inflation-growth nexus in Botswana: Can lower inflation really spur growth in the country?

Mothuti, Gosego and Phiri, Andrew

Department of Economics, Nelson Mandela University

20 June 2018

INFLATION-GROWTH NEXUS IN BOTSWANA: CAN LOWER INFLATION REALLY SPUR GROWTH IN THE COUNTRY?

G. Mothuti

Department of Economics, Faculty of Business and Economic Studies, Nelson Mandela University, Port Elizabeth, South Africa, 6031.

And

A. Phiri

Department of Economics, Faculty of Business and Economic Studies, Nelson Mandela University, Port Elizabeth, South Africa, 6031.

ABSTRACT: Does inflation affect economic growth in Botswana over the short-run and long-run? In applying bounds procedure for modelling ARDL cointegation effects applied to empirical data collected between 1975 and 2016 we find that this hypothesis does not hold true for Botswana as inflation is found to be insignificantly related with economic growth over both the short and long-run. Our growth equation estimates point to exports (positive), government size (negative) and an Pula/Dollar exchange rate (negative) as being significantly correlated with steady-state GDP growth. Further empirical exercises show that an appreciated Pula/dollar exchange rate increases inflation whilst bearing no effect on economic growth. Conversely, a depreciated Pula/Dollar exchange simultaneously decreases inflation and economic growth for the Botswana economy. Policymakers should be this aware that attainment of lower inflation rates which occurs through a depreciated Pula/Dollar currency will only retard economic growth.

Keywords: Inflation; Economic growth; Exchange rates; Bank of Botswana; Nonlinear autoregressive distributive lag (N-ARDL) model.

JEL Classification Code: C13; C32; C52; E31; F43.

1 INTRODUCTION

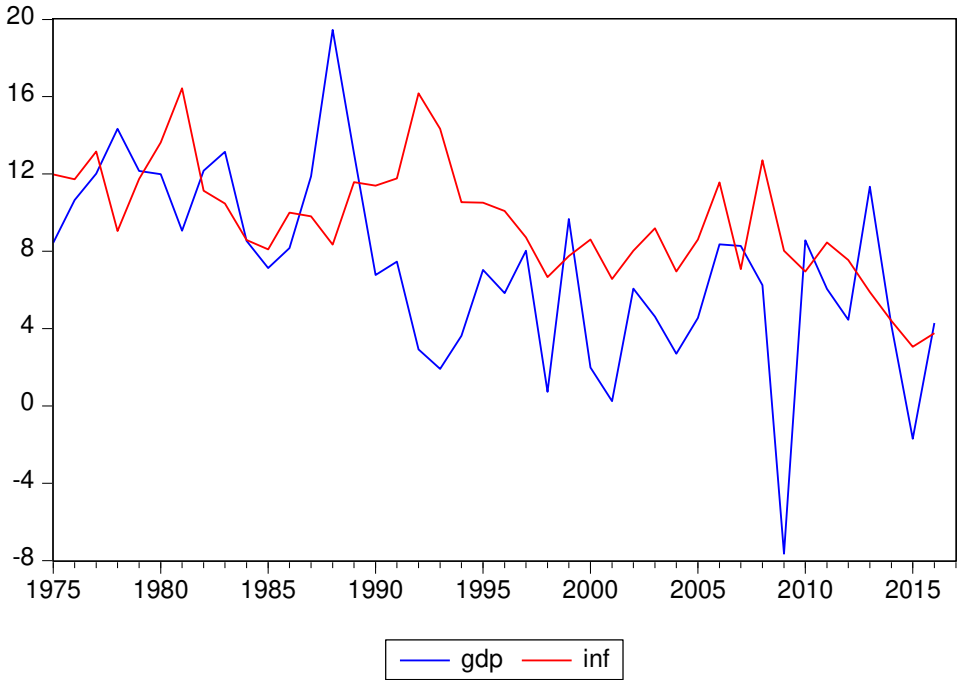
This article seeks to examine the effect of inflation on economic growth for Botswana as a small, open Sub-Saharan African economy. Acemoglu et al. (2001) more popularly describes Botswana as an "Africa success story" in the sense of having no favourable conditions during independence; having a high disease burden; being landlocked and thus no access to seaports; mainly a geographically dessert area and yet boasts one of the strongest economies in backed by its Diamond industry which accounts for over half of the country's economic growth. Unlike other African economies Botswana has experienced no coups, no political instability, no civil wars, no threats of succession and incorrupt leadership (Harvey, 2015). Moreover, the country is also well known for having one of the lowest levels of corruption on the African continent; exceptionally low government debt levels; one of the highest credit ratings globally and has substantial foreign exchange reserves (HaileTaye, 2011). Much of the country's success has been attributed to the refrainment from nationalization and has instead embarked on joint ventures with multinational mining countries (Atta et al. 1999).

Historically, monetary authorities in Botswana have relied on the crawling pegs exchange rate policy which has played a pivotal role on keeping exports competitive in international markets and is often cited as the reasons as to why the country has not been cursed with the so-called 'Dutch-disease' (Mogotsi, 2002). Pegg (2010) argues that Botswana has "…benefited from the coexistence of good governance and abundant diamonds to materialize growth [and] no clear evidence can be found that deterioration in the terms of trade would negatively affect economic development…". Nevertheless, as of 2002, the Bank of Botswana has explicitly adopted an inflation target of 3 to 6 percent and yet it should be noted that the Central Bank does not engage in formal inflation-targeting which would require the BoB to sacrifice her crawling pegs in favour of flexible exchange rate regime. The grounds for the BoB adoption of the specific target is based on the Bank's commitment to achieving macroeconomics stability and improved economic growth. And this becomes even more important considering that the many economies worldwide, including Botswana, are still on a

recovery phase following the 2007 financial crisis and 2009 global recession period. Whether the inclusion of the 3 to 6 percent mandate has assisted in achieving improved economic growth has received very little attention in the empirical literature and is thus open to deliberation.

Figure 1 shows the time series plot of inflation and economic growth in Botswana over 1975 to 2016. As can be quickly observed, despite inflation generally being on a decreasing trend over the last couple of decades, the BoB only started realizing its set objective of 3 to 6 percent in 2013. Incidentally, the decrease in inflation trends over the sample period has been accompanied by deteriorating economic growth performance more notably so for periods subsequent to the global financial crisis of 2007-2008, where GDP recorded negative figures in 2013 which corresponded with lowest inflation rates experienced over three decades.

Figure 1: Inflation-growth time series plot in Botswana: 1975 to 2016



Nonetheless, the sole visual scrutiny of the time series is not sufficient enough in drawing conclusions on the empirical inflation-growth relationship. Our study thus formally investigates the inflation-growth relationship for Botswana between 1975 and 2016 using the

nonlinear ARDL model as developed by Shin et al. (2014). This model has recently gained popularity amongst econometric enthusiasts and is increasing being recognized as being superior to other empirical models found in the literature. For starters, the N-ARDL model does not impose restrictive assumptions that the time series in the cointegration system should be integrated of similar order. Secondly, the model can be used with a small sample size which is relevant towards studies focused on single African countries where data availability in high frequency is usually problematic. Thirdly, the N-ARDL model produces unbiased estimate from a single reduced-form equation yields consistent results for both the long-run and short-run nonlinear, even when some the regressors are endogenous. To the best of our knowledge, this current study is the first in the literature to apply the N-ARDL model the inflation-growth context.

Against this background, we structure the rest of the paper as follows. Section 2 presents the review of theoretical and empirical literature. Section 3 outlines the methodology used in the study. The data and empirical analysis is presented in Section 4 whilst a discussion of the obtained results is found in Section 5 of the paper. Section 6 concludes the study.

2 LITERATURE REVIEW

The role of inflation within dynamic growth theory can be traced to the seminal work of Nobel laureate James Tobin (1965). In his modification of the Neo-classical model popularized by another laureate Robert Solow (1965), inflation, which is defined as an increase in money supply issued out by government agents, has a positive effect on capital accumulation which then leads to an increase in steady-state equilibrium growth. Sidrauski (1967) challenged this Tobin's 'hypothesis' by demonstrating that within a money-within-utility maximizing framework inflation only exerts an effect on nominal variables leaving the real variables such as capital accumulation and economic growth unaffected. This effect is better known as the 'superneutrality effect of money'. More prominent inflation-growth dynamic models were then

established within the endogenous growth paradigm, in which inflation acts as a tax on factors of production such as labour and/or capital hence causing inefficient reallocation of resources leading to lower steady-state economic growth. Pioneering contributors to the literature include Stockman (1981), Greenwood and Huffman (1987) and Cooley and Hansen (1989).

From this overview of the theoretical literature, the relationship between inflation and growth can summarized as either be i) positive (Tobin effect) ii) insignificant (Sidrauski effect) or iii) negative (Stockman-effect). A vast majority of the earlier empirical literature based their empirical estimates on panels consisting of both developing and developed economies (Fischer (1993), Barro (1995), Bruno and Easterly (1998), Sarel (1996), Ghosh and Phillips (1998) and Kahn and Senhadji (2001), Drukker et al. (2005), Hineline (2007), Kremer et. (2009), Vaona (2012), Vinayagathasan (2013), Seleteng et al. (2013), Eggoh and Kahn (2014), Ibarra and Trupkin (2016) and Ndoricimpa (2017)). Notably these studies advocate for a negative effect of inflation on economic growth in both developed and developing economies, although inflation was deemed to have a stronger adverse effect in industrialized economies. Another implication from these studies was that inflation has varying effects on economic growth, a phenomenon which became more popularly known as 'nonlinearity' or 'threshold' effects' of inflation on growth. Nevertheless, these studies have been criticized on the premise of generalizing the findings from homogenous estimates for a whole host of countries with different country-specific economic features. The literature then began to expand in a direction in which researchers focused more on single country studies (Mubarik (2005), Munir and Mansur (2009), Leshoro (2012), Adusei (2012), Munyeka (2014), Tung and Thanh (2015), Mkhatshwa et al. (2015), Phiri (2010, 2018), Iyke and Odhimabo (2017) and Mavikela et al. (2017)).

Despite the growth in the academic literature for country-specific studies, there exists only one study, to the best of our knowledge, which has examined the inflation-growth relationship for the Botswanan economy. The study of Phetwe and Molefe (2016) investigates

the inflation-growth relationship for Botswana using annual data collected from 1994 to 2014 using OLS estimates employed to i) a quadratic threshold model, and ii) an endogenous threshold model. Moreover, the authors employ two different measures of GDP, namely, the non-mining GDP and the non-mining-government-agriculture GDP. When the 'non-mining GDP' variable is used in the quadratic model there are no significant effects of inflation on growth whereas for the 'non-mining-government-agriculture GDP' variable significant threshold effects are found with inflation above rates of 6.9 percent whilst positively affecting growth above this level. On the other hand, under the endogenous model, the authors only use the 'non-mining-government-agriculture GDP' variable and establish a threshold of 6.8 where inflation below this level positively and insignificantly affects economic growth whilst the above this level inflation negatively and significant affects growth.

3 METHODOLOGY

Generally, the literature tends to rely on traditional estimation techniques, more especially the endogenous threshold model (Sarel (1996), Mubarik (2005), Munir and Mansur (2009), Phiri (2010), Leshoro (2012), Adusei (2012), Munyeka (2014), Tung and Thanh (2015), Mkhatshwa et al. (2015) and Phetwe and Molefe (2016)). Nevertheless, it has become increasingly acknowledged that these method suffer from certain empirical shortcomings such as requiring mutual integration of the time series for estimation purposes and being devoid of cointegration analysis which could easily render the obtained estimates as being spurious (Phiri, 2017). As previously mentioned we rely on the nonlinear ARDL model of Shin et al. (2014) which is an asymmetric extension of the ARDL model introduced by Pesaran et al. (2001). We start of by specifying our baseline growth model which as:

$$GDP_t = \alpha_t + \beta_1 \, inf_t + \beta_X X_t + e_t \quad (1)$$

Where GDP_t is a measure of economic growth, inf_t is the inflation rate, X_t is a vector of control variables and e_t is a well-behaved disturbance term. In following suggestions provided by Barro (1991), De Long and Summers (1991), Levine and Renelt (1992), Barro and Sala-i-Martin (1995) and Sala-i-Martin (1997), we employ the following vector of control variables:

$$X_t = \{\text{inv, school, gov, exports, exchange, dum2009}\} \quad (2)$$

Where *inv* is domestic investment as a share of GDP, *school* is level of human capital development, *gov* is a measure of government size, *exports* is the share of exports in GDP and *exchange* is the nominal exchange rate between the Pula and the dollar and *dum2009* is a dummy variable accounting for the global recession period of 2009. Following intuition provided by Shin et al. (2014), and decompose the inf_t variable into positive and negative partial sum processes i.e. $inf_t^+ = \sum_{j=1}^{i} \Delta inf_j^+ = \sum_{j=1}^{i} \max(\Delta \text{inf}_j, 0)$ and $inf_t^- = \sum_{j=1}^{i} \Delta inf_j^- = \sum_{j=1}^{i} \min(\Delta \text{inf}_j, 0)$. Thereafter the N-ARDL (p, q) model can be expressed as the following nonlinear error correction function:

$$\Delta gdp_t = \sum_{j=1}^{p} \rho_i gdp_{t-j} + \Phi_j^+ inf_{t-j}^+ + \Phi_j^- inf_{t-j}^- + \kappa_x x_{t-j} + \sum_{j=1}^{p-1} \psi_i \Delta gdp_{t-j} + \sum_{j=0}^{q-1} (\alpha_j^+ \Delta inf_{t-j}^+ + \alpha_j^- \Delta inf_{t-j}^-) + \sum_{j=0}^{q-1} \sigma_x \Delta x_{t-j} + \lambda ECT_{t-1} + \zeta_t \quad (3)$$

Where Δ denotes a first difference operator, ρ_i, ρ_i, Φ_i, β_i, λ_i, α_i, and σ_i are the long-run and short-run coefficients, ECT_{t-1} is the error correction term which measure the speed of adjustment back to steady-state equilibrium subsequent to a shock to the system and $e_t \sim N(0, \sigma^2)$. From regression (3), the long-run budgetary elasticities are calculated as $\beta^+ = -(\Phi^+/\rho)$ and $\beta^- = -(\Phi^-/\rho)$. Before estimating the empirical N-ARDL model we need to test for three empirical hypotheses as proposed by Shin et al. (2014). The first hypothesis is a test for N-ARDL cointegration effects which tests the null hypothesis of symmetric ARDL cointegration effects

(i.e. H_{10}: $\rho = \Phi^+ = \Phi^-$) against the alternative of asymmetric ARDL effects (i.e. H_{11}: $\rho \neq \Phi^+ \neq \Phi^-$). The second pair of hypotheses is concerned with testing for long-run asymmetric effects in which the null hypothesis of symmetric long-run ARDL cointegration effects, H_{20}: $-(\Phi^+/\rho) = -(\Phi^-/\rho)$, is tested as which is tested against the alternative of asymmetric long-run ARDL effects (i.e. H_{21}: $-(\Phi^+/\rho) \neq -(\Phi^-/\rho)$). The final pair of hypothesis tested focuses on validating short-run asymmetric effects, whereby the null hypothesis of symmetric short-run ARDL effects (i.e. $\sum_{i=0}^{q-1} \alpha_j^+ = \sum_{i=0}^{q-1} \alpha_j^-$) is tested against the alternative of asymmetric short-run ARDL effects (i.e. $\sum_{i=0}^{q-1} \alpha_j^+ \neq \sum_{i=0}^{q-1} \alpha_j^-$).

4 DATA AND RESULTS

6.1 Data description and unit root tests

Table 1 presents the data description and summary statistics of the time series used in the study. From these summary statistics, the inflation average of 7 percent over the entire sample period is well above the 3 to 6 percent target set by the Bank of Botswana which is accompanied by economic growth averages of 6 percent. Also note that on averages exports, domestic investment and government expenditure account for approximately 53 percent, 31 percent and 22 percent of GDP, respectively. The reported standard deviations indicate high volatility mainly in economic growth rates, domestic investment and exports whereas other variables like inflation and exchange rates are not so volatile. Moreover, the reported Jarque-Bera statistics further testify to the normality of all utilized time series, that is, with the sole exception of the dummy variable which is technically not a 'growth-determinant' per se.

Table 2 presents the correlation matrix between the time series variables. A number of interesting and somewhat controversial statistics are reported in Table 2. For instance the positive inflation-growth correlations as well as the negative schooling-growth variables are preliminary results which are contrary to conventional economic theory. One the other hand, the positive investment-growth, exports-growth as well as the negative exchange rate-

economic growth correlations are found to adhere to conventional growth theory. Referring to the unit root tests (i.e. ADF, PP and DF-GLS) reported in Table 3, none of the time series is found to contain a unit root in their first differences regardless of whether the test if performed with a drift or with a drift and intercept. Recall, that the N-ARDL model is only functional with time series integrated of order I(0) or I(1).

Table 1: Data description and summary statistics

symbol	Time series	period	obs	Mean	Std. dev	j-b
gdp	GDP growth (annual %)	1975-2016	42	7.112784	4.880192	2.765831
Inf	Inflation, consumer prices (annual %)	1975-2016	42	9.548355	2.980438	0.165394
Inv	Gross capital formation (% of GDP)	1975-2016	42	31.37199	6.297464	0.499064
School	Secondary education, pupils	1975-2016	37	8.688930	8.404374	6.167161
Gov	Government expenditure on education, total (% of GDP	1975-2016	42	22.94455	3.543702	1.903961
Exports	Exports of goods and services (% of GDP)	1975-2016	42	53.66967	7.596473	4.884379
Exchange	Official exchange rate (LCU per US$, period average)	1975-2016	43	4.077680	2.964375	3.831973
Dum2009	Dummy variable crated to account for the global recession period of 2009	1975-2016	43	0.023810	0.154303	2672.080

Table 2: Correlation matrix

	gdp	inf	inv	school	gov	exchange	export	Dum1
gdp	1.000000							
Inf	0.466289	1.000000						
Inv	0.009209	0.250140	1.000000					
School	-0.610206	-0.676122	0.074826	1.000000				
Gov	0.004292	0.242488	-0.286599	-0.478301	1.000000			
Exchange	-0.634086	-0.740547	-0.073865	0.933782	-0.443592	1.000000		
Export	0.463434	-0.099867	-0.683008	-0.295703	0.201621	-0.248105	1.000000	
Dum1	-0.530004	-0.081703	0.196103	0.300172	-0.080300	0.185166	-0.420275	1.000000

Table 3: Unit root test results

	ADF		PP		DF-GLS	
	Intercept	Intercept and trend	Intercept	Intercept and trend	Intercept	Intercept and trend
gdp	-7.168855***	-7.061439***	-18.78758***	-16.81845***	-8.347976***	-8.988459***
	(1)	(1)	(15)	(1)	(0)	(0)
Inf	-8.870861***	-66.142201***	-8.992791***	-9.261251	-8.981645***	-9.001982***
	(0)	(1)	(1)	(2)	(0)	(0)
Inv	-6.605902***	-6.477377***	-6.617595***	-6.6484957***	-4.711584***	-6.094214***
	(0)		(2)	(2)	(0)	(0)
School			-4.961897***	-4.830921***		
			(1)	(2)		
Gov	-5.458907***	-5.507600	-5.4716741***	-5.980262	-4.666469***	-5.326860
	(0)	(0)	(8)	(12)	(0)	(0)
Exports	-6.457391***	-6.357774	-6.458234***	-6.358125***	-5.270785***	-6.204772***

	(0)	(0)	(1)	(1)	(0)	(0)
Exchange	-4.792894***	-4.987218***	-4.536826***	-4.757940***	-4.725216***	-4.990474***
	(0)	(0)	(5)	(10)	(0)	(0)

Notes: "***", "**", "*" represent the 1 percent, 5 percent and 10 percent critical levels, respectively. Optimal lag length for each test is reported in parentheses ().

6.2 Empirical results

Table 4 reports the empirical results from our nonlinear ARDL model estimates. Regression (1) estimates the bi-variate inflation-growth relationship for the data, whereas regressions (2) to (5) are multivariate regressions with equation (2) adding investment and schooling time series as control variables, equation (3) adds investment, schooling and government size, equation (4) uses investment, schooling, government size and exports whilst equation (5) includes investment, schooling, government size and exports. Note that a dummy variable corresponding to the 2008-2009 crisis is included in each of the estimated regressions for control purposes. The optimal lag of each of the estimated N-ARDL regressions is chosen through the minimization of the Schwarz Criterion (SC) information criterion and the selected optimal lags are reported in Panel A of Table 4. Also reported in Panel A of Table 4 are the associated test for nonlinear ARDL cointegration effects i.e. tests for asymmetric cointegration, tests for long-run asymmetries and tests for short-run asymmetries. The reported F-statistics point to significant asymmetric cointegration effects in all regressions with the exception of regression (4), in which the obtained F-statistics of 1.98 lies below the lower bound of the 10 percent critical values. Accordingly, this later finding implies that the evidence of long-run asymmetric coefficients estimates are invalid. So even though the empirical estimates of regression (4) are reported in Table 4, we do not consider the long-run asymmetric coefficient estimates as plausible findings.

The long-run ARDL estimates are respectively reported in Panel B of Table 4. Across all estimated regressions, our main independent variable, the inflation rates, produces statistically insignificant coefficient estimates in both the long-run and the short-run, a finding which is contrary to previous empirical evidence for similar African countries (Leshoro (2012),

Adusei (2012), Mkhatshwa et al. (2015), Phiri (2010, 2018), and Mavikela et al. (2017)). Nevertheless, our findings adhere to the superneutraility hypothesis as theoretically advocated by Sidrauski (1967). Similarly unconventional findings are reported for the coefficients on the investment variable, which are found to be statistically insignificant in the long-run for all regressions whereas the coefficients turn negative and significant in the short-run at a critical levels of at least 5 percent. These findings are contrary to recent evidence presented by Uneze (2013) who find capital formation being a positive contributor to economic growth in African countries. Moreover, both the schooling variable (equations 2, 3, 4 and 5) produce negative and statistically insignificant estimates in both the long-run and short-run whereas the government size (equation 3, 4 and 5) produce negative and statistically significant estimates in the long-run and yet exert no significant effect in the short-run. Similar results have been recently found in Guesh (1997) and Gyimah-Brempong et al. (2006), respectively, for other developing economies. The positive coefficient on the exports variable is also expected as exports contribute to a major portion of Botswana's GDP as confirmed in a recent study by Ee (2016).

We lastly note that the negative coefficient found on the exchange rate variable (equation 5) indicates that an appreciation of the Pula to the dollar (i.e. fall in nominal amount of Pula exchange for foreign US currency) leads to improved economic growth, whilst the opposite supposedly holds true. This finding highlights the important role played by exchange rate policy in attaining higher economic growth over the long-run. In light of these findings, it would be interesting to segregate the effects of an appreciation and depreciation of currency on economic growth, as policymakers may resort to different exchange rate policies during the upswings and downswings of the business cycle. We address this issue in the next sub-section of the paper.

Table 4: Nonlinear estimates (inflation and growth)

	1	2	3	4	5
Panel A: Cointegration tests					
Asymmetric cointegration	7.742815***	3.820520**	3.221966**	2.887447*	3.3266930**
Long-run asymmetries	4.794564**	4.512841**	3.7852657**	1.981275	3.557896**
Short-run asymmetries	15.34567***	8.184141***	5.5864596***	7.4241254***	9.5789321***
Panel B: Long-run estimates					
inf_POS	--0.336004	0.056998	0.04414	0.257290	-0.034495
	(0.4768)	(0.8855)	(0.8670)	(0.3240)	(0.8936)
inf_NEG	-0.099178	0.361098	0.311697	0.383991	0.080177
	(0.8016)	(0.3618)	(0.2909)	(0.1002)	(0.7786)
Inv		0.005650	-0.027008	0.215342	-0.044147
		(0.9671)	(0.7949)	(0.0149)**	(0.5576)
School		0.194351	0,040434	-0.043037	0.162539
		(0.4250)	(0.8415)	(0.7426)	(0.3196)
Gov			-0.4606299	-0.311139	-0.472685
			(0.0046)***	(0.0076)***	(0.0034)***
exports				0.39057	
				(0.0016)***	
exchange					-1.1447487
					(0.0271)**
dum2009	-15.174568	-13.041231	-11.112065	-5.488093)	-11.348005
	(0.0000)***	(0.0000)***	(0.0000)***	(0.0118)**	(0.0000)***
Panel C: Short-run estimates					
ΔInf POS	-0.20685	0.306	0.084638	0.311651	0.235536
	(0.55576)	(0.3268)	(0.7693)	(0.2678)	(0.4592)
ΔInf NEG	-0.157426	-0.043150	-0.036136	0,205598	-0.170209
	(0.6205)	(0.8668)	(0.8817)	(0.4177)	(0.5045)
ΔInv		-0.270170	-0.364533	0.123963	-0.337304
		(0.0339)**	(0.0032)***	(0.4865)	(0.0086)***
ΔSchool		-0.009585	-0.008192	0.052945	-0.022310
		(0.9778)	(0.9799)	(0.8717)	(0.9472)
ΔGov			0.083272	-0.190827	-0.078351
			(0.7456)	(0.4699)	(0.7835)
Δexports				0.546251	
				(0.0064)***	
Δexchange					-1.4095704
					(0.1975)
Δdum2007	-15.599217	-14.808378	-14.636756	-7.903148	-13.562304
	(0.0000)	(0.0000)***	(0.0000)***	(0.0067)***	(0.0000)***
Ect(-1)	-0.637706	-0.667470	-0.754393	-0.915156	-0.820142
	(0.0002)***	(0.0007)***	(0.0001)***	(0.0001)***	(0.0003)***
Panel D: Diagnostic tests					
Nor.	0.692460	0.629205	0.770981	0.648267	0.728090
SC	0.1256	0.5452	0.2790	0.0487	0.1224
Het.	0.3097	0.4240	0.1685	0.4257	0.2654
FF	0.0030	0.1288	0.4515	0.0490	0.9285
CUSUM	S	S	S	S	S
CUSUMSQ	S	S	S	S	S

Notes: "***", "**", "*" represent the 1 percent, 5 percent and 10 percent critical levels, respectively. Nor, SC, Het., FF denote tests for normality, serial correlation, heteroscedasticity and functional form. Observe that none of the estimated regression suffers from non-normality of error terms, autocorrelation, heteroscedasticity and incorrect functional form. Moreover, the CUSUM and squares of CUSUM plots indicate stability of all estimated regressions.

6.3 Examining the asymmetric effect of nominal exchange rates on economic growth

In this section of the paper we re-estimate regression (5) from the previous section, this time making use of the exchange rate time series as the 'switching variable'. Panel A of Table 5 reports the nonlinear cointegration tests for asymmetric cointegration, long-run asymmetries and long-run asymmetries. The produced F-statistics of 3.24, 5.04 and 13.35, respectively, reject the corresponding null hypotheses of no asymmetric, no long-run asymmetry and short-run asymmetry at all levels of significance. As can be observed from the long-run estimates reported in Panel A, the exchange_POS variable produces an estimate of -1.10 which is statistically significant at a 10 percent critical level whereas the exchange_NEG produces a negative and statistically insignificant estimate. Note that we do not find any significant estimates for either Δexchange_POS or Δexchange_NEG variables over the short-run. Moreover, the remaining control variables produce similar insignificant estimates for the inflation, investment and schooling variables and also retaining a negative coefficients estimates for the government size variable. In a nutshell, our results imply that economic growth is hampered during a depreciation of the Pula to the US dollar whilst an appreciation of the currency to the dollar yields no significant effect on economic growth.

Table 5: N-ARDL estimates (Exchange rate and economic growth)

	coefficient	p-value
Panel A: Cointegration tests		
Asymmetric cointegration	3.242921**	
Long-run asymmetries	5.04***	
Short-run asymmetries	13.35***	
Panel B: Long-run estimates		
exchange_POS	-1.104497*	(0.0529)
exchange_NEG	0.683505	(0.7328)
Inf	-0.049031	(0.8516)
Inv	-0.071054	(0.4047)
School	-0.075710	(0.8062)
Gov	-0.603623***	(0.0007)
Panel C: Short-run estimates		
Δexchange_POS	-0.249573	(0.8681)
Δexchange_NEG	-1.112849	(0.5831)
ΔInf	0.084021	(0.6962)
ΔInv	-0.258591*	(0.0618)
ΔSchool	-0.885865***	(0.0088)
ΔGov	-0.022084	(0.9489)
Ect(-1)	-0.990803***	(0.0000)
Panel D: Diagnostic tests		
Nor.	0.70	0.71
SC	2.26	0.13
Het.	1.40	0.24
FF	0.07	0.94
CUSUM	S	
CUSUMSQ	S	

Notes: "***", "**", "*" represent the 1 percent, 5 percent and 10 percent critical levels, respectively. Nor, SC, Het., FF denote tests for normality, serial correlation, heteroscedasticity and functional form. Observe that none of the estimated regression suffers from non-normality of error terms, autocorrelation, heteroscedasticity and incorrect functional form. Moreover, the CUSUM and squares of CUSUM plots indicate stability of all estimated regressions.

6.4 Effectiveness of exchange rates in controlling inflation

We now examine the long-run and short-run asymmetric relationships between exchange rates and inflation in Botswana as means of evaluating the effect of the Pula/Dollar exchange rate on inflation using N-ARDL framework. Table 6, reports the findings of this empirical exercise. Panel A provides evidence of a significant evidence of three forms of nonlinearity i) nonlinear cointegration effects ii) nonlinear long-run effects and ii) nonlinear short-run effects. The long-run estimates, shown in Panel B, show that the devaluation of the Pula to the US dollar is inflationary such that an appreciation of the currency by a percentage

point increases inflation by 2.12 percent whereas a depreciation of the currency by one percent decreases inflation by 1.10 percent. We consider these findings plausible because an appreciation of the Pula to the dollar, causes imports to be cheaper which in turn heightens the probability of inflation passing through import prices whilst a depreciation of currency to the dollar weakens the possibility of inflation via import pass through effects as the prices of international goods and services becomes more expensive to purchase in domestic prices. Nevertheless, the issue of exchange rate pass-through effects to inflation is subject beyond the scope of this current study and is reserved for future studies.

Table 6: N-ARDL estimates (Inflation and Exchange rate)

	coefficient	**p-value**
Panel A: Cointegration tests		
Asymmetric cointegration	5.56***	
Long-run asymmetries	8.49***	
Short-run asymmetries	16.26***	
Panel B: Long-run estimates		
exchange_POS	-1.109185***	(0.0000)
exchange_NEG	-2.182723**	(0.0149)
Panel C: Short-run estimates		
Δexchange_POS	-0.770224	(0.2680)
Δexchange_NEG	-1.180227	(0.3985)
Ect(-1)	-0.745671***	(0.0000)
Panel D: Diagnostic tests		
Nor.	0.645236	0.3617
SC	0.149875	0.8529
Het.	0.546547	0.6322
FF	0.165478	0.8699
CUSUM	S	
CUSUMSQ	S	

Notes: "***", "**", "*" represent the 1 percent, 5 percent and 10 percent critical levels, respectively. Nor, SC, Het., FF denote tests for normality, serial correlation, heteroscedasticity and functional form. Observe that none of the estimated regression suffers from non-normality of error terms, autocorrelation, heteroscedasticity and incorrect functional form. Moreover, the CUSUM and squares of CUSUM plots indicate stability of all estimated regressions.

5 CONCLUSION

In this study we investigate the inflation-growth relationship for Botswana between the period of 1975 and 2016 using the recently developed nonlinear ARDL model of Shin et al.

(2014). We employ other control variables dictated by growth theory, such as domestic investment, human capital, government size, exports and the Pula/Dollar exchange rate as means of estimating. Whilst some of the variables such as exports produce the correct positive and significant effect on economic growth, other variables such as investment and schooling generally have an insignificant effect on economic growth hence undermining their influence on economic growth. Moreover, the negative and significant finding of government size on economic growth indicates inefficiency and counter-productivity of government spending and be further attributed to deficiencies in monitoring and implementing government finance projects.

However, concerning our main explanatory variable, the inflation rate, we are unable to find any significant effects of inflation on economic growth and after further investigation we find that a depreciation of exchange rate to the dollar leads to lower economic growth whereas an appreciation has no effect on growth. Moreover, an appreciation of the exchange rate is found to be inflationary whilst a depreciation of the exchange rate is found to be deflationary. Overall, the aforementioned presents a dilemma towards local monetary authorities since it is established that a depreciation of the Pula against the Dollar, both lowers inflation and economic growth whereas an appreciation of the currency has cause inflation whilst exerting no significant effect on economic growth. Therefore, whilst the Pula is pegged against a basket of currencies this study demonstrates the importance of the monetary authorities particularly monitoring the exchange rate against the dollar as an indicator of the health of the economy. Also against the incompleteness of our present study, future studies are advised on focusing on the exchange rate pass-through to import prices for the Botswana economy.

REFERENCES

Acemoglu D., Johnson S. and Robinson J. (2001), “An African success story: Botswana”, MIT Department of Economics Working Papers No. 01-37, July.

Adusei M. (2012), "The inflation-growth nexus: Estimating the threshold effect for South Africa", *Journal of Money, Investment and Banking*, 26, 87-93.

Atta J., Jefferis K. and Siwana-Ndai P. (1999), "Exchange rate policy and price determination in Botswana", AERC Research Paper 93, March.

Barro R. (1991), "Economic growth in a cross section of countries", *Quarterly Journal of Economics*, 106(425), 407-443.

Barro R. (1995), "Inflation and growth", NBER Working Paper No. 5326, October.

Barro R. (2013), "Inflation and growth", *Annals of Economics and Finance*, 14(1), 121-144.

Barro R. and Sala-i-Martin X. (1995), "*Economic growth*", New York: McGRaw-Hill.

Bick A. (2010), "Threshold effects of inflation on economic growth in developing countries", *Economic Letters*, 108(2), 126-129.

Bruno and Easterly (1998), Inflation crisis and long-run growth", *Journal of Monetary Economics*, 41(1), 3-26.

Clark J. (1991), "The exchange rate and the price level in a small open economy: Botswana", *Journal of Policy Modeling*, 13(2), 309-315.

Cooley T. and Hansen G. (1989), "The inflation tax in a real business cycle model", *American Economics Review*, 79(4), 733-748.

De Long and Summers (1991), “Equipment Investment and economic growth”, *The Quarterly Journal of Economics*, 106(2), 445-502.

Dukker D., Gomis-Porqueras P. and Hernandez-Verme P. (2005), “Threshold effects in the relationship between inflation and growth: A new panel-data approach”, MPRA Working Paper No. 38225, February.

Ee C. (2016), “Export-led growth hypothesis: Empirical evidence from selected Sub-Saharan African countries”, *Procedia Economics and Finance*, 35, 232-240.

Eggoh J. and Kahn M. (2014), “On the nonlinear relationship between inflation and growth”, *Research in Economics*, 68(2), 133-143.

Fischer S. (1993), “The role of macroeconomic factors of growth”, *Journal of Monetary Economics*, 32(3), 485-512.

Ghosh and Phillips (1998), “Warning: Inflation may be harmful to your growth”, *IMF Staff Papers*, 45(4), 672-710.

Greenwood J. and Huffman G. (1987), “A dynamic equilibrium model of inflation and unemployment”, *Journal of Monetary Economics*, 19(2), 203-228.

Guesh J. (1997), “Government size and economic growth in developing countries: A political-economy framework”, *Journal of Macroeconomics*, 19(1), 175-192.

Gyimah-Brempong K., Paddison O. and Mitiku W. (2006), “Higher education and economic growth in Africa”, *The Journal of Development Studies*, 42(3), 509-529.

Harvey R. (2015), “From diamonds to coal? Critical reflections on Botswana’s economic future”, *The Extractive Industries and Society*, 2(4), 827-839.

Hineline D. (2007), “Examining the robustness of the inflation and growth relationship”, *Southern Economic Journal*, 73(4), 1020-1037.

Ibarra R. and Trupkin D. (2016), “Re-examining the relationship between inflation and growth: Do institutions matter in developing countries”, *Economic Modelling*, 52(B), 332-351.

Iyke B. and Odhimabo N. (2017), “Inflationary thresholds, financial development and economic growth: New evidence from two West African countries”, *Global Economy Journal*, 17(2), 1-11.

Kahn M. and Senhadji A. (2001), “Threshold effects in the relationship between inflation and growth”, IMF Staff Papers, 48(1), 1-21.

Kebret-Taye H. (2013), “The determinants of inflation in Botswana and Bank of Botswana’s medium-term objective range”, *Botswana Journal of Economics*, 11(15), 57-74.

Kremer S., Bick A. and Nautz D. (2009), “Inflation and growth: New evidence from a dynamic panel threshold analysis”, *Empirical Economics*, 44(2), 861-878.

Lesotho O., Motlaleng G. and Ntsosa M. (2016), “Stock market returns and exchange rates in Botswana”, *African Journal of Economic Review*, 4(2), 16-42.

Leshoro T. (2012), “Estimating the inflation threshold for South Africa”, ERSA Working Papers No. 285, May.

Levine R. and Renelt D. (1992), A sensitivity analysis of cross-country regressions", *American Economic Review*, 82(4), 942-963.

Majumder S. (2016), "Inflation and its impacts on economic growth of Bangladesh", *American Journal of Marketing Research*, 2(1), 17-26.

Mavikela N., Mhaka S. and Phiri A. (2017), "The inflation-growth relationship in SSA inflation-targeting countries", MPRA Paper No. 82141, October.

Mkhatshwa Z., Tijani A. and Masuku M.(2015), "Analysis of the relationship between inflation, economic growth and agricultural growth in Swaziland from 1980-2013", *Journal of Economics and Sustainable Development*, 6(18), 189-204.

Mogotsi I. (2002), "Botswana's diamonds boom: Was there a Dutch disease?", *South African Journal of Economics*, 70(1), 128-156.

Mubarik Y. (2005), "Inflation and growth: An estimate of the threshold level of inflation in Pakistan", *SBP Research Bulletin*, 1-2, 35-44.

Munir Q. and Mansur K. (2009), "Non-linearity between inflation rate and GDP growth in Malaysia", *Economics Bulletin*, 29(3), 1555-1569.

Munyeka (2014), "The relationship between economic growth and inflation in the South African economy", *Mediterranean Journal of Social Sciences*, 5(15), 119-129.

Ndoricimpa A. (2017), "Threshold effects of inflation on economic growth" Is Africa different?", *International Economic Journal*, 31(4), 599-620.

Pegg S. (2010), "Is there a Dutch disease in Botswana?", *Resource Policy*, 35(1), 14-19.

Phetwe M. and Molefe L. (2016), "Inflation and economic growth: Estimation of a threshold level of inflation in Botswana", *Bank of Botswana Research Bulletin*, 29(1),12-23

Phiri A. (2010), "At level is inflation least detrimental towards finance-growth activity in South Africa?", *Journal of Sustainable Development in Africa*, 12(6), 354-364.

Phiri A. (2017), "Changes in inflation persistence prior and subsequent to the subprime crisis: What are the implications for South Africa?", *Journal of Reviews on Global Economics*, 6, 198-207.

Phiri A. (2018), "Nonlinear impact of inflation on economic growth in South Africa", *International Journal of Sustainable Economy*, 10(1), 1-17.

Sala-i-Martin X. (1997), "I just ran four million regressions", *American Economic Review*, 87(2), 178-183.

Sarel M. (1996), "Nonlinear effects of inflation on economic growth", *IMF Staff Papers*, 43(1), 199-215.

Setlhare L. (2004), "Bank of Botswana's reaction function: Modelling Botswana's monetary policy strategy", *South African Journal of Economics*, 72(2), 384-406.

Seleteng M., Bittencourt M. and van Eyden R. (2013), "Non-linearities in the inflation-growth nexus in the SADC region: A penal smooth transition regression approach", *Economic Modelling*, 30(C), 149-156.

Shin Y., Yu B. and Greenwood-Nimmo M. (2014), "*Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework*", Festsschrift in honor of Peter Schmidt: Econometric Methods and Applications, eds. By R. Sickels and W. Horace, Springer, 281-314.

Sidrauski M. (1967), “Rational choice and patterns of economic growth in a monetary economy”, *American Economic Review*, 57(2), 534-544.

Solow R. (1965), “A contribution to the theory of economic growth”, *Quarterly Journal of Economics*, 70(1), 65-94.

Stockman M. (1981), “Anticipated inflation and capital stock in a Cash-in-Advance Economy”, *Journal of Monetary Economics*, 8(3), 387-393.

Taye H. (2011), “Botswana’s debt sustainability: Tracking the path”, BIDPA Working Paper No. 28, March.

Tobin J. (1965), “Money and economic growth”, *Econometrica*, 33(4), 671-684.

Tung L. and Thanh P. (2015), “Threshold in the relationship between inflation and economic growth: Empirical evidence in Vietnam”, *Asian Social Sciences*, 11(10), 105-112.

Uneze E. (2013), “The relation between capital formation and economic growth: Evidence from sub-Saharan African countries”, *Journal of Economic Policy Reform*, 16(3), 272-286.

Vaona A. (2012), “Inflation and growth in the long run: A New Keynesian theory and further semiparametric evidence”, *Macroeconomics Dynamics*, 16(1), 94-132.

Vinayagathasan T. (2013), “Inflation and economic growth: A dynamic panel threshold analysis for Asian economies”, *Journal of Asian economies*, 26, 31-41.