Bank of Papua New Guinea

How much is too much? Estimating Inflation-Growth Threshold for PNG

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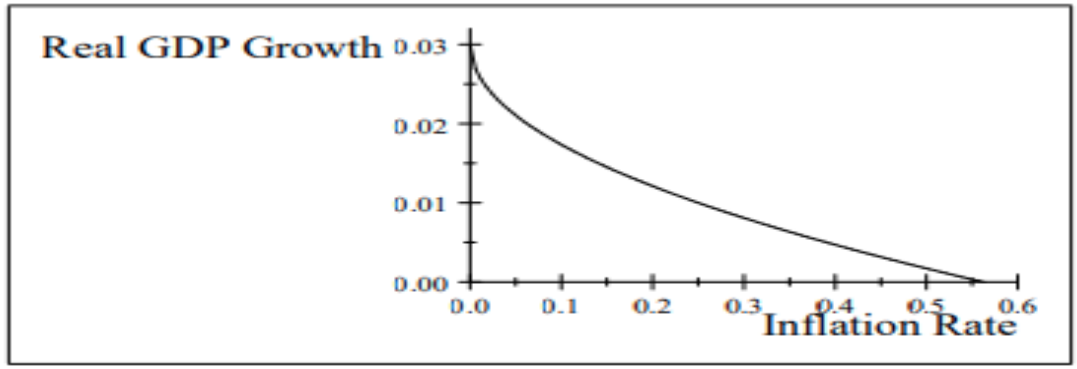
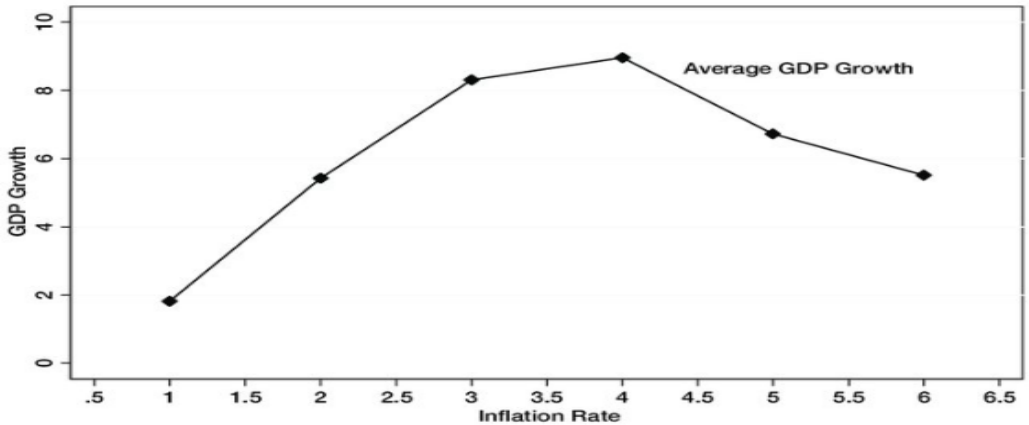
Presentation Outline

Background



Neoclassical Theory.



- Why study inflation and economic growth relationship? *Macroeconomic stability and growth.*
- Theory: general trade off between inflation and economic growth *(Neo-classical -Phillips-curve)*
- (1) Is the relationship between inflation and economic growth positive, negative or insignificant? (2) How high should inflation be in order to adversely impact on growth?
- Recent studies find non-linearity in inflation-growth relationship,i.e. positive or ambiguous at low inflation levels whilst negative at higher levels
- Adverse adverse effects of inflation only occurs when inflation exceeds some turning point (threshold)

Research Problem and Motivation

- The BPNG is mandated to achieve and maintain price stability whilst promoting economic growth. *Price stability* is in general terms as BPNG does not have an explicit or an implicit inflation target.
- Hence, the question on how low should inflation be to reflect price stability is still unanswered empirically for PNG? Alternatively, at what inflation level is negative for economic growth? At what level would the Bank or the government know that price is stable or not growth-hindering?
- Recent amendments to Central banking Act 2000 to include promotion of employment and economic growth alongside price stability as equal monetary policy goals may also conflict with price stability objective due to trade-offs from policy mix. E.g. exchange rate depreciation or fiscal deficit financing
- Given equal weighting of policy goals, how would the Bank prioritise policy objectives given the level of inflation?

Objective of the Study

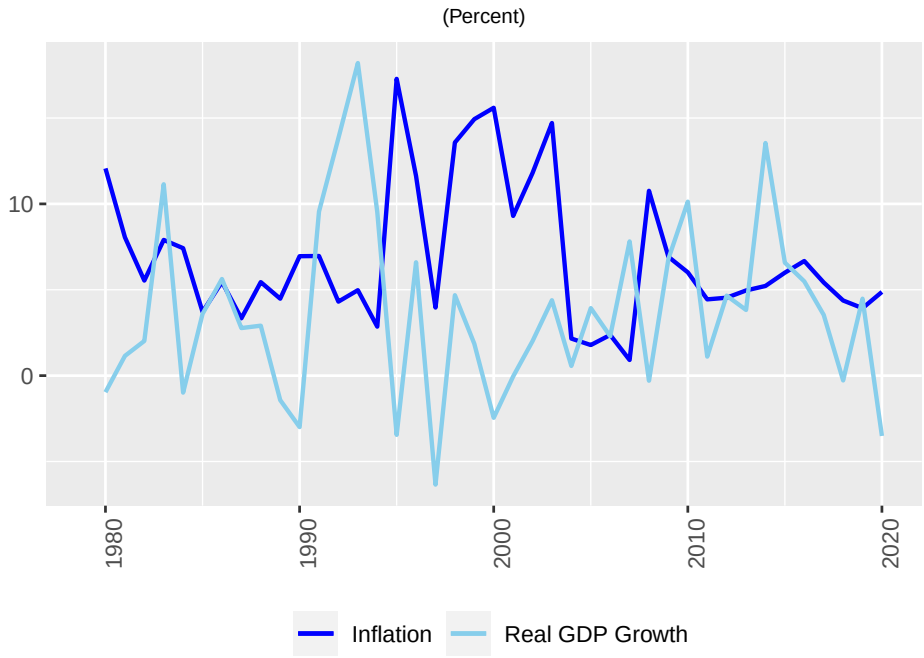
- To investigate the relationship between inflation and growth in the case of PNG and to determine whether there is a turning point or a threshold level of inflation, above which the inflation affect economic growth negatively
- In particular, the study attempts to answer the following questions:
  1. 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?
- For BPNG, relevant policy-related questions could be:
  1. What is the comfortable or tolerable inflation at which the Bank can afford to accommodate without restraining the real GDP growth?
  2. 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?

Literature Review

- Literature is inundated with studies on inflation threshold with mixed results
- Broadly, inflation threshold levels lower than 3 percent seems to prominant for developed countries while double digit inflation threshold seem to be noticeable for developing countries.
- Literature for PICs is scarce. For PNG, no study has been undertaken, hence, this is the first to fill the literature gap.

No.	Author(s) (Year)	Methodology & Period	Country/Region	Findings (Outcomes)
1	Fisher (1993).	Cross-sectional and panel regression	Developed and developing countries	Evidence of non-linear relationship
2	Sarel (1996)	Panel regression (1970-1990)	87 Countries	Structural break at 8% inflation level
3	Ghosh and Phillip (1998)	Panel regression (1960-1996)	IMF Member countries	Inflation Threshold at 2-3 %
4	Khan and Senhadji(2001)	Unbalanced panel regression (1960-1998)	140 Industrialised and developing countries	Inflation threshold for developed 1-3% and developing 7-11%
5	Kremer et al (2009)	Dynamic panel threshold model (1950-2004)	124 industrial and non-industrial countries	Inflation threshold for developed 2% and developing 17%
6	Leshoro (2012)	OLS and 2SLS (IV) (1980Q2-2010Q3)	South Africa	Inflation threshold is 4%
7	Fabayo and Ajilore (2006)	Threshold regression model (1970-2003)	Nigeria	Inflation threshold is 6%
8	Frimpong and Oteng-Abayie (2010)	Threshold regression model (1960-2008)	Ghana	Inflation threshold is 11%
9	Jayaraman et al (2013)	Threshold regression model (1970-2008)	Fiji	Inflation threshold is 3.6%

Stylised Facts



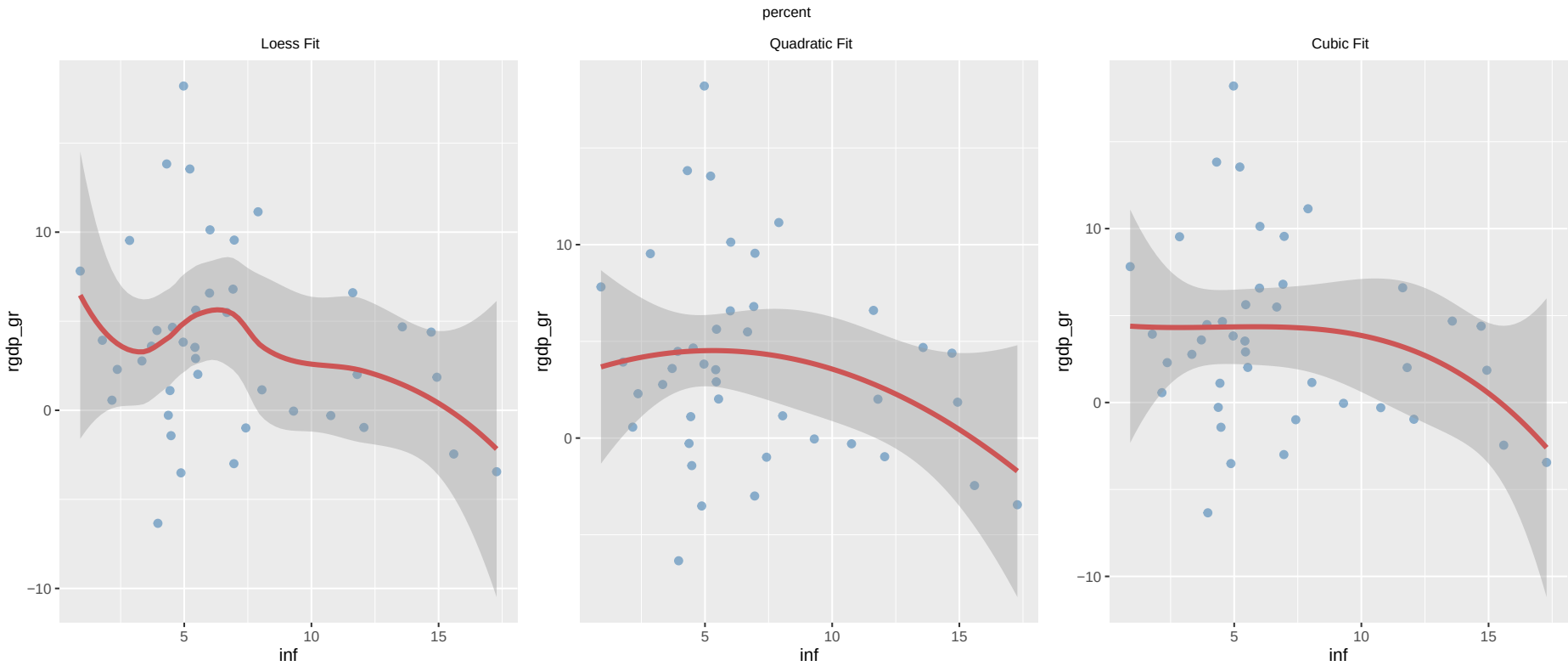
Source:BPNG

1. Anticipated negative relationship is unclear from the char
2. However, 1994-2003, inflation and growth moved in opposite directions-this is period of historically high inflation
3. Let's see more clearly in scatter plots next.....

- **(1975-1993) Hard Kina Policy** Inflation low 6 percent, at a cost of economic growth. Exception, 1991-1994, growth bolstered to 13.9 percent (boom in mineral and AFF sectors).
- **(1994-1997) Exchange rate devaluation, AFC and El Nino** High inflation 14.5 percent, 1995 17.3 percent. Growth dampened to around 1.0 percent
- **(1998-2003) Fiscal Mismanagement and Resource Project Maturity** Inflation remain elevated-averaged 13.2 percent (lagged effects), growth remained subdued-averaged 1.7 percent
- **(2004-2009) High Commodity Prices** In early part, inflation low 1.8 percent (strong PGK/USD). 2008 inflation shot to 10.8 percent (high fuel and food prices), 2009 inflation dropped to 6.9 percent (GFC and global recession). Growth (nominal) improved by 12.8 percent (strong commodity prices)
- **(1998-2003) PNG LNG and Fiscal Deficits** Inflation, broadly, stabilised-averaged 5.0 percent. Surprising, LNG period-inflation only averaged 4.7 percent

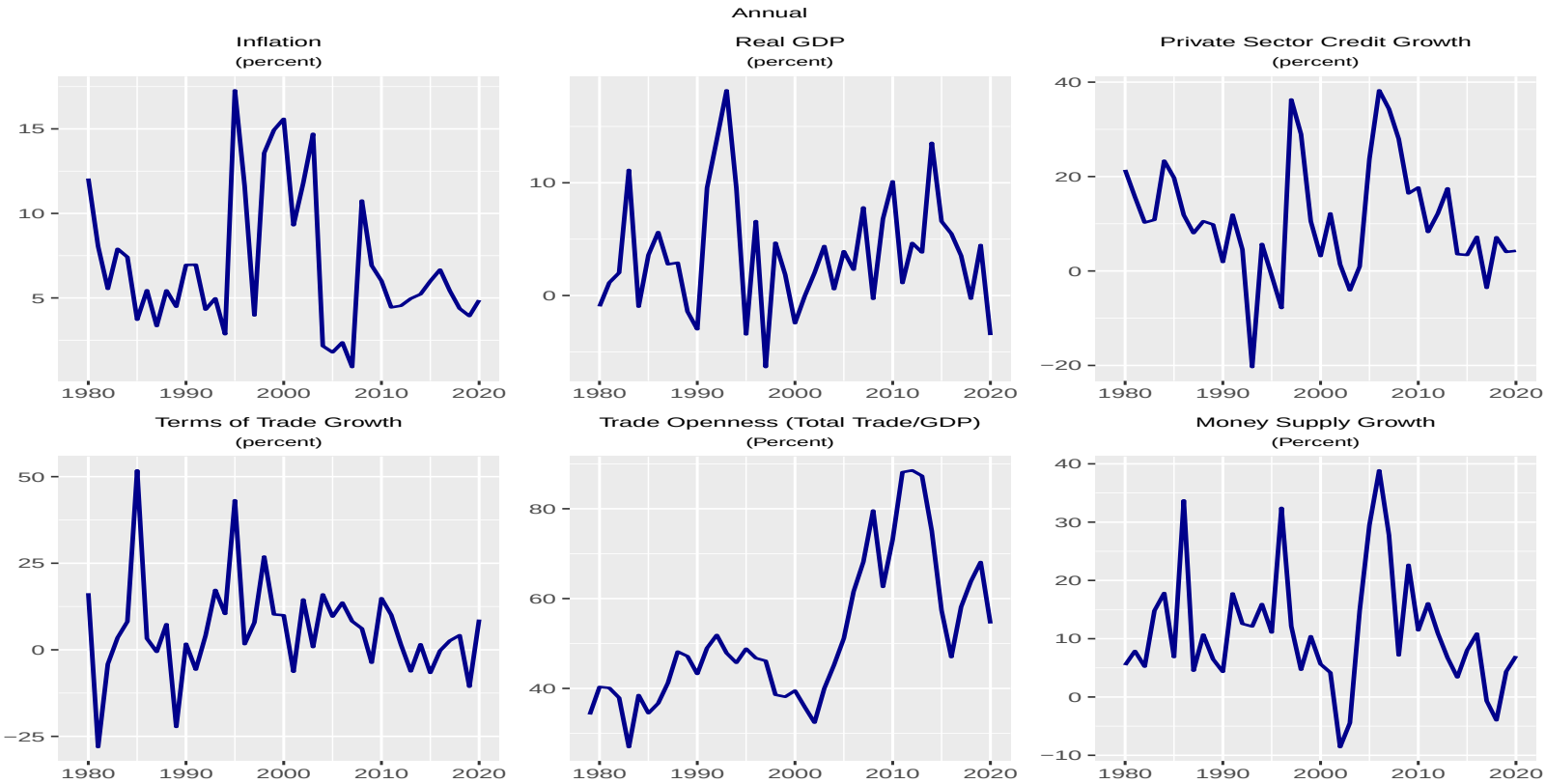
Stylised Facts

Scatter Plots



- All non-linear curve (loess, quadratic and cubic) fitting show a tendency for real GDP to decline as inflation increases over certain threshold level
- Both quadratic and cubic fit show that relationship turn negative at around 7.5 percent
- Still...need more rigorous approach to establish this inflation-growth threshold..we do this next...

Data



- *Period of Study:* Annual data from 1980-2020:
- *Key Variables:* Inflation, Real GDP growth, Private Sector Credit Growth, Terms of Trade Growth, Trade Openness, Money Supply Growth .
- *Data Sources:* BPNG's QEB Tables, National Statistics Office, World Development Indicators (WDI) database of World Bank and IMF's International Financial Statistics (IFS)

Methodology

- I adopt the threshold regression approach of Khan and Senhadji(2001).
  1. Model Specification

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

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 control variables including trade openness, growth rate of terms of trade, investment growth (*proxied by private sector credit growth*) and financial development (*proxied by total money supply/nominal GDP*), $\epsilon_{i,t}$ is the i.i.d error term and $\alpha_0 \ldots . \alpha_{1i}$ are coefficients of the model.

D_t is the dummy variable where:

$$D_t = \begin{cases} 1, & \text{if } \pi_t > \overline{\pi} \\ 0, & \text{otherwise} \end{cases} \tag{2}$$

  2. Inflation threshold value is searched from 1 to 15 (16 percent in maximum level of inflation in PNG (1980-2020). $S_1(\pi)$ = residual sum of squares. The optimal threshold inflation level,$\overline{\pi}$, is achieved when the function $S_1(\pi)$ is minimized, that is:

$$\overline{\pi} = argmin\{S_1(\pi), \pi = 1, 2, \ldots . 15\} \tag{3}$$

  3. Econometric models were estimated using Ordinary Least Squares (OLS) (accounting for heteroscedasticity and robust standard errors)
  4. Effect of inflation on GDP growth:
  (i) α_1 effect of inflation on GDP growth where $\pi \leq \overline{\pi}$
  (ii) $\alpha_1 + \alpha_2$ effect of inflation on GDP growth where $\pi > \overline{\pi}$

Preliminaries

Unit Root and Granger Causality Tests

- *Check for stationarity in the variables*: ADF and KPSS unit root tests show that all variables are stationary
- *Check direction of causality*: There is evidence of the unidirectional Granger causality running from inflation to real GDP at lag 3. But no feedback from real GDP to inflation
- So variables are good to go for estimation....
- Here support for inflation to be used as explanatory variable for growth, not otherwise

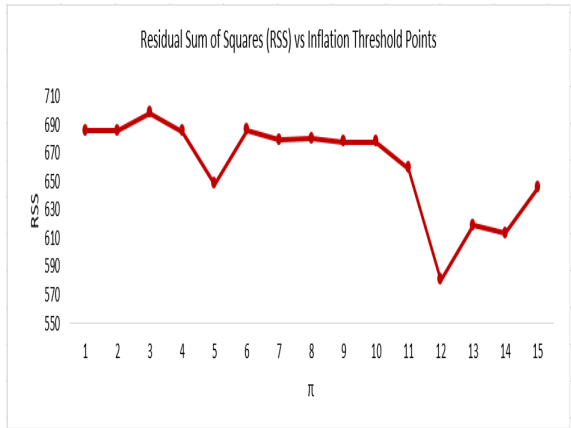
Variable	ADF Test Statistics		KPSS Test Statistics	
	Drift	Trend	Drift	Trend
open	-1.88	-2.36	0.66***	0.08
cpi_dlog	-3.35**	-3.30*	0.12	0.11
rgdp_dlog	-3.44**	-3.39*	0.06	0.05
tot_dlog	-4.06***	-4.13**	0.10	0.10
mon_dlog	-3.21**	-3.37*	0.13	0.07
cred_dlog	-3.55**	-3.50**	0.07	0.07

Table: Pairwise Granger-Causality Test

heightDirection	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

Estimation Results

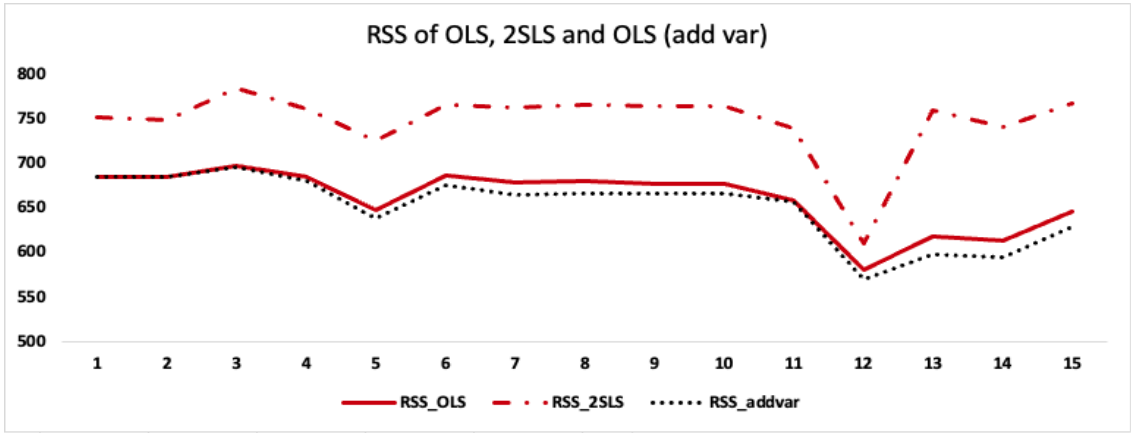
Inf*	Variable	Coefficient	Std.Error	R-squared	RSS
7%	Inf	-0.015	0.617	0.312	679.55
	d(Inf-Inf*)	-0.644	0.733		
	mon	0.172***	0.062		
	open	0.061	0.043		
	cred	-0.205**	0.088		
	c	1.022	3.258		
8%	Inf	0.153	0.476	0.311	680.53
	d(Inf-Inf*)	-0.815	0.756		
	mon	0.176***	0.064		
	open	0.053	0.039		
	cred	-0.197**	0.083		
	c	0.675	3.165		
9%	Inf	0.044	0.415	0.313	678.21
	d(Inf-Inf*)	-0.994	0.796		
	mon	0.178***	0.068		
	open	0.052	0.040		
	cred	-0.204**	0.084		
	c	1.211	3.170		
10%	Inf	0.044	0.415	0.313	678.21
	d(Inf-Inf*)	-0.994	0.796		
	mon	0.178***	0.068		
	open	0.052	0.040		
	cred	-0.204**	0.084		
	c	1.211	3.170		
11%	Inf	-0.170	0.296	0.332	659.65
	d(Inf-Inf*)	-1.543*	0.802		
	mon	0.206***	0.070		
	open	0.062	0.041		
	cred	-0.225***	0.079		
	c	1.527	2.877		
12%	**Inf**	**-0.123**	**0.232**	**0.412**	**580.71**
	d(Inf-Inf*)	**-4.946*** **	**0.881**		
	mon	**0.213*** **	**0.072**		
	open	**0.063**	**0.039**		
	cred	**-0.243*** **	**0.072**		
	c	**1.379**	**2.776**		
13%	Inf	0.020	0.255	0.373	619.71
	d(Inf-Inf*)	-4.610	0.863		
	mon	0.202***	0.076		
	open	0.062	0.039		
	cred	-0.221***	0.080		
	c	0.646	2.876		



- RSS is minimized at inflation level of 12 percent.
- Low inflation coefficient (-0.123) not stat.significant, but dummy variable, d(Inf-Inf*) (-4.945) is stat.significant = High inflation (-5.069).
- But statistically significance of threshold effect- not straightforward. Under *Ho* : $\alpha_2 = 0$, threshold is not identified leading to tests such as t-test have non-standard distributions
- Following Hansen(2000), I employ bootstrap method to simulate an asymptotic distribution of likelihood ratio test of *Ho*. Result = χ^2 (8.81) p-value = 0.097. Evidence that threshold effect holds.
- Control variables money supply growth and credit growth are stat.sig.
- But wait, let's check robustness of results.....

Robustness checks

- Check for robustness checks through different estimation technique, additional variable (growth rate of terms of trade), and data frequency (quarterly)



1. *Sensitivity to estimation techniques* - confirm inflation threshold to be 12.0 percent
2. *Sensitivity to additional explanatory variables* - confirm inflation threshold to be 12.0 percent
3. *Sensitivity to data frequencies* - Inflation threshold-7.0 percent. Sign of coefficients opposed to prior expectation - inflation threshold dummy is positive and not statistically significant.

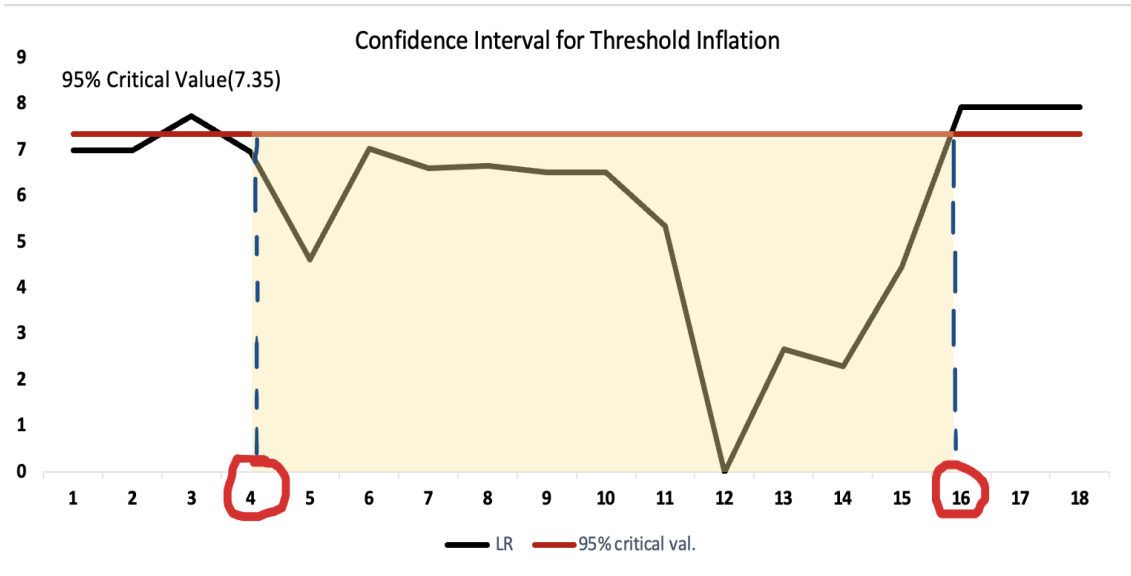
4. Great! BUT **How precise is this inflation threshold level ? Is this threshold level different from any other threshold levels?**

Confidence Interval for Threshold

1. Hypothesis test is equivalent to testing $Ho : \overline{\pi} = \pi_1$, that is, test that two potential thresholds are equal.
2. Follow Hansen(2000), I estimate the critical value α percent significance level as $c(\alpha) = -2log(1 - \sqrt{1-\alpha})$ of the likelihood ratio test :

$$LR_1(\pi_1) = \frac{(S_1(\overline{\pi}) - S_1(\pi_1))}{\widehat{\sigma}^2} \tag{4}$$

3. Decision rule: Reject Ho when asymptotic significance if $LR_1(\pi_1)$ is greater critical value $c(\alpha)$. Hence, rejection region on the chart is below the 95 percent critical value.
4. **Results**.....confidence interval is between 4.0-16.0 percent, that is threshold estimate of 12.0 percent is not significantly different from a number of other potential threshold level. Implying a level uncertainty/imprecision of the threshold estimate.



Summary Results

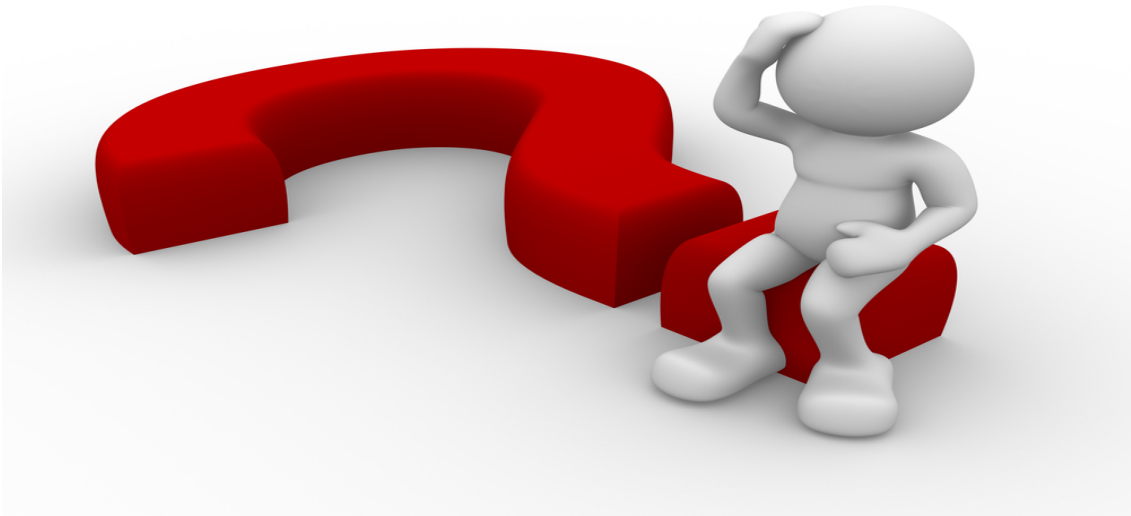
1. Inflation threshold in PNG is estimated to be 12.0 percent. Broadly, double digit inflation above threshold level is growth-hindering for PNG.
    - Consistent with historical account....(1995-2003)
    - Supported by literature for developing countries ....Kahn and Senhadji (2001) (7.0-11.0 percent), Kremer et al (12.0 percent), Frimpong and Oteng-abayie (2010) 11.0 percent for Ghana and Bawa and Ismaila (2021) for Nigeria....
    - Consistent with developing countries status....
2. Relationship between inflation and growth lower than threshold point, 12.0 percent is ambiguous
    - Supported by literature ....Mubarik(2005) for Pakistan
3. Inflation threshold is not precise, but can range between 4.0-16.0 percent.
    - Supported by literature ....for most developing countries,threshold estimates are relatively imprecise
    - Khan and Senhadji (2001) estimates confidence interval for developing countries to be between 1.0-20.0 percent.

Conclusion and Policy Implication

- The study established existence of inflation-growth in PNG and is estimated to be 12.0 percent.
- But since threshold is not precise, it can range between 4.0-16.0 percent.
- Inflation level below threshold is not growth-enhancing either-its ambiguous.

- **Policy considerations**
  1. The Bank to strive to keep inflation levels below the threshold level, more preferably at single digits. $\leq$ 4.0 percent
  2. This threshold estimate can be used as benchmark if the Bank decides to pursue inflation-targeting monetary policy regime in the future.
  3. Threshold level can guide policy prioritising given multiple policy goals-applicable to recent amendments to monetary policy objectives in Central Banking Act 2000.
- **Future research**
  1. Consider other price measures-underlying inflation/ GDP deflator or employ real non-mining GDP growth
  2. Extention to dissaggregated inflation-threshold on sectoral level (currently undergoing)

The End



Questions? Comments?

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