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ENDOGENOUS MONETARY APPRAOCH TO OPTIMAL INFLATION-GROWTH NEXUS IN SWAZILAND

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ABSTRACT: With the inflation-growth nexus being a hotly debated issue within the academic paradigm, the purpose of our study is to examine the relationship for Swaziland between 1975 and 2016 of which there currently exists very limited country-specific evidence. In the design of our study we theoretically depend on an endogenous monetary model of economic growth augmented with a credit technology which causes a nonlinear relationship between inflation and growth. Econometrically, we rely on the smooth transition regression (STR) which allows us to estimate an optimal inflation rate characterized by smooth transition between different inflation regimes. Our empirical results point to an inflation threshold estimate of 7.64% at which economic growth gains are maximized or similarly growth losses are minimized. In particular, we find that above the inflation threshold economic agents may be able to protect themselves from inflation through credit technology and a more urbanized population yet such high inflation adversely affects the influence of exports on economic growth. This noteworthy since a majority of government revenues is from trade activity via the country's affiliation with the Southern African Customs Union (SACU). Nevertheless, the major contribution of this paper is that it becomes the first to use endogenous growth theory to estimate the inflation threshold for any African country which will hopefully pave a way for similar studies on other African countries.

Keywords: Inflation; Economic growth; Endogenous monetary growth model; Smooth transition regression; Swaziland; African country.

JEL Classification Code: C22; C32; C51; C52; E31; O47.

1 INTRODUCTION

The relationship between inflation and growth has undergone a number of stages of development primarily facilitated by advancements made in applied econometric techniques. Initially Fisher (1993) applied a piece-wise estimation with two predetermined breaks at 15% (moderate inflation) and 40% (high inflation) to examine the inflation-growth nexus on a global platform. The authors discover for a panel of 93 developing and industrialized economies a negative inflation-growth relationship only significantly holds at inflation rates below 40 percent whereas above this level the relationship turns insignificant. Using a similar empirical technique applied to a larger dataset, Bruno and Easterly (1998) provide evidence in support of Fisher (1993) findings whilst Barro (1996) discredited Fisher's (1993) results by observing a negative inflation-growth relationship across all levels of inflations. Later Sarel (1996), Ghosh and Phillips (1998), Khan and Senhadji (2001) as well as Kremer et al. (2013) applied more refined techniques, as inspired by Hansen's (1999, 2000) threshold autoregressive (TAR) framework, to identify an optimal 'inflation threshold' at which the effects of inflation on growth switched. The general consensus from this later group of studies is that inflation 'thresholds' differ between developing and industrialized economies in which the thresholds are established to be higher for developing countries. From a policy perspective these studies assume that the mandate of keeping low inflation is more of a priority in more advanced countries as less developed nations should be more concerned with more fundamental processes such as openness, political instability and tax policy (Epstein, 2002).

From the earlier studies of Fisher (1993), Barro (1995) and Bruno and Easterly (1998) to the more advanced studies of Sarel (1996), Ghosh and Phillips (1998) as well as Khan and Senhadji (2001), one fallacy in these estimation techniques used is the assumption of an abrupt transition between low and high inflation regimes. As argued by Hasanov et al. (2013) and Phiri (2018), it is more likely that economic units do not behave simultaneously and in the same direction. Moreover, decisions taken by monetary policy authorities are usually smoothed out over time in their adjustment of short-term policy instruments used to control inflation. Another fallacy of these previous studies is the panel 'homogeneity' problem in which a singular empirical finding is generalized for a host of countries with multiple difference in economic circumstances and structures. In the case of African countries, Seleteng et al. (2013), Ndoricimpa (2017) and Omay et al. (2018) serve as prime examples to these fallacies. Nevertheless, country-specific studies on the inflation-growth relationship have gained popularity within the empirical literature for African economies (see Fabayo and Ajilore (2006) for Nigeria, Frimpong and Oteng-Abayie (2010) for Ghana, Phiri (2010) and Adusei (2012) for South Africa, Phiri (2013) for Zambia, Nkume and Ngalawa (2014) for Malawi, Yabu and Kessy (2015) for Uganda, Kenya and Tanzania, Mkhatshwa et al. (2015) for Swaziland and Phetwe and Molefe (2016) for Botswana). Notably this latter group of studies has primarily relied on similar threshold estimation techniques employed by Sarel (1996) and Kahn and Senhadji (2001) which render these studies prone to the fallacy of abrupt transition between inflation regimes.

In our study we examine the inflation-growth dynamics for Swaziland as a small, landlocked African monarchy. To this end, we rely on an endogenous monetary model of growth developed by Gillman et al. (2004) and we particularly apply the smooth transition regression (STR) model of Terasvirta (1994) to examine the empirics. Besides the lack of country-specific empirical evidence in comparison to other African economies, we consider the Kingdom of Swaziland as an interesting case, since the country's monetary policy stance has been closely tied to that of South Africa despite these countries having contrasting levels of economic development. Nevertheless, by virtue of Swaziland affiliation with a common monetary agreement in which the Swazi lilangeni, Lesotho Loti and Namibian Dollar are pegged of equal value to the South African Rand, much of the monetary policy decisions taken by the South African Reserve Bank (SARB) are emulated by the Central Banks of Swaziland (CBS). Consequentially, the 3 to 6 inflation percent target adopted by the SARB serve as blueprint for the smaller BOLESWA countries (Botswana, Lesotho and Swaziland) which are collectively and historically connected with South Africa via the Southern African Customs Union (SACU). It is therefore important for the CBS to know as to whether the 3 to 6 percent inflation target covers the range of some optimal or threshold inflation point for the Swazi economy.

The implications of establishing a significant inflation threshold point for the Kingdom of Swaziland have far reaching policy ramifications. For starters, it may be possible that monetary practices by the CBS may be too restrictive to promote sustainable economic growth as has been proven by the available empirical literature presented so far. Take for instance, the study of Seleteng et al. (2013) who find an optimal inflation threshold of 18.9 percent for a panel of 10 members of the Southern African Development Community (SADC) countries inconclusive of Swaziland. Similarly, Ndoricimpa (2017) finds an inflation threshold of 8 percent for a group of 47 African economies whilst Omay et al. (2018) establish an inflation threshold of 12 percent for 11 SADC members which are also inclusive of Swaziland. Collectively, these findings from Seleteng et al. (2013), Ndoricimpa (2017) and Omay et al. (2018) imply that the commonly pursuit of low, single-digit inflation rates in these African countries may be over-prioritized at the expense of other development objectives. On the other hand, it may be possible that the current inflation may be higher than some 'threshold' which would deteriorate welfare and economic growth. However, with little empirical existing for the case of Swaziland, as a country-specific case study, this subject matter is not at all conclusive and is open to further scrutiny for the Kingdom.

Having provided a basic introduction to the study, the rest of the paper is structured as follows. The next section outlines the theoretical model used in our study whereas section 3 describes the STR model used to estimate our main regression. Section 4 present the data and the empirical analysis whist the paper is concluded in Section 5 of the paper.

2 THEORETICAL FOUNDATION OF THE STUDY

The modelling of the dynamic relationship between inflation on economic growth over the last 50 years or so, can be broadly classified into three strands of theoretical thought. Firstly, Tobin (1965) used a neoclassical model of Solow (1965) to demonstrate that inflation defined as an increase in money supply, cause economic agents to shift away from the use of money to interest bearing capital stock which then increase steady-state economic growth via capital accumulation. The 'Tobin-effect' is thus one describing a positive inflation-growth relationship. Secondly, Sidrauski (1967) demonstrates that within a utility maximization framework, an increase in money supply (i.e. inflation) only affects nominal variables yet leaving real variables like capital accumulation and steady-state growth unaffected. This effect is known as the superneutrality effect of money which discards any significant steady-state relationship between inflation and growth. Lastly, there is the doctrine of endogenous growth theorists, who argue that inflation acts as a tax on physical and/or human capital hence adversely influencing steady-state growth. Chief amongst these later group of endogenous theorists are Stockman (1981), Lucas and Stokey (1987), Greenwood and Huffman (1987), Cooley and Hansen (1989), De Gregorio (1992, 1993) and Gomme (1993).

More recently, Gillman et al. (2004) develop a hybrid, endogenous model of inflation and growth in which certain theoretical foundations/principles expounded by Tobin (1965), Sidrauski (1967) and Gomme (1993) are comprehensively incorporated within a singular theoretical framework. The authors consider a five-sector comprising of i) households ii) goods production iii) human capital production iv) credit production (exchange technology) v) government sector. The representative agent's current period of utility consists of a choice between consumption, c_t, and leisure (unproductive time), x_t, is given by:

$$U\left(c_t, x_t\right) = \frac{c_t^{1-\theta} x_t^{\alpha(1-\theta)}}{1-\theta} \tag{1}$$

The production of the singular consumption good, y_t, is achieved via a constant returns-to-scale technology i.e.

$$y_t = A_g(s_{gt}, k_t)^{1-\beta}(l_{gt}, h_t)^{1-\beta} \tag{2}$$

Where A_g is a positive shift parameter of the production function of the consumption good, k_t is the economy's stock of physical capital, h_t is the stocks of human capital, s_{gt} is the share of physical capital in goods production, l_{gt} is the fraction of time spent in goods production. It is further assumed that human capital is CRS produced with capital not used in goods (i.e. $1 - s_{gt}$) k_t and time not spent in leisure $(1 - x_t - l_{gt} - l_{ft})$. In denoting δ_h as a depreciation in human capital, then the 'motion' equation for investment in human capital is expressed as:

$$\dot{h}_t = A_h P(1 - x_t - l_{gt} - l_{ft})^{\delta} h_t(1 - s_{gt})^{1-\delta} - k_t - \delta_h h_t \qquad (3)$$

The first order conditions from the production function for consumption goods (2) set the market real interest rate ($r=(1-\beta)A_g[(s_{gt}k_t)/(l_{gt}h_t)]^{-\beta}$) and real wage equal to the marginal products ($w=\beta A_g[(s_{gt}k_t)/(l_{gt}h_t)]^{1-\beta}$). Therefore, households in the economy can earn interest on owned assets, r, and can use income in the form of wages, w, to purchase the output produced within the economy. An alternative mechanism for purchasing output produced is through credit technology which is assumed to be perfect substitute for money. The production of credit, d_t, is achieved using an effective labour-only technology which is Cobb-Douglas in $l_{ft}h_t$, and c_t such that:

$$d_t = A_f(l_{ft}h_t)^{\gamma} c_t^{1-\gamma} \qquad (4)$$

Where A_f is a positive shift parameter of the production function of credit services and l_{ft} is the fraction of time spent in producing credit services. In denoting a $\in(0,1)$ as a fraction of purchases made with cash (i.e. $d_t = (1 - a_t)c_t$) and making use of the Lucas (1980) 'Clower constraint' which ensures that money, M_t and credit are perfect substitutes (i.e. $M_t = a_t P_t c_t$ with P_t being the domestic price level), equation (3) can be re-specified as:

$$M_t = [1 - A_f(\frac{l_{ft}h_t}{c_t)^{\gamma}})P_t c_t] \qquad (5)$$

It is also assumed that government's only role in the economy is to change the money supply form the initial value, m_0, and making lump-sum transfers, V_t. Denoting money growth rate by, σ, the evolution of money supply can be expressed as:

$$M_{t+1} = M_t + V_t = M_t(1+\sigma) \quad (6)$$

In considering the agents total nominal financial capital constraint, Q_t, which comprises of money balances, M_t, and the current financial value of physical capital, $P_t k_t$, i.e.

$$Q_t = M_t + P_t k_t \quad (7)$$

And by setting the income of $r_t P_t s_{gt} k_t + w_t P_t l_{gt} h_t + V_t + \dot{P}_t k_t$ minus the expenditure of $P_t c_t + \delta_k Ptk_t$ to zero results in the following the nominal income constraint:

$$\dot{Q}_t = r_t P_t s_{gt} k_t + w_t P_t l_{gt} h_t + V_t + \dot{P}_t k_t - P_t c_t - \delta_k P_t k_t \quad (8)$$

The representative agent maximizes the discounted stream of the period utility of equation (1) subject to the constraints equation (5), (6), (7), and (8). The resulting equilibrium balanced-path growth rate of the model, g, is given by:

$$g = \dot{c}/c = \dot{k}/k = \dot{h}/h = [r - p]/Q \quad (9)$$

Where the equality of the return of physical capital in goods production, r, to the return on effective labour in human capital production can be expressed as:

$$r = (1-x)A_h\beta(s_h k/l_h h)^{1-\beta}-\delta_h \quad (10)$$

Moreover, the marginal rate of substitution between goods and leisure can be equated as follows:

$$\alpha c/xh = wc/(1 + aR + wl_f h) \quad (11)$$

Where R is the nominal interest rate of money which is expected to directly rise and fall with inflation. From the steady-state conditions depicted in equations (9) through (11), one can describe two order effects of inflation on economic growth. Firstly, there is the Tobin effect, which arises since inflation, causes an increase in the input price ration, w/r, as the representative agent increases time in leisure, x_t, and this induces a shift away from effective labour towards capital which increases capital intensity. Secondly, there creeps in a negative effect resulting from the fall in return to capital, r, caused directly by an increase in leisure, x_t, which ultimately reduces balanced path level of economic growth.

The magnitude of the nonlinear inflation-growth relationship is dependent on the agent's use of credit technology. In a cash-only-economy with no credit facilities (i.e. a=1), Gillman and Heyak (2004) show that the negative effect of inflation on growth is of a linear form. However, the more the agent relies on credit technology switching away from money during periods of rising inflation, the smaller is the magnitude of increased time in leisure. In turn, this dampens the long-term negative effect of inflation on steady-state growth as convened by traditional endogenous monetary models (Stockman (1981), Lucas and Stokey (1987), Greenwood and Huffman (1987), Cooley and Hansen (1989), De Gregorio (1992, 1993) and Gomme (1993)), and with higher levels of credit technology this may nullify the long-term effect of inflation on economic growth as found in Sidrauski (1967). In collectively assembling the different components of the endogenous model the following econometric baseline function can be derived:

$$GDP = a + a_1\pi_t + a_2\, inv/gdp_t + a_3\, urban_t + a_4\, urban_t + a_5\, gov_t + a_6\, trade_t + e_t \qquad (12)$$

Where π_t is a measure of inflation, inv/gdp_t is measure of capital accumulation who Gillman et al (2004) note is also a good indicator of real interest rate, $credit_t$ is a measure of credit technology and $urban_t$ is a measurement of urbanized and relatively informed population who most likely has access to advanced credit technology. We include two addition control variables, gov_t which is a measurement of government size which in our model is responsible for creating and distribution money and we also include $trade_t$ which measures the country's openness to the global world. Note that equation (12) is linear in parameters and as a result Gillman et al. (2014) use different spline specifications at pre-determined inflation 'thresholds' to capture the nonlinearities between inflation and growth. In our study apply the more sophisticated smooth transition regression (STR) model which allows us to endogenously determine and estimate the inflation threshold point responsible for smooth regime switching behaviour in the model.

3 SMOOTH TRANSITION REGRESSION (STR) METHODOLOGY

To capture the dynamic relationship between inflation and economic growth we rely on the STR model of Terasvirta (1994). In its baseline for the STR model can be given as:

$$y_t = \beta_0' x_t + \beta_1' x_t \, G(z_t;\, \gamma, c) + \varepsilon_t \qquad (13)$$

Where y_t is a scalar; are parameter vectors; x_t is the vector of explanatory variables, with β_0' and β_1' are associated parameter vectors of the linear and nonlinear part, respectively, and e_t is a well-behaved error term. Nonlinearity is incorporated into the regression via the transition function $G(z_t; \gamma, c)$ which consists of a transition or threshold variable z_t, a transition parameter, γ, and a threshold value, c, and the transition function determines whether the economy is in the 'high regime' or is in the 'low regime' or is transitioning between the two regimes. Note that $G(z_t; \gamma, c)$ is normalized and bound between 0 and 1 (i.e. $G(z_t; \gamma, c) \in [0,1]$) such the $G(z_t; \gamma, c) \in [0,1]$ such that the when G=0 then the model collapses into a linear model whereas when G = 1 then the model turns into a two-regime TAR model as in Hansen (1999). In following Terasvirta (1994) we consider that the transition function is logistic i.e.

$$G(z_t;\, \gamma, c) = [1 + \exp(-\gamma(z_t - c_k))]^{-1} \qquad (14)$$

Where $\gamma > 0$ and $c_1 \leq c_2 \leq \ldots c_m$. We restrict the LSTR to the cases of k=1 and k=2 which yield the LSTR(1) and LSTR(2) regressions, respectively. To estimate the LSTR model we follow Terasvirta (1994) who propose a three-stage estimation process of the STR model. The first stage of this process consists of testing for linearity against the alternative of a LSTR model. However, testing for linearity is complicated by nuisance parameters in the variables under the supposed null hypothesis of no linearity i.e. H_0: $\gamma = 0$ or H_0: $\beta_1 = 0$. We therefore follow Luukkonen et al. (1998) who suggest circumventing this identification problem by the replacing the transition function $G(z_t; \gamma, c)$ by it's first order Taylor expansion around $\gamma = 0$ i.e.

$$y_t = \mu_t + \beta_0'^{*} x_t + \beta_1'^{*} x_t z_t + \beta_2'^{*} x_t z_t^2 + \beta_3'^{*} x_t z_t^3 + \varepsilon_t^* \quad (15)$$

Where the regression parameters are $\beta_1'^{*}$, $\beta_2'^{*}$and $\beta_3'^{*}$ are multiples of γ and $\varepsilon_t^* = \varepsilon_t + R_3\beta_1' x_t$, with R_3 being the remnant portion of the Taylor expansion. Hereafter, the null hypothesis of linearity can be tested as:

$$H_0^*: \beta_3^* = \beta_2^* = \beta_1^* \quad (16)$$

And the null hypothesis in (17) can be tested with using an LM test statistic which does not violate asymptotic χ^2 distribution. Once nonlinearity is validated, one must proceed to select between a LSTR(1) and LSTR(2) regression. We therefore apply the decision rule presented by Terasvirta (1994) based on the following sequence of hypotheses tests:

$$H_{04}^*: \beta_3^* = 0 \quad (17)$$

$$H_{03}^*: \beta_2^* = 0/\beta_3^* = 0 \quad (18)$$

$$H_{02}^*: \beta_1^* = 0/\beta_2^* = \beta_3^* = 0 \quad (19)$$

Of which the above hypotheses are tested using F-tests denoted F4, F3 and F2, respectively. Thereafter we choose an LSTR(2) model if the F3 statistic produces the lowest p-value (i.e. highest rejection) otherwise we select the LSTR(1) specification. Once the selection of the LSTR form is validated, one can proceed to the second stage of the empirical process in which the LSTR model is estimated. Lundbergh et al. (2003) suggest, a two dimension grid search should be performed in a linear grid for c and log-linear in grid for γ, and thereafter the remainder of the regression parameters from the selected LSTR model are estimated using a form of the Newton-Raphson algorithm to maximize the conditional maximum likelihood function.

In the final stage of the empirical process, the estimated model is evaluated for misspecification of the estimated models. There are quite a handful of conventional tests which are proposed in the literature such as LM tests for no autocorrelation, LM-type tests of no autoregressive conditional heteroscedasticity (ARCH) and the Jarque-Bera tests for normality in regression residuals. Note that these misspecification tests are merely an extension of the conventional linear case to a nonlinear setting. In addition, we also carry out the LM test for no remaining non-linearity which are extensively described in Eitrheim and Terasvirta (1996).

4 DATA AND UNIT ROOT TESTS

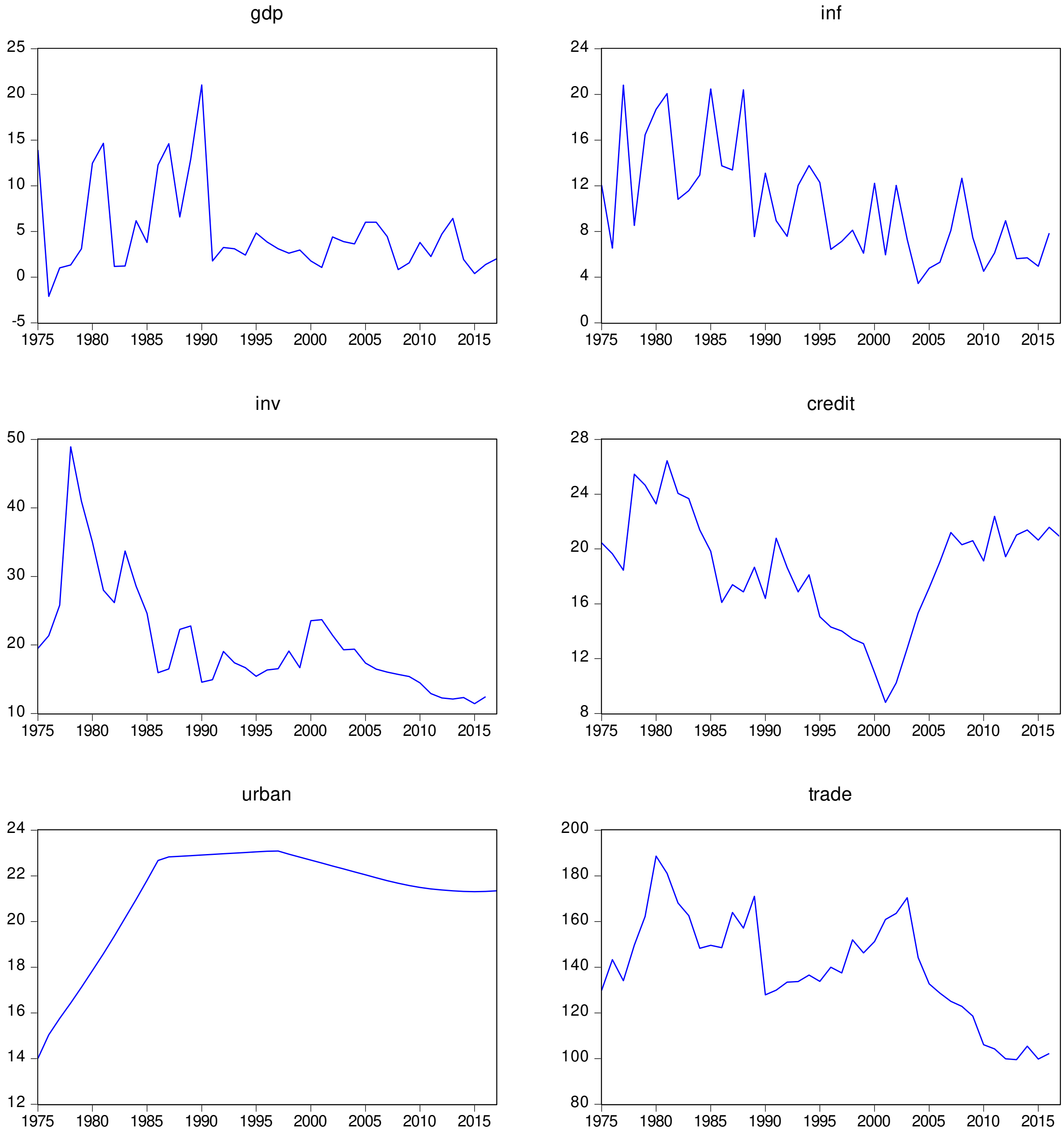
4.1. Data description

All our empirical data has been sourced from the World Bank online database and consists of 6 time series variables (GDP growth, inflation, investment, credit-to-private sector, urbanization, government size and terms of trade) collected on an annual basis over the period 1970 to 2016. The summary statistics and correlation matrices of these variables are provided in Panels A and B of Table 1, respectively, whilst the time series plots of the variables are given in Figure 1.

Table 1: Summary statistics and correlation matrix of time series

Panel A: summary statistics	gdp	π	inv	credit	urban	trade
Mean	4.84	10.29	20.31	18.55	21.16	139.60
Median	3.23	8.73	17.38	19.10	21.86	138.74
Maximum	21.02	20.81	48.92	26.44	23.08	188.65
Minimum	-2.12	3.45	11.44	8.81	14.00	99.48
Std. dev.	4.85	4.81	7.94	4.12	2.39	23.09
Skewness	1.53	0.79	1.71	-0.37	-1.62	-0.08
Kurtosis	4.82	2.71	6.11	2.70	4.60	2.37
j-b	22.14	4.48	37.44	1.11	22.99	0.74
p-value	0.00	0.11	0.00	0.57	0.00	0.69
observations	42	42	42	42	42	42
Panel B: Correlation matrix						
gdp	1					
π	0.34	1				
inv	-0.02	0.43	1			
credit	0.05	0.21	0.35	1		
urban	0.02	-0.28	-0.55	-0.55	1	
trade	0.28	0.48	0.65	-0.11	-0.13	1

Figure 1: Time series plots of variables



4.2 Unit root test results

Before modelling our empirical STR model, it is important to establish stationary in the time series. Conventional unit root tests such as the ADF and PP tests have weak power in rejecting the unit root hypothesis if the underlying data generating process of the time series is nonlinear (Kapetanois et al., 2003). We therefore rely on the STR-based unit root test of Kapetanois et al. (2003) (KSS hereafter) to examine the stationarity properties of the time series. The authors proposed the following empirical regression which is derived by approximating an ESTAR model by a higher order Taylor series/approximation:

$$\Delta Y_t = \delta_i Y_{t-i}^3 + \sum_{j=1}^{p} \rho_i \Delta Y_{t-i} + e_t \qquad (20)$$

Where the null hypothesis of a linear unit root process can be now tested as H_0: $\delta_i = 0$ against the alternative of stationary ESTAR process (i.e. H_1: $\delta_i = 0$) and the asymptotic critical value of the KSS unit root test is computed as:

$$t_{NL} = \frac{\hat{\delta}}{S.E.(\hat{\delta})} \qquad (21)$$

Where $\hat{\psi}$ is the estimated value of ψ and S.E.($\hat{\psi}$) is the standard error of $\hat{\psi}$. Since the t_{NL} statistic does not follow an asymptotic standard normal distribution, KSS derive critical values for the test statistics. The results of the KSS test performed on our empirical data alongside that of the conventional ADF test (for comparison sake) are presented in Table 1.the ADF test finds stationarity at a 1% critical level in both inflation and economic growth series whilst the remaining 'control variables' fail to reject the unit root null hypothesis at all critical levels. On the other hand, the KSS test produces the desired result of rejecting the unit root hypothesis for all series at significance levels of at least 10%. Our presented evidence demonstrates the importance of accounting for nonlinearities in distinguishing between unit root and stationary process and more encouragingly permits us to proceed to model the empirical STR model using all observed time series.

Table 2: ADF and KSS unit root tests results

Time series	ADF		KSS	
	t-stat	lag	t-stat	lag
gdp	-4.86***	0	-5.42***	1
π	-4.31***	0	-2.39**	2
inv	-2.03	0	-2.65**	1
credit	-1.76	0	-2.49**	3
urban	-2.14	1	-3.42***	2
gov	-2.06	0	-2.11*	1
trade	-1.30	0	-2.14*	2

Notes: "***', '**', '*' represent the 1%, 5% and 10% critical levels, respectively. Critical values derived from Kapetanois et al. (2003) are -2.82(1%), -2.22 (5%), -1.92(10%). Optimal lags length is determined by the Schwarz criterion.

5 EMPIRICAL ANALYSIS

5.1 Tests for linearity

We begin the reporting of our empirical results by presenting the results of tests for linearity performed on each possible candidate transition. The results from this empirical exercise are reported in Table 4. To recall, the rule of thumb is that the variable with highest rejection of linearity (i.e. lowest p-value) is chosen as our transition variable responsible for regime switching. As can be observed form Table 4, only the government size (*gov*) and the inflation variable (π) produce F-statistics which manage to reject the null hypothesis of no LSTR effects whereas the remaining candidate variable cannot reject the linearity null hypothesis. However, note that the inflation variable provides the higher rejection or lower p-value out of the two variables and hence is selected as our transition variable. In further evaluating the p-values of the F4, F3 and F2 test statistics, we further note that the F2 statistics produces a lower p-value compared to those from the associated with the F4 and F3 statistics hence the LSTR(1) specification is most suitable for empirical purposes. Therefore, having provided sufficient evidence on LSTR regime switching behaviour in our estimated growth regression, with inflation having been validated to be the most suitable transition variable, we proceed to estimate our LSTR regression.

Table 3: Linearity tests

transition variable	test statistics				decision
	F	F4	F3	F2	
π	0.0064	0.3803	0.0176	0.0071	LSTR1
inv	0.1413	0.1269	0.3093	0.3585	Linear
credit	0.7806	0.4741	0.9774	0.3862	Linear
urban	0.6590	0.1874	0.0014	0.0065	Linear
gov	0.0287	0.2681	0.0084	0.3519	LSTR2
trade	0.5491	0.5649	0.1498	0.0474	Linear

Note: The F-test for non-linearity are performed for each possible candidate of the transition variable and the variable with the strongest test rejection (i.e. lowest p-value) is tagged with symbol #.

5.2 LSTR regression estimates

The empirical findings from the estimation of the LSTR(1) model are summarized in Table 4. Panel of Table 4 presents the findings from our grid search for the threshold, c, and the smoothness, γ, parameters, both which produce highly statistically significant estimates. Note that the estimated threshold, c, on our transition variable, inflation is 7.64% which is the optimal rate of inflation which maximizes economic growth or similarly minimizes growth loses in the Kingdom of Swaziland. Note that the estimated smoothness parameter of 6.62 is rather abrupt and this is confirmed in the transition plot provided in Figure 2 in which the threshold estimate of 7.64% is found in the middle of the transition from the lower to upper inflation regime. We further note that in comparison to a majority of previous studies which have included Swazi data in the estimated panel, our obtained inflation threshold estimate is substantially lower than the 11%, 1, 18.9% and 12% inflation thresholds obtained in the studies of Khan and Senhadji (2001), Kremer et al. (2013), Seleteng et al (2013) and Omay et al. (2018), respectively. Encouragingly enough our obtained threshold estimate is closer in value to the 8% and 7% reported in the works of Sarel (1996) and Ndoricimpa (2017), respectively.

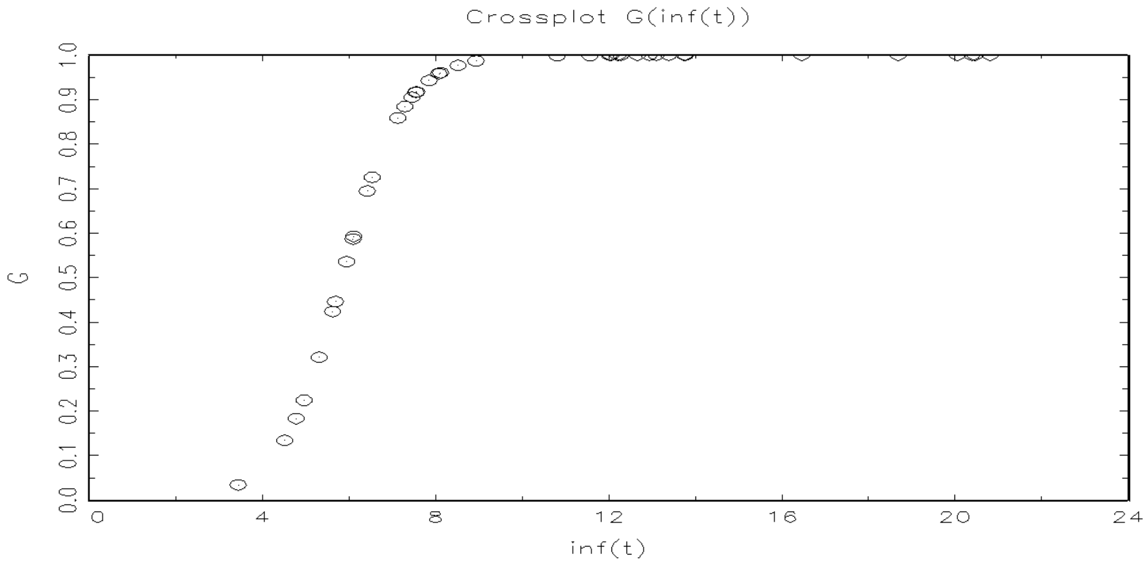
In scrutinizing through the regression estimates reported in Panels B and C of Table 4, we find that our results can be best summarized in the following 5 observations. Firstly, the investment variable produces a negatively and highly significant estimate in the lower inflation regime (i.e. $\pi < 7.64\%$) whilst turning insignificant in the upper inflation regime (i.e. $\pi > 7.64\%$). Even though this finding is at odds with conventional growth theory, we consider this finding plausible since investments in Swaziland are not 'Greenfield' investments which would boost economic growth. This observation has been confirmed in the recent work of Phiri (2018) albeit for the South African economy. Secondly, government size is insignificantly related with growth in both inflation regimes, hence implying that Swazi government may be allocating state funding to unproductive expenditure items. Thirdly, credit is also found to insignificant in the lower regime, implying that during periods of low inflation, Swazi economic agents use an insignificant amount of credit facilities which has no significant impact on growth. However, at inflation rates above the threshold, economic agents rely more on credit technology which is significant enough to boast economic growth. Fourthly, trade is found to significantly improve economic growth in a low inflation environment whereas it is insignificant affects growth at higher inflation levels. Lastly, in a lower inflation regime, urbanization is detrimental to growth whereas in high inflation regime urbanization assists in improving economic growth. This finding is comparable to the recent findings of Nguyen and Nguyen (2018) who find similar regime switching behaviour of urbanization on economic growth for ASEAN economies.

Table 4: LSTR regression estimates of endogenous growth model

variable	start	estimate	Std. dev.	t-stat	p-value
Panel A: Grid search results					
γ	6.62	5.42	0.52	10.42	0.00***
c	7.64	7.40	0.47	15.80	0.00***
Panel B: Linear part					
π	0.06	0.05	0.03	1.64	0.11
inv	-2.41	-2.48	0.88	-2.81	0.00***
credit	-0.50	-0.17	1.26	-0.13	0.89
urban	-4.60	-4.16	1.80	-2.31	0.02**
gov	-0.32	-0.59	1.57	-0.38	0.71
trade	3.13	3.84	2.22	1.73	0.09*
Panel C: Nonlinear part					
π	-0.06	-0.08	0.10	-0.78	0.44
inv	5.52	5.92	4.26	1.39	0.18
credit	4.54	5.01	2.32	2.16	0.04**
urban	23.74	25.38	7.48	3.39	0.00***
gov	-0.54	-0.81	3.60	-0.23	0.82
trade	-3.33	-3.78	5.89	-0.64	0.53

Notes: "***', '**', '*' represent the 1%, 5% and 10% critical levels, respectively. The effect of the regression variables on economic growth in the nonlinear part of the regression are computed by adding the coefficients from both the linear and nonlinear parts i.e. $\beta_0 + \beta_1$.

Figure 2: Transition function plot for estimated LSTR(1) model



5.3 Diagnostic tests

Table 5 presents the evaluation tests with Panel A reporting the diagnostic tests whilst Panel B reports the tests for no remaining nonlinearity. The tests performed for serial correlation, autoregressive conditional heteroscedasticity (ARCH) effects and the Jarque-Bera tests for normality fail to establish any evidence of autocorrelation, ARCH effects and non-normality in the estimated regression disturbance term. Similarly, the F-test statistic conducted for non-remaining nonlinearity fails to establish any evidence of any additive nonlinearity. Collectively, these results indicate that our estimated LSTR(1) regression conforms to the classical regressions assumption and hence our regression estimates can be interpreted with confidence.

Table 5: Evaluation tests on estimated LSTR model

Panel A: Diagnostic tests	p-values
LM(4)	0.0484
ARCH(4)	0.9236
J-B	0.8319
Panel B: Tests of no remaining nonlinearity	
F	0.1699
F4	0.3935
F3	0.9895
F2	0.5568

Notes: LM and ARCH denote the Lagrange Multiplier and Ljung-Box statistics for autocorrelation, respectively, whilst the J-B denotes the Jarque Bera normality test of the regression residuals.

6 CONCLUSION

The currently available empirical evidence on the inflation-growth relationship in Swaziland is dominated by panel-based studies whose findings are questionable on the grounds of 'homogeneity' problem in which a singular estimate is generalized for a host of countries with multidimensional economic disparities. Single-country studies have this been thought to be a much safer alternative more especially when estimating the threshold or optimal level at which inflation maximizes economic growth or similarly minimizes growth losses. Our study contributes to the literature by estimating an inflation threshold for the Kingdom of Swaziland over the period 1975 to 2016. To achieve this feat, we rely on an endogenous monetary model of economic growth in which credit technology mainly accounts for nonlinearity existing in the steady-state relationship between inflation and growth. We particularly estimate the growth regression using the STR model which endogenously estimates the inflation threshold and allows for a smooth transition between different inflation regimes.

Indeed, our empirical findings testify on a nonlinear relationship between inflation and growth with the optimal rate of inflation being found at 7.64%. More impressively, our STR estimates emulate those dictated by the theoretical model, in the sense of Swazi economic agents not making significant economic use of credit technology at lower inflation rates whilst at higher rates of inflation increased use of credit technology as well as a more urbanized population positively affects steady-state economic growth. In retrospective, these results imply that even though credit technology can be used by economic agents as a 'hedge' against higher inflation although policymakers should be aware that inflation above the 7.64% threshold deteriorates the positive effect of trade on economic growth. This is important since a large chunk of government revenue incomes is from trade activities conducted under the SACU agreements and further given the Swazi government's current fiscal woes caused by decreased/plummeting SACU revenues, accommodating inflation rates higher than 7.64% would probably worsen already deteriorating economic conditions in the Kingdom. So even though the CBS has not explicitly adopted an inflation target regime, Swazi monetary authorities should consider incorporating some sort of informal inflation target rang within the current policy design.

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