher terms of trade has been beneficial for PNG as it results in increased inflows of export revenue to the government and impacts on growth. On the flip side, large negative terms of trade shocks could have adverse effects on balance of payments and trade, and overall economic growth. Hence, we expect a positive association of the growth rate of terms of trade and economic growth. However, a negative relationship between the variables cannot be ruled out for PNG especially if sustained positive terms of trade shocks appreciates domestic currency, thus, deteriorate the non-tradable sector and export competitiveness of the country.

Investment growth is proxied by the private sector credit growth as there is lack of available data for the gross fixed investment in PNG for the recent period.[6] An increase in private sector credit growth in developing countries like PNG provides much needed capital for investments, which in turn leads to higher economic growth in the medium to long term, as well as stimulates consumption behaviour of households and firms. Hence, we expect a positive association between private sector credit growth and economic growth. In the same vein, we expect a positive association between financial development proxied by the growth of total money supply, and economic growth. In many growth literature,especially for the developing counties, financial development is pivotal for economic growth as it provides the necessary financial resources and capital to enhance business and economic activity. An efficient and robust financial system ensures efficient allocation of resources to productive use, hence, promote growth.

4.3 Methodology

Following the threshold regression approach of Khan and Senhadji (2001), we first estimate an econometric model using the standard ordinary least squares(OLS) with heteroscedasticity robust standard errors.[7]. In search of an appropriate specification of the model and using equation 4.1, we estimate about 14 different equations varied by different combinations of the control variables. The accepted model specification is based on the adjusted R-squared of the estimated models and is expressed in equation

[6]The compilation of Gross Fixed Investment under the expenditure method of GDP compilation by the National Statistics Office for PNG was discontinued in 2006.

[7]Although heteroscedasticity does not produce biased OLS coefficient estimates, if not accounted, it could render statistical inferences untrustworthy as it biases the variance-covariance matrix, in turn affecting t-statistics and F-statistics produced by the model

4.3:

$$rgdp_t = \alpha_0 + \alpha_1\pi_t + \alpha_2 D_t * (\pi_t - \overline{\pi}) + \alpha_3 mon_t + \alpha_4 cred_t + \alpha_5 open_t + \varepsilon_t \qquad (4.3)$$

We subsequently estimate equation 4.3 with parameter values of $\overline{\pi}$ ranging from 1.0 percent to 15.0 percent, close to 17.0 percent which is the maximum level of inflation for PNG over the study period 1980-2020. $\overline{\pi}$ is arbitrarily chosen and inputted into the model for estimation of the optimal $\overline{\pi}$ which is the value that minimizes the residual sum of squares (RSS) of the estimated model or alternatively, maximizes the adjusted R-squared statistics of the estimated model. The approach is described in a compact notations in equation 4.4:

$$rgdp_t = X\beta_\pi + \varepsilon, \qquad \pi = 1, 2, ..., 15 \qquad (4.4)$$

Where, $rgdp_t$ is the real GDP growth rate, X is the matrix of observations on the explanatory variables, β is the vector of coefficient parameters including $\alpha_0, \alpha_1, \alpha_2 ..... \alpha_5$, π is the threshold level of inflation and $\varepsilon_{i,t}$ is the i.i.d error term. The indexation of coefficient vector β by π depicts its dependency on the threshold level of inflation which ranged from 1 to 15. In our model, the residual sum of squares is defined as $S_1(\pi)$ with the threshold level π. The optimal threshold inflation level,$\overline{\pi}$, is achieved when the function $S_1(\pi)$ is minimized, that is:

$$\overline{\pi} = argmin\{S_1(\pi), \pi = 1, 2, ...15\} \qquad (4.5)$$

The parameter, $\overline{\pi}$, which represents the inflation threshold level, has the following property with respect to coefficient interpretations. (1) when π_t is greater than $\overline{\pi}$, the estimated coefficient on inflation would be interpreted as $\alpha_1 + \alpha_2$, that is, high inflation exists. (2) when π_t is less than $\overline{\pi}$, the estimated coefficient on inflation would be interpreted as α_1, that is, low inflation exists. While inflation levels above the threshold level, $\overline{\pi}$, is expected to have a negative impact on economic growth, inflation levels lower than the threshold level could have a positive impact on inflation. However, many studies have established that the relationship of inflation and growth at levels lower than the threshold point have not always been positive as theoretically expected, rather ambiguous or sometimes negative. Nonetheless, in general, we expect to see a non-linear relationship between inflation and economic growth for PNG.

Prior to the OLS estimation, we check for stationarity in the variables through the application of the Augmented Dickey Fuller (ADF) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) unit root tests. This is to ensure that the model is stable and that it does not produce spurious results which could render statistical inference untrustworthy. Further, we employ the Granger-causality test to establish the direction of causality

between inflation and economic growth, which the result, is critical to qualify inflation as an explanatory variable to growth.

In the post-model estimation, we first ascertain the estimated inflation threshold by employing the likelihood ratio test to test the statistical significance of coefficient associated with the dummy interaction inflation threshold variable. This implies testing the null hypothesis $H_0 : \alpha_2 = 0$ in equation 4.3. This is done since under the null hypothesis that threshold inflation is not identified and that standard tests such as t-test assume non-standard distributions which could lead to inaccurate statistical results and inferences. Following Khan and Senhadji(2001), we apply bootstrap approach to simulate an asymptotic distribution of the following likelihood ratio test of H_0.

$$LR_0 = \frac{(S_0 - S_1)}{\widehat{\sigma}^2} \tag{4.6}$$

Where, S_0 and S_1 are the residual sum of squares under $H_0 : \alpha_2 = 0$, and $H_1 : \alpha_2 \neq 0$, respectively; and $\widehat{\sigma}^2$ is the residual variance under H_1. In other words, S_0 and S_1 are the RSS for 4.1 without and with threshold effects, respectively.

Furthermore, we ascertain the precision of the inflation threshold estimate, that is, we establish if the estimate is significantly different from other threshold levels. In other words, we apply confidence interval around the threshold estimate. This entails testing the hypothesis $H_0 : \overline{\pi} = \pi_1$. In order to test this hypothesis, the following likelihood ratio test is computed:

$$LR_1(\pi_1) = \frac{(S_1(\overline{\pi}) - S_1(\pi_1))}{\widehat{\sigma}^2} \tag{4.7}$$

Where, $S_1(\overline{\pi})$ and $S_1(\pi_1)$ are the residual sum of squares from equation 4.1 with threshold $\overline{\pi}$ and π_1, respectively; and $\widehat{\sigma}^2$ is the residual variance from equation 4.1 with threshold $S_1(\pi_1)$. It is important that we differentiate LR_0 and LR_1, that is, LR_0 tests the existence of a threshold effect while LR_1 tests the equality of two potential thresholds. Hansen(2000) shows the approach to estimating the α percent critical value as $c(\alpha) = -2log(1 - \sqrt{1 - \alpha})$. The hypothesis test $H_0 : \overline{\pi} = \pi_1$ is rejected at the asymptotic level α if $LR_1(\pi_1)$ is greater than $c(\alpha)$.

Finally, we deploy few approaches to check the robustness of the estimated results which included, testing the sensitivity of the results to different estimation methods, sensitivity to data frequency and sensitivity to additional explanatory variable.

5 Estimation and Results

5.1 Main Results

We first present the summary of the unit root test results for both the ADF and KPSS tests for all the variables in levels in Table 1. The null hypothesis of the ADF test is that the variables are stationary while the KPSS is that the variables have a unit root, that is, they are non-stationary. Hence, a rejection of null hypothesis under the ADF test implies that the series is stationary while a rejection of the null hypothesis under the KPSS test means that the variables are non-stationary, that is, they are devoid of unit root process. The results presented in Table 1 show that for the ADF test, all variables appear to be stationary except the trade openness for models with both the drift and trend. The KPSS unit root test results confirm most of the ADF test results but also revealed trade openness to be a trend stationary variable. [8]

Table 1: Unit Root Test Results

Variable	ADF Test Statistics		KPSS Test Statistics	
	Drift	Trend	Drift	Trend
open	-1.88	-2.36	0.66***	0.08
cpi_dlog	-3.35**	-3.30*	0.12	0.11
rgdp_dlog	-3.44**	-3.39*	0.06	0.05
tot_dlog	-4.06***	-4.13**	0.10	0.10
mon_dlog	-3.21**	-3.37*	0.13	0.07
cred_dlog	-3.55**	-3.50**	0.07	0.07

Next we employ the Granger causality test to establish the directional causality between inflation and real GDP growth. Of particular interest is the direction of influence from inflation to real GDP growth, we test if the lagged values of inflation have an impact on real GDP growth. The result would justify the use of inflation as an explanatory variable in equation 4.1. Using annual inflation series, there was no evidence that inflation Granger-Causes real GDP or otherwise [9]. Notwithstanding this result, we employ the quarterly data for inflation and GDP growth to see if results is unbiased across different data frequencies. We find evidence of the unidirectional Granger causality running from inflation to real GDP at lag 3 as depicted in Table 2.

Subsequent to the Granger-causality analysis and unit root tests, we estimate the model using OLS, correcting for potential issue of heteroscedasticity that may arise. The full

[8] Note that 1.0, 5.0, and 10.0 percent critical values for ADF test for variables with drift is -3.58,-2.93 and -2.60 percent, respectively, and for variables with a trend is -4.15, -3.50 and -3.18, respectively. Similarly, the 1.0, 5.0, and 10.0 percent critical values for KPSS test for variables with drift is 0.35,0.46 and 0.57 percent, respectively, and for variables with a trend is 0.12, 0.15 and 0.18. The asterisks *,**, and ***, respectively represents the variable to be statistically significant at 1.0,5.0 and 10.0 percent levels

[9] The result is available on request

Table 2: Pairwise Granger-Causality Test

	Null Hypothesis	F-stat	Pr(>F)	Decision
Growth-> Inflation	GDP Growth does not Granger-cause Inflation	0.693	0.558	Fail to Reject H0
Inflation->Growth	Inflation does not Granger-cause GDP growth	4.625	0.004	Reject H0

results of 15 estimated models based on arbitrary inflation threshold levels from 1.0 percent to 15.0 percent are presented in Table 5. We select, mod12 as the optimal model as it has the highest adjusted R-square of 0.311 compared to other models. This is the model that applied an inflation threshold level of 12.0 percent. The summary of the table with only the Residual Sum of Squares (RSS) is displayed in Table 3. The RSS from the table are minimized at the threshold inflation level of 12.0 percent. Table 5 also shows that the coefficient estimate for inflation (low inflation) is negative, but is not statistically significant while the estimate for inflation threshold dummy is negative and is statistically significant. The magnitude of the coefficient of low inflation is -0.123 while high inflation is -5.069 (-0.123 - 4.946). The results could imply that inflation levels above 12.0 percent could hurt real GDP growth in PNG more than the inflation levels lower than the 12.0 percent. However, the effect of inflation on GDP growth below 12.0 does not hold, hence, ambiguous as the associated estimated coefficient is statistically insignificant.

Table 3: Summary RSS for OLS and 2SLS

	OLS_RSS	2SLS_RSS
inf=1	686.06	752.39
inf=2	685.99	749.93
inf=3	698.31	784.83
inf=4	685.51	762.13
inf=5	648.17	725.46
inf=6	686.61	765.96
inf=7	679.55	763.55
inf=8	680.53	766.32
inf=9	678.21	764.50
inf=10	678.21	764.50
inf=11	659.65	740.36
inf=12	580.71	611.08
inf=13	619.00	760.84
inf=14	613.37	742.06
inf=15	645.71	767.59

To ascertain the significance of the coefficient estimate associated with the dummy inflation threshold term, we apply the likelihood ratio test with a zero constraint imposed on the dummy term. The result of the likelihood ratio test reports a χ^2 statistics

of 7.94 with a p-value of 0.0189, hence, a rejection of the null hypothesis. However, accounting for the Khan and Senhadji's(2001) argument of the distribution of LR_0 being non-standard which dominates the χ^2 distribution , we apply 1000 boostrap replications and generated a distribution of LR_0 and found a mean χ^2 statistics of 8.81 with a p-value of 0.097, which is still statistically significant at 10.0 percent level. This validates the results that inflation threshold effect is statistically significant and holds for the case of PNG.

Furthermore, we attempt to establish the precision of the inflation threshold estimate through the construction of a confidence interval. Figure 4 shows the confidence region for the threshold estimate. The area under the 7.35 critical value at 95.0 percent level of significance depicts the 'no rejection region' or the confidence interval. The result from the confidence region shows that the threshold estimate of 12.0 percent is not significantly different from a large number of other potential threshold level, implying that there is a substantial uncertainty about the threshold level. In fact, the confidence interval is computed to be between 4.0 and 16.0 percent.

Figure 4: Confidence Interval Construction for Threshold

5.2 Robustness Checks

We deploy few approaches to check the robustness of the above results which include; testing the sensitivity of the results to different estimation methods, to different data frequencies and sensitivity to additional explanatory variable.

Sensitivity to estimation techniques

For sensitivity to different estimation approach, we employ the Two Stage Least Squares (2SLS) to address the argument of potential endogeneity bias arising from the inclusion of inflation and investment (here proxied by private sector credit growth). For

inflation, Fisher(1993) argued that the problem of simultaneity bias may not be severe if the causality runs from inflation to GDP growth and not the other way around. We have established evidence of causality running from inflation to growth and not the other way around. Similarly, investment through the private sector credit growth is likely to be endogenous to growth as an increase in investment directly stimulates production and hence growth, whilst an increase in economic growth encourages increases in investments due to high return on investment. We partially correct for such endogeneity bias by applying the 2SLS method which is instrumented by the lags of the both the dependent and explanatory variables including the lag of inflation, trade openness, credit growth, terms of trade and money supply. Also included are the inflation dummy threshold. The results of the 2SLS model are consistent with the results from the Ordinary Least Squares(OLS). Specifically, 2SLS also established 12.0 percent as the threshold level of inflation. The summary RSS of the 2SLS model is presented together with the OLS model in Table 3 while the full model result is presented in Table 6.

Sensitivity to additional explanatory variables

According to the endogenous growth theory, any factors that improves efficiency in the economy is critical to growth. To test this, and to see if above results are robust with the inclusion of additional explanatory variables, we include the growth of terms of trade as an additional explanatory variable. Growth rate of terms of trade has been included in other past studies such as Khan and Senhadji (2001) as one of the key control variable of the inflation threshold model. It has also been established to be an important factor for economic growth for PNG. The estimation results as displayed in Table 7 is consistent with the results of the base model. In particular, the location of the threshold is estimated to be at 12.0 percent as the adjusted R-squared is maximised with a value of 0.303. In addition, the signs and magnitude of the coefficient estimates of inflation and inflation threshold dummy are consistent with the base model.

Sensitivity to data frequencies

We employ quarterly data from the period 1980Q1-2020Q4 to examine how different data frequency affects the location and the magnitude of the threshold effect and the estimation results of 4.1. The summary results of the threshold estimate of the robust OLS model run with the quarterly data including the respective RSS is presented in Table 4 while the full model estimation result is presented in Table 8. The results differed markedly, that is, the inflation threshold level is now estimated to be 7.0 percent compared to 12.0 percent estimated with the annual data. The signs of the coefficient are opposed to prior expectations, that is, the coefficient associated with lower inflation is negative while the coefficient associated with the inflation threshold dummy is positive. Furthermore, the coefficient associated with the threshold effect is not statistically significant, hence, we can conclude here that the threshold effect is not found when we employ quarterly data.

Table 4: Summary RSS for OLS and 2SLS

	OLS_RSS	2SLS_RSS
inf=1	3478.12	3515.98
inf=2	3489.80	3527.49
inf=3	3485.94	3520.55
inf=4	3360.16	3394.10
inf=5	3450.96	3485.02
inf=6	3382.56	3403.21
inf=7	3253.28	3286.96
inf=8	3324.06	3364.43
inf=9	3373.56	3410.68
inf=10	3370.67	3408.42
inf=11	3371.79	3411.82
inf=12	3375.88	3391.80
inf=13	3345.05	3393.53
inf=14	3350.64	3400.44
inf=15	3434.88	3469.55

6 Discussion and Policy Implication

The key results from the empirical analysis provides evidence of the existence of inflation threshold level for the case of PNG. In particular, the study established the inflation threshold to be at 12.0 percent. Although the impact on growth is as anticipated for higher level of inflation, that is, it adversely impacts growth at inflation levels beyond 12.0 percent, its impact at inflation levels lower than 12.0 percent is statistically insignificant and therefore, ambiguous. That is, it can either have positive or negative impact on growth at lower levels. The ambiguity in the relationship in the inflation levels lower than the threshold is not an isolated case as other studies have also found similar results. For example, Mubarik(2005) uncovered a statistically insignificant relationship of inflation and economic growth at levels lower than the threshold level. To interpret the coefficient estimate of the inflation threshold levels higher than 12.0 percent, a 1.0 percent increase in inflation induces an average 5.1 percent decline in real GDP growth, holding all other factors constant. [10]

The results on inflation threshold level is consistent with the historical accounts of inflation in PNG as discussed in the section on stylised facts. Notably during the period 1995-2003, inflation largely hovered above the 12.0 percent inflation threshold, aver-

[10]We further contextualize these interpreted results and enhance clarity using a hypothetical scenario. Given an inflation level of 12.0 percent in the current year, an increase in 1.0 percent in the following year implies a 0.12 percentage point increase to 12.12 percent by the end of the following year. Correspondingly, real GDP growth,if assumed to be at 4.0 percent in the current year, would decline by an average of about 0.2 percentage point to about 3.8 percent in the following year, keeping all other variables unchanged.

aging about 12.5 percent. On the other hand, real GDP growth recorded its lowest average of 0.8 percent over the same period, which is historically the lowest growth period in PNG. This clearly depicts a negative relationship of inflation and growth, especially for higher inflation in PNG. In addition, the negative relationship of inflation and growth, especially, at higher levels, is substantiated by the past findings of Gani(1997) who found high inflation to be detrimental to economic growth in PNG.

The threshold estimate of 12.0 percent is not unique to PNG as some key past studies for the developing economies have established the inflation thresholds to be around this level. For example, Khan and Senhadji (2001) found the threshold level of inflation for the industrial countries to be within the range of 1.0-3.0 percent while for the developing countries to be around 7.0-11.0 percent. Further, Kremer et al (2009) also found the threshold level for the industrial countries to be 2.0 percent and 12.0 percent for the developing countries. Apart from the above two studies which confirmed that results using a panel data approaches for group of countries, studies based on individual countries which accounted for intrinsic country characteristics particularly for the developing countries have also shown evidence of inflation threshold to be around the established 12.0 percent range. For instance, Frimpong and Oteng-Abayie (2010) undertook a similar study for Ghana and found evidence of the inflation threshold to be at 11.0 percent whilst Bawa and Ismaila (2021) provided evidence of inflation threshold at 13.0 percent for Nigeria, thus, supporting the 12.0 inflation threshold estimate for PNG.

On the precision of the inflation threshold, the study established that there is uncertainty still surrounding the inflation threshold estimate of 12.0 percent. This is reflected by the confidence interval of the inflation threshold which is between 4.0 percent and 16.0 percent. However, we can find comfort that this result is no different to most developing countries where the confidence interval is relatively wide which implies that the threshold estimate for developing countries is broadly imprecise. In addition, many developing countries studies having a wide range of inflation threshold estimates varying from single digits to double digits. For instance, Khan and Senhadji(2001) estimated a confidence interval of 1.0 percent to 20.0 percent for the developing countries.

The findings of the paper have some important policy implications for monetary policy and macroeconomic management. First, the inflation threshold estimate provides an important guide for the management of monetary policy as it would encourage the Bank of PNG to strive to keep inflation levels below the threshold level, more preferably at single digits as inflation levels above the threshold would endanger the long-term economic growth of the country. Second, the inflation threshold can be used as a guide when choosing an optimal or target level of inflation, either explicitly or implicitly. Ideally, the Bank could take the inflation threshold as the optimal level. However, with the imprecision of the inflation threshold level, that is, a confidence interval of 4.0-16.0 percent, a single digit would be more appropriate. Finally, with the recent amendment to include promotion of employment and economic growth as the Central Bank's monetary policy objective, the Bank could find this result as a guide to decide

which goals to pursue or prioritise given the level of inflation. At inflation levels lower than the inflation threshold, both the employment and economic growth, and price stability can be pursued. However, at inflation levels higher than the inflation threshold, policy priority should be geared towards controlling inflation given the potential it has to negate long term growth.

7 Conclusion

We employ annual country-specific PNG data for the period 1980-2020 to estimate an inflation threshold for Papua New Guinea. Following the threshold regression approach by Khan and Senhadji(2001), the study established the threshold level of inflation to be at 12.0 percent. This means that at inflation levels above the threshold level, inflation adversely impacts on real GDP growth. However, the relationship of inflation and growth at levels lower than the threshold level is ambiguous, that is, it could either have a positive or negative impact on growth. Further, the study established a confidence interval of 4.0-16.0 percent for the threshold level, thus reflecting the imprecision of the threshold level which is prevalent in the related studies for developing countries. The results have crucial policy implications for the management of monetary policy as it provides a benchmark through which the price stability objective or target can be measured against. If the monetary authority, the Bank of PNG, decides to pursue an inflation targeting regime of monetary policy, a single digit inflation level below the inflation threshold could be used as an inflation target as a price stability objective. Furthermore, with the recent amendment to the Central Banking Act 2000 to include employment and growth as key monetary policy objectives together with price stability, the inflation threshold would be a guide when deciding which policy objectives to be given priority considering the policy trade-offs and the level of inflation.

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Table 5: OLS (with robust se) estimation results

	Dependent Variable: Real GDP Growth Rate														
	mod1	mod2	mod3	mod4	mod5	mod6	mod7	mod8	mod9	mod10	mod11	mod12	mod13	mod14	mod15
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Constant	6.790**	11.560***	4.750	5.169	4.107	0.825	1.022	0.675	1.211	1.211	1.527	1.379	0.646	0.727	1.184
	(2.970)	(3.780)	(5.794)	(5.080)	(4.426)	(4.016)	(3.258)	(3.165)	(3.170)	(3.170)	(2.877)	(2.776)	(2.876)	(2.833)	(2.757)
cpi_dlog	−0.213	−5.491***	−1.442	−1.256	−1.043	0.149	−0.015	0.153	0.044	0.044	−0.170	−0.123	0.020	0.018	−0.085
	(0.214)	(1.073)	(2.563)	(1.352)	(1.192)	(0.748)	(0.617)	(0.476)	(0.415)	(0.415)	(0.296)	(0.232)	(0.255)	(0.203)	(0.197)
mon_dlog	0.153***	0.155**	0.168**	0.150**	0.140**	0.172***	0.172***	0.176***	0.178***	0.178***	0.206***	0.213***	0.204***	0.202***	0.193***
	(0.059)	(0.061)	(0.069)	(0.065)	(0.069)	(0.062)	(0.062)	(0.064)	(0.068)	(0.068)	(0.070)	(0.072)	(0.076)	(0.075)	(0.066)
open	0.054	0.054	0.053	0.044	0.069*	0.051	0.061	0.053	0.052	0.052	0.062	0.063	0.062	0.061	0.062
	(0.039)	(0.040)	(0.040)	(0.042)	(0.037)	(0.038)	(0.043)	(0.039)	(0.040)	(0.040)	(0.041)	(0.039)	(0.039)	(0.039)	(0.038)
cred_dlog	−0.209	−0.208***	−0.200**	−0.184**	−0.209**	−0.191**	−0.205**	−0.197**	−0.204**	−0.204**	−0.225***	−0.243***	−0.221***	−0.222***	−0.214***
	(0.079)	(0.081)	(0.083)	(0.078)	(0.087)	(0.087)	(0.088)	(0.083)	(0.084)	(0.084)	(0.079)	(0.072)	(0.080)	(0.078)	(0.077)
d1:f1															
d2:f2		5.276***													
		(1.054)													
d3:f3			1.192												
			(2.569)												
d4:f4				0.924											
				(1.360)											
d5:f5					0.547										
					(1.203)										
d6:f6						−0.612									
						(0.795)									
d7:f7							−0.644								
							(0.733)								
d8:f8								−0.815							
								(0.756)							
d9:f9									−0.994						
									(0.796)						
d10:f10										−0.994					
										(0.796)					
d11:f11											−1.543*				
											(0.802)				
d12:f12												−4.946***			
												(0.881)			
d13:f13													−4.610***		
													(0.863)		
d14:f14														−2.368***	
														(0.581)	
d15:f15															
Observations	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42
R^2	0.305	0.305	0.293	0.306	0.343	0.304	0.312	0.311	0.313	0.313	0.332	0.412	0.373	0.379	0.346
Adjusted R^2	0.208	0.186	0.171	0.186	0.231	0.185	0.194	0.192	0.195	0.195	0.217	0.311	0.265	0.272	0.255
Residual Std. Error	4.365	4.427	4.467	4.426	4.303	4.429	4.406	4.409	4.402	4.402	4.341	4.073	4.205	4.186	4.235
F Statistic	3.159**	2.560**	2.412**	2.566**	3.050**	2.553**	2.640**	2.628**	2.657**	2.657**	2.895**	4.082***	3.469***	3.554***	3.806***

Table 6: 2SLS estimation results

	Dependent Variable: Real GDP Growth Rate														
	mod1	mod2	mod3	mod4	mod5	mod6	mod7	mod8	mod9	mod10	mod11	mod12	mod13	mod14	mod15
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Constant	2.088	5.312	−1.651	1.027	−1.396	−3.509	−2.750	−2.961	−2.300	−2.300	−1.328	−1.726	−1.281	−1.304	−1.115
	(7.175)	(12.640)	(9.488)	(8.073)	(6.519)	(5.555)	(4.955)	(4.835)	(4.884)	(4.884)	(4.259)	(8.636)	(4.339)	(4.286)	(4.285)
cpi_dlog	−0.156	−3.673	0.068	−0.899	−0.162	0.626	0.297	0.339	0.194	0.194	−0.050	−0.032	−0.012	0.037	−0.052
	(0.232)	(7.944)	(3.633)	(2.036)	(1.453)	(1.025)	(0.757)	(0.551)	(0.513)	(0.513)	(0.379)	(0.501)	(0.321)	(0.279)	(0.261)
mon_dlog	0.114	0.116	0.135	0.136	0.180	0.174	0.164	0.163	0.152	0.152	0.157	0.272	0.108	0.115	0.110
	(0.169)	(0.177)	(0.201)	(0.174)	(0.167)	(0.172)	(0.160)	(0.161)	(0.170)	(0.170)	(0.180)	(0.545)	(0.167)	(0.165)	(0.166)
open	0.091*	0.090	0.088	0.069	0.077	0.069	0.081	0.081	0.083	0.083	0.087	0.090	0.084	0.081	0.087
	(0.054)	(0.055)	(0.058)	(0.062)	(0.058)	(0.060)	(0.063)	(0.055)	(0.055)	(0.055)	(0.054)	(0.060)	(0.055)	(0.053)	(0.054)
cred_dlog	−0.096	−0.097	−0.064	−0.055	−0.080	−0.057	−0.066	−0.061	−0.067	−0.067	−0.082	−0.198	−0.038	−0.047	−0.048
	(0.153)	(0.154)	(0.158)	(0.147)	(0.154)	(0.155)	(0.154)	(0.147)	(0.151)	(0.151)	(0.147)	(0.233)	(0.141)	(0.137)	(0.138)
d1:f1															
d2:f2		3.512													
		(7.943)													
d3:f3			−0.247												
			(3.629)												
d4:f4				0.609											
				(2.018)											
d5:f5					−0.265										
					(1.459)										
d6:f6						−0.950									
						(1.025)									
d7:f7							−0.743								
							(0.806)								
d8:f8								−0.702							
								(0.922)							
d9:f9									−0.763						
									(1.043)						
d10:f10										−0.763					
										(1.043)					
d11:f11											−1.343				
											(1.388)				
d12:f12												−4.898			
												(3.721)			
d13:f13													−4.039		
													(2.923)		
d14:f14														−1.697	
														(4.689)	
d15:f15															
Observations	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41
R^2	0.222	0.225	0.189	0.212	0.250	0.208	0.211	0.208	0.210	0.210	0.235	0.368	0.214	0.233	0.207
Adjusted R^2	0.111	0.088	0.046	0.073	0.118	0.069	0.071	0.068	0.070	0.070	0.100	0.257	0.075	0.098	0.093
Residual Std. Error	4.636	4.696	4.804	4.735	4.619	4.746	4.739	4.748	4.742	4.742	4.666	4.239	4.731	4.672	4.683

Table 7: OLS (additional variable) estimation results

	Dependent Variable: Real GDP Growth Rate														
	mod1	mod2	mod3	mod4	mod5	mod6	mod7	mod8	mod9	mod10	mod11	mod12	mod13	mod14	mod15
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Constant	6.706**	11.460***	4.610	4.926	3.488	0.282	0.163	−0.310	0.281	0.281	1.300	1.060	0.185	0.306	0.810
	(3.088)	(3.896)	(5.938)	(5.297)	(4.747)	(4.192)	(3.479)	(3.498)	(3.522)	(3.522)	(2.964)	(2.765)	(2.854)	(2.815)	(2.755)
cpi_dlog	−0.222	−5.492***	−1.481	−1.265	−0.963	0.207	0.082	0.305	0.181	0.181	−0.131	−0.111	0.015	0.013	−0.093
	(0.210)	(1.080)	(2.618)	(1.372)	(1.236)	(0.773)	(0.654)	(0.544)	(0.479)	(0.479)	(0.314)	(0.233)	(0.248)	(0.199)	(0.195)
mon_dlog	0.152***	0.153**	0.168**	0.147**	0.136**	0.165***	0.167***	0.172**	0.174***	0.174***	0.200***	0.210***	0.202***	0.199***	0.190***
	(0.059)	(0.061)	(0.070)	(0.065)	(0.068)	(0.060)	(0.061)	(0.062)	(0.066)	(0.066)	(0.071)	(0.072)	(0.075)	(0.074)	(0.065)
open	0.055	0.055	0.054	0.043	0.071*	0.055	0.067	0.056	0.056	0.056	0.063	0.067	0.068*	0.067	0.068*
	(0.041)	(0.042)	(0.042)	(0.042)	(0.037)	(0.039)	(0.046)	(0.041)	(0.041)	(0.041)	(0.042)	(0.041)	(0.042)	(0.041)	(0.041)
cred_dlog	−0.210***	−0.209**	−0.200**	−0.183**	−0.210**	−0.195**	−0.211**	−0.200**	−0.207***	−0.207***	−0.225***	−0.249***	−0.230***	−0.230***	−0.222***
	(0.080)	(0.081)	(0.083)	(0.076)	(0.085)	(0.085)	(0.085)	(0.080)	(0.080)	(0.080)	(0.078)	(0.071)	(0.076)	(0.075)	(0.074)
tot_dlog	0.012	0.012	0.018	0.031	0.043	0.044	0.054	0.054	0.049	0.049	0.024	0.043	0.060	0.057	0.053
	(0.052)	(0.053)	(0.052)	(0.055)	(0.045)	(0.049)	(0.051)	(0.050)	(0.051)	(0.051)	(0.048)	(0.038)	(0.042)	(0.042)	(0.043)
d1:f1															
d2:f2		5.268***													
		(1.064)													
d3:f3			1.210												
			(2.624)												
d4:f4				0.879											
				(1.379)											
d5:f5					0.382										
					(1.262)										
d6:f6						−0.806									
						(0.872)									
d7:f7							−0.951								
							(0.849)								
d8:f8								−1.152							
								(0.868)							
d9:f9									−1.259						
									(0.886)						
d10:f10										−1.259					
										(0.886)					
d11:f11											−1.611*				
											(0.860)				
d12:f12												−5.225***			
												(0.849)			
d13:f13													−5.527***		
													(1.085)		
d14:f14														−3.450***	
														(1.031)	
d15:f15															
Observations	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42
R^2	0.306	0.306	0.294	0.311	0.354	0.315	0.326	0.325	0.325	0.325	0.335	0.422	0.394	0.397	0.362
Adjusted R^2	0.187	0.163	0.149	0.169	0.221	0.173	0.187	0.186	0.186	0.186	0.198	0.303	0.269	0.273	0.252
Residual Std. Error	4.425	4.489	4.526	4.472	4.332	4.461	4.423	4.427	4.428	4.428	4.395	4.095	4.196	4.184	4.243
F Statistic	2.570**	2.141*	2.027*	2.192*	2.658**	2.229*	2.350**	2.337**	2.335**	2.335**	2.442**	3.551***	3.153**	3.198**	3.306**

Table 8: OLS (Quarterly) estimation results

	Dependent Variable: Real GDP Growth Rate														
	mod1	mod2	mod3	mod4	mod5	mod6	mod7	mod8	mod9	mod10	mod11	mod12	mod13	mod14	mod15
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Constant	5.813***	5.317***	5.182***	4.019***	5.278***	5.016***	4.948***	5.652***	6.429***	6.413***	6.337***	6.231***	6.275***	6.222***	5.729***
	(1.118)	(1.174)	(1.325)	(1.484)	(1.440)	(1.361)	(1.366)	(1.464)	(1.344)	(1.311)	(1.242)	(1.210)	(1.198)	(1.192)	(1.194)
cpi_dlog	1.891	−0.417	−0.623	0.520	−0.291	−0.247	−0.277	−0.443*	−0.641***	−0.633***	−0.611***	−0.580***	−0.596***	−0.578***	−0.458***
	(1.201)	(1.409)	(0.675)	(0.534)	(0.333)	(0.251)	(0.227)	(0.251)	(0.204)	(0.170)	(0.126)	(0.112)	(0.108)	(0.103)	(0.101)
mon_dlog	0.116***	0.117***	0.119***	0.117***	0.124***	0.128***	0.112***	0.116***	0.113***	0.114***	0.117***	0.113***	0.111***	0.108***	0.108***
	(0.031)	(0.031)	(0.031)	(0.030)	(0.031)	(0.029)	(0.032)	(0.031)	(0.030)	(0.030)	(0.031)	(0.030)	(0.030)	(0.030)	(0.031)
open	0.004	0.006	0.005	0.006	0.006	0.009	0.017	0.012	0.010	0.010	0.009	0.010	0.011	0.008	0.007
	(0.031)	(0.031)	(0.031)	(0.030)	(0.031)	(0.031)	(0.030)	(0.030)	(0.031)	(0.031)	(0.031)	(0.031)	(0.030)	(0.030)	(0.031)
cred_dlog	−0.059	−0.063*	−0.063**	−0.060**	−0.061**	−0.059**	−0.053*	−0.057*	−0.054*	−0.055*	−0.056*	−0.057*	−0.056*	−0.049	−0.056*
	(0.032)	(0.032)	(0.031)	(0.030)	(0.030)	(0.030)	(0.030)	(0.031)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.031)
d1:f1	−2.205														
	(1.181)														
d2:f2		0.097													
		(1.404)													
d3:f3			0.288												
			(0.687)												
d4:f4				−0.748											
				(0.544)											
d5:f5					0.075										
					(0.350)										
d6:f6						0.145									
						(0.284)									
d7:f7							0.395								
							(0.283)								
d8:f8								0.563*							
								(0.295)							
d9:f9									0.686**						
									(0.267)						
d10:f10										0.704***					
										(0.258)					
d11:f11											0.642**				
											(0.281)				
d12:f12												0.545			
												(0.431)			
d13:f13													0.229		
													(0.458)		
d14:f14														0.168	
														(0.485)	
d15:f15															0.282
															(0.734)
Observations	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164
R^2	0.140	0.137	0.138	0.169	0.146	0.163	0.195	0.178	0.166	0.166	0.166	0.165	0.173	0.171	0.150
Adjusted R^2	0.107	0.104	0.105	0.137	0.114	0.131	0.165	0.146	0.134	0.134	0.134	0.133	0.141	0.140	0.118
Residual Std. Error	4.707	4.715	4.712	4.626	4.688	4.642	4.552	4.601	4.635	4.633	4.634	4.637	4.616	4.620	4.677
F Statistic	4.251***	4.150***	4.183***	5.319***	4.491***	5.111***	6.354***	5.661***	5.194***	5.221***	5.211***	5.173***	5.461***	5.409***	4.634***