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**Article**

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# Pursuing the Phillips Curve in an African Monarchy: A Swazi Case Study

Andrew Phiri 

## ABSTRACT

The purpose of this study is to examine whether we can identify a Phillips curve fit for the Kingdom of Eswatini as a low middle income Sub-Saharan Africa monarchy using data collected between 1991 and 2016. In our approach we rely on the recently introduced nonlinear autoregressive distributive lag (N-ARDL) model to a variety of Phillips curve specifications. For robustness sake, we further employ three filters (one-sided HP, two-sided HP, and Corbae-Ouliaris filters) to extract the gap variables necessary for empirical analysis. Our findings point to a linear, short-run traditional Phillips curve whereas we find strong support for concave shaped unemployment-gap and output-gap based Phillips curve specifications. Given the specific form of concavity discovered in the Phillips curves, the low inflation rate experienced over the last couple of decades can be attributed to a worsening labour and goods markets. Moreover, our evidence further cautions Swazi policy-makers of 'overheating' of the economy during economic booms in which stabilization tools are required to implemented in such instances.

## KEY WORDS:

inflation, unemployment, nonlinear Phillips curve, nonlinear autoregressive distributive lag (N-ARDL) model, Eswatini.

**JEL Classification:** 22, C32, C52, E24, E31.

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## 1. Introduction

The Phillips curve, which is simple but important relationship between inflation and unemployment or demand deficit, was first brought into existence in the seminal contribution of Phillips (1958) and has since remained at heart of many macroeconomic policy models and debate. The simple yet powerful notion of the existence of an inverse relationship between inflation and unemployment or demand pressure, has had far reaching ramifications for policymakers as it assumes that Central Banks are able to use expansionary monetary policy to reduce unemployment rates (Abu, 2019). The failure to identify a correct functional form of the Phillips curve has proven to be costly to policymakers, and

in previous times has been primarily responsible for destabilizing many macroeconomies with periods of stagflation experienced worldwide in the 1970's serving as a classic example.

Over the last 60 years the validity of the Phillips curve has been heavily debated, with the relationship being assumed to be dead in 1970's and 1980's (Gordon, 1989), to being "alive and well" in 1990's and 2000's (Fuhrer, 1995; Gordon, 2013) and then being proclaimed to be dead once again in the post global financial crisis era (Dorn, 2020). Many recent studies conducted for industrialized economies, such as the US and the UK, reveal that the Phillips curve has weakened and become flatter since policymakers have been able to successfully

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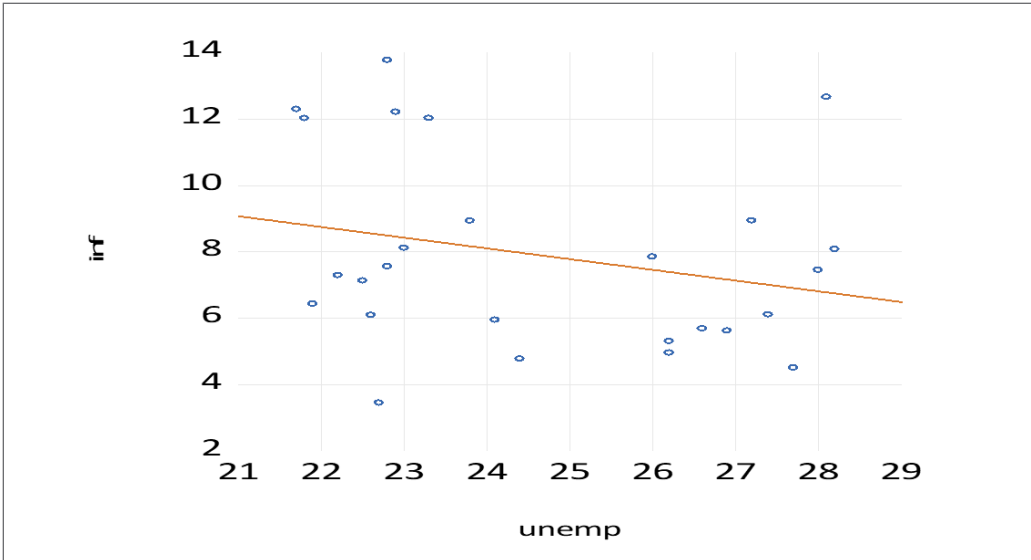
anchor and stabilize inflation expectations at “close-to-zero” levels, which, in turn, has deteriorated the Central Banks ability to predict or influence inflation through market pressures resulting in the so-called “periods of missing (dis)inflation” (Coibion & Gorodnichenko, 2015; Eser et al., 2020; Alexius et al., 2020; Alvarez and Correa-Lopez, 2020; Conti, 2021). Kabundi et al. (2019) note that the whilst the Phillips curve may have flattened in industrialized economies where expectations have become better anchored relatively early in the IT regime, the pattern in emerging countries, such as South Africa, is different and the curve can be still used as a policy guide for Central Banks in these nations.

In this current research, we contribute to the literature by examining the usefulness of the Phillips curve in modelling inflationary behaviour in the Kingdom of Eswatini, as a low middle income Sub-Saharan Africa monarchy, whose monetary policy conduct is closely linked to that of South Africa via her affiliation to a common monetary area (CMA) agreement (Phiri, 2020). Whilst this arrangement helps the country manage inflation, it reduces the

room for policymakers to respond to shocks using its main policy tool, the discount rate, and this makes fiscal-policy the primary counter-cyclical tool which has also been restricted due to low budgetary space, particularly in the post-2010 period (Brixiova-Schwidrowski et al., 2021). Nevertheless, the CBS should not be considered a ‘lame duck’ as the Reserve Bank is empowered to vary its policy stance using other policy tools in order to achieve its primary policy goal of price stability (Dlamini & Skosana, 2017). Therefore, whilst the CBE has not formally adopted inflation targeting as a policy framework, the ability of the Central Bank to forecast inflation and respond to inflationary pressures arising from domestic or external imbalances remains an important part of its modus operandi.

There are some stylized patterns that one can visually observe from inflation and unemployment data sourced from the World Bank for the Swazi economy which makes the Kingdom an interesting case study for empirical investigation of the Phillips curve. Firstly, judging from the scatterplot of CPI inflation and unemployment, over the period

Figure 1  
Scatterplot Between Inflation and Unemployment in Eswatini (1992-2016)



Note: Inflation (inf) and total unemployment (unemp) data sourced from World Bank development indicators. Fitted regression line estimated by OLS.

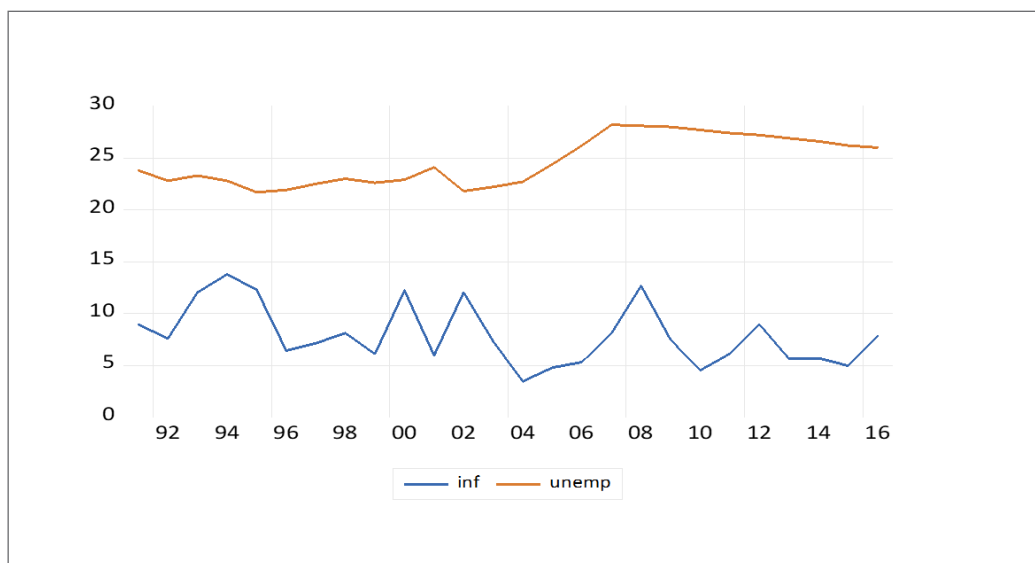
1992-2016, as depicted in Figure 1, it is easy to note that the fitted regression line depicts an inverse co-movement between inflation and unemployment over the sample period. Moreover, from the time series plot of the variables in Figure 2, one can observe inverse long-run and short-run co-movements. For instance, over a long-term period of 2000 to 2016, unemployment increased from 22.9% to 26% whilst inflation decreased from 12.2% to 7.8%. Conversely, over a shorter and more recent period of 2013 – 2016 unemployment has decreased from 27% to 26% whilst inflation increased from 5.6% to 7.8%. Interestingly, a previous study by Eitan and Khumalo (2016) similarly finds a negative relationship between inflation and unemployment for Eswatini albeit the authors find the relationship to be statistically insignificant. Secondly, further judging by the time series plot of variables in Figure 2, it is clear to see observe that the co-movement between the time series is non-monotonic. This is important to note since the previous study conducted by Khumalo and Eita (2016) used linear cointegration methods in attempting to capture the Phillips curve, which is

most likely asymmetric in form, and this could be the reason why the authors fail to find any significant long-run or short-run Phillips effects in their study.

The primary motivation for this study is that, with the exception of Khumalo and Eita (2016), no other academic attempts have been made in estimating a Phillips curve specification for the Swazi economy and notably the previous study of Khumalo and Eita (2016) does not take into consideration possible asymmetric cointegration between the time series. In our study, we make use of the nonlinear autoregressive distributive (N-ARDL) model of Shin et al. (2014) to examine the possibility of an existing Phillips curve for the Swazi economy using data collected between 1991 and 2016. Our choice of empirical modelling provides us with some useful advantages in conducting the empirical analysis. For instance, unlike other cointegration models, the N-ARDL is functional with a combination of stationary and first difference stationary variables, hence relieving the pressure on econometricians to only use time series variables that are integrated of similar order.

**Figure 2**

*Time Series Plot Between Inflation and Unemployment in Eswatini (1992-2016)*



Note: Inflation (inf) and total unemployment (uemp) data sourced from World Bank development indicators.

Moreover, the N-ARDL model, on account of being an asymmetric extension of the ARDL model (Pesaran et al., 2001), allows us to explore the possibility of convexities and concavities frequently claimed to exist within the Phillips curve (Clark et al., 1996; Debelle & Laxton, 1997; Eisner, 1997; Laxton et al., 1999; Nell, 2006, 2018; Stiglitz, 1997; Turner, 1995). To ensure robustness of our empirical analysis, we also employ three filters (i.e., one-sided Hodrick-Prescott [1s-HP], two-sided Hodrick-Prescott [2s-HP], Corbae-Oularis [C-O] filters) to extract the 'gap variables' used as proxies for demand pressures in the Phillips curve regressions.

The rest of the paper is structured as follows. The following section of the paper outlines the empirical Phillips curve specifications and the N-ARDL model used to estimate these empirical specifications is presented in the third section. The data and empirical results are presented in the fourth section of the paper whereas the study is concluded in the fifth section primarily in the form of policy recommendations.

## 2. Literature Review

### 2.1. Theoretical Development of Phillips Curve

In retrospect, the emergence and development of the Phillips curve as theoretical workhorse, can be described as evolving in four interrelated stages. The first phase of development can be traced to the seminal contribution of Phillips (1958) who initially found an inverse relationship between unemployment ( $U$ ) and nominal money wage rates ( $WN$ ) for the United Kingdom between 1861 and 1957 by estimating the following regression curve:

$$WN = f(U) \quad (1)$$

Lipsey (1960) extended upon Phillips (1958) contribution by conceptualizing the empirical findings into a formal theoretical model reflecting gradual disequilibrium adjustment in the labour market whereby excess labour demand leads to nominal wage inflation whilst excess labour supply causes nominal wage deflation. Lipsey (1960) further assumed that unemployment can be used as a proxy for excess labour demand or supply, such that the

Phillips curve should be considered a relationship between price level and imbalances in the labour market. The Phillips-Lipsey synthesis was then recast as a useful policy guidance tool for monetary authorities in the seminal paper of Samuelson and Solow (1960) which offered policymakers a trade-off between inflation and unemployment and hence the central banks task was reduced to finding an optimal combination within this relation which minimized the unemployment cost of fighting inflation. However, extended periods of stagflation as experienced worldwide in the 1970's cast a lot of doubt on the existence of a long-run Phillips curve and hence fostered the need for the reformation of the original Phillips curve.

The second phase of development of the Phillips curve came about when mainstream neoclassical economists began to vouch for a vertical long-run Phillips curve in which a trade-off between inflation and demand deficiencies is only permitted over the short-run. The main contributors to this neoclassical paradigm are Phelps (1967, 1968) and Friedman's (1968, 1977) whose works can be collectively summarized as follows. Firstly, the authors re-specified the Phillips curve in real wage terms. Secondly, the authors distinguished between the long-run and short-run effects of an unanticipated change in aggregate nominal demand hence allowing for the incorporation of adaptive inflation expectations (i.e.,  $\pi_t^e$ ) into the nominal wage adjustment process. Lastly, the authors argue against a stable inflation-unemployment trade-off and suggest the existence of a 'natural rate of unemployment' ( $NRU_t$ ), of which unemployment can be kept below the  $NRU_t$  (i.e.,  $U_t < NRU_t$ ) at the expense of accelerated inflation, or above it (i.e.,  $U_t > NRU_t$ ) by accelerated deflation. The resulting 'accelerationist', 'expectations-based' Phillips curve can be specified as:

$$\pi_t = \alpha \pi_t^e + \beta(U_t - NRU_t) \quad (2)$$

In differing from the original Phillips curve, the neoclassical version assumes that monetary authorities cannot peg unemployment at a constant rate of inflation, but they can choose a steady-state inflation rate at which unemployment returns to

its natural rate. Nevertheless, the Phillips curve remained prone to criticism as it was still unable to account for the periods of stagflation caused by supply shocks. This led to the third phase of development of the Phillips curve which came courtesy of the consecutive seminal papers presented by Gordon (1984, 1989, 1990) who proposed the extension of the Phillips curve to that of a triangular function consisting of inertia, demand pressure and supply shocks. In the triangular framework, (a) inertia enters through lagged inflation, (b) demand pressures enter through the level and change in the output gap and (c) supply shocks enter through disturbances such as oil prices, import prices and price controls (Gordon, 1990). Denoting GDP as output growth,  $GDP^{pot}$  as its 'potential' and  $SS$  as supply shocks, the triangular form of the Phillips curve can be represented as:

$$\pi_t = \alpha\pi_{t-1} + \beta(GDP_t - GDP_t^{pot}) + SS_t \quad (3)$$

Gordon (2011) finds that the inclusion of supply shocks is able to explain the 'twin peaks' of inflation and unemployment in 1970's and 1980's, and further observes that inflation and unemployment can either be negative or positively correlated depending on the source of the shocks, the policy response and the length of the lagged responses. Moreover, the framework allows for a time-varying NAIRU and assumes monetary authorities to respond to shocks in context of price stickiness, which together provides a stable foundation for nominal GNP growth targeting (Gordon, 1990).

Nonetheless, economists were still dissatisfied with the lack of micro-foundational theoretical underpinnings of the Phillips curve which led to the fourth stage of development of the Phillips curve by New Keynesian economists who made four distinct contributions to form the New Keynesian Phillips Curve (NKPC). Firstly, the NKPC is derived from deep structural parameters from models that incorporate nominal rigidities generating price stickiness and staggered price setting behaviour under an environment of dynamically optimizing agents (Gordon, 2013). Secondly, the NKPC explicitly models the forward-looking behaviour of economic agents who can jump in response

to policy changes and this is closely related to the practical framework of a forward-looking, inflation-targeting policymaker (Olafsson, 2006). Thirdly, the NKPC assumes that real marginal costs are a more theoretically appealing measure of the forcing demand variable in the Phillips curve compared to the output gap (Gali & Gertler, 1999). Lastly, a hybrid version of the model which incorporates both backward-looking and forward-looking behaviour in which the latter allows for deviations of inflation from its equilibrium to persist due to previous inflation (Gali et al., 2005). In its hybrid form, the reduced-form representation of the NKPC can be specified as:

$$\pi_t = \alpha_1\pi_{t-1} + \alpha_2E\pi_{t+1} + \lambda mc_t \quad (4)$$

In differing from the previous versions of Phillips curve, the NKPC assumes that the expectations of economic agents are rational as opposed to being adaptive, and hence economic agents can predict policy outcomes and act on these anticipations. Therefore, systematic monetary policy cannot influence real variables such as unemployment and output in the short-run and monetary authorities can only create a divergence between actual and expected inflation (Humphrey, 1985). The ability of the NKPC to use agent-based model to realistically articulate the dynamics of key macroeconomic variables within a monetary policy framework has been what Brissimis and Magginnis (2008, p. 2) refer to as "... the closet [theoretical framework] there is to standard perfection ..."

## 2.2. Review of Recent Empirical Literature

The advent of the great recession period of 2008-2010, in which the world economy was characterized by a combination of high inflation and unemployment rates (i.e., stagflation), has resurrected the debate on whether the Phillips curve is still alive and which version best models the inflation dynamics. Many authors have likened this recent revival of empirical interest to that which occurred in periods subsequent to stagflation period of 1970's and early 1980's, and the reoccurring policy question is whether the Phillips curve is a useful policy tool or whether it should be discarded

altogether (Dorn, 2020; Hooper et al., 2020). Gordon (2011, 2013) describes a bifurcation of the recent empirical literature investigating the Phillip curve along two paths, a left fork path which follows the dictates of the triangular Philips curve model and the right fork which advances the theoretical foundations of the NKPC.

On one hand, the studies of Bhattarai (2016), Ball and Mazumder (2019), Kabundi, Schaling and Some (2019) and Botha et al. (2020) have recently taken the left-fork approach into the empirical investigation of Phillips curve. Bhattarai (2016) estimate Phillips curve for OECD countries using VAR, cointegration analysis and causality tests and finds that the Phillips curve fits in 28 out of 53 countries. Ball and Mazumder (2019) estimate a wage-based, expectations-augmented Phillips curve for the US and find that when slack is captured by short-term unemployment, then the Phillips curve explains the behaviour of inflation since 2000. Kabundi et al. (2019) use an unobserved components model to estimate the triangular Philips curve for the South African economy and find that the slope of the Philips curve has flattened since the adoption of the inflation targeting regime in the early 2000's but find that the curve is still significant. Botha et al. (2020) follow up on the study of Kabundi et al. (2019) and estimate a triangular Phillips curve specification and find strong evidence of the Philips curve in South Africa although the authors further observe that this relationship has slightly weakened since 2016.

On the other hand, the studies of Coibion and Gorodnichenko (2015), Bhattarai (2016), Bobeica and Jarocinski (2019), Hindrayanto et al. (2019), Del Negro et al. (2020), Hazell et al. (2021), Wardhono et al. (2021), Furuoka et al. (2021), have taken the right-fork approach into investigating Phillips curve. Coibion and Gorodnichenko (2015) estimate a NKPC augmented with supply shocks for the US economy and find that whilst the supply shocks explain the simultaneous rise in inflation and unemployment experienced between 2009 and 2011, the overall US Phillips curve has been declining due to structural changes and infrequent price changes. Bobeica and Jarocinski (2019) estimate the NKPC for the Euro area using vector

autoregressive (VAR) model with internal and external variables and find that domestic factors in the model explain most of the missing inflation episodes of 2012-14. Hindrayanto et al. (2019) estimate an Unobserved Components NKPC for the US economy and find that the US Philips curve is still alive and has not changed much since the great Recession period.

More recently, Del Negro et al. (2020) applies VAR, structural VAR and DSGE estimators to a rational-expectations NKPC for US data and present evidence of a flatter Phillips curve particularly in the post-1990 era which they attribute to the improvement in the policymaker's ability to stabilize inflation at lower rates. Hazell et al. (2021) also estimate the NKPC for the US economy and find that the Phillips curve is steeper before 1993 but has considerably flattened after 2000. Wardhono et al. (2021) estimate the NKPC for 5 ASEAN economies using generalized methods of moments (GMM) estimators and find a good fit of the model for explaining inflation dynamics and observe no periods of missing inflation. Furuoka et al. (2021) estimate the time-varying slope of the NKPC for 5 ASEAN countries and finds evidence of a disappearing Phillips curve coefficient which has progressively been converging towards zero.

Notably, a separate branch of literature can be identified which focuses on asymmetric behaviour in the different forms of Phillips curve specification using nonlinear econometric techniques. Albuquerque and Baumann (2017) estimate time-varying and rolling window regressions to the NKPC and find that when asymmetric behaviour is taken into consideration the Philips curve still holds in the US. Egan and Leddin (2017) estimate the triangular Phillips curve for the Chinese economy using a Markov-switching regression and find that the economy is characterized by two states: a first state (before 1994) in which inflation responds strongly to the output gap and weakly to exchange rates and second state (after 1994) in which inflation responds weakly to output gap and stronger to exchange rates. Ho and Iyke (2019) estimate an expectations-based Philips curve for 11 Eurozone countries using a panel threshold regression model and find three-regimes separated by two unemployment

thresholds at 5% and 6.54%, in which the Phillips curve holds in the lower regime, turns positive in the middle regime and insignificant at the upper regime. Abreu and Lopes (2021) estimate a 3-regime threshold regression model of the US NKPC and find two unemployment thresholds at 5.7% and 7.63, with a strong Phillips curve found at the middle regime which turns insignificant at higher regimes. In a study using a similar methodology to ours, Mihajlovic and Marjanovic (2020) use N-ARDL model to estimate a NKPC for 3 Baltic states and find that Philips curve is significant during expansionary periods and insignificant during recessionary periods, that is, concave Phillips curve.

### 3. Empirical Methodology

In our study we estimate five variants of the Phillips curve, namely: (a) the traditional Phillips curve specification, (b) the “unemployment-gap” base Phillips curve specification, (c) the ‘output-gap based’ Phillips curve specification, (d) the triangular form of the unemployment-gap Phillips curve and (e) the triangular form of the output-gap Phillips curve, respectively. We make use of the N-ARDL model which we consider as being superior to other nonlinear econometrics frameworks, such as the threshold autoregressive (TAR) or the Markov-switching models commonly used in previous studies. For instance, the N-ARDL model is flexible in that it can accommodate a mixture of stationary and first difference time series, unlike other frameworks which require the series to be integrated of the same order. Furthermore, the NARDL framework reduces the chances of regression biasness by accommodating the modelling of long-run and short-run asymmetric cointegration relations whilst remaining robust to possible endogeneity arising from the estimated regression.

As a baseline econometric model, we consider the following long-run asymmetric model regression:

$$\pi_t = \beta_0 + \beta^{pos} X_t^{pos} + \beta^{neg} X_t^{neg} + error, \quad (5)$$

$$X_t = X_0 + X_t^{pos} + X_t^{neg}$$

Where,  $\pi_t$  is the inflation rate,  $X_t$  is a  $K \times 1$  vector of demand pressure proxies,  $\beta^{pos}$  and  $\beta^{neg}$  are asymmetric long-run parameters and  $X^+$  and  $X^-$  are partial

sum processes of positive and negative changes in  $X_t$  which are specifically defined as:

$$X_t^{pos} = \sum_{j=1}^i \Delta X_t^{pos} = \sum_{j=1}^i \max(\Delta X_j, 0) \quad (6)$$

$$X_t^{neg} = \sum_{j=1}^i \Delta X_t^{neg} = \sum_{j=1}^i \min(\Delta X_j, 0) \quad (7)$$

From these partial sum process various forms of asymmetries relative to the business cycle can be captured. For instance, Shin et al. (2014) use the partial sum process to model Okun's law during recessionary and expansionary phases of the business cycle. In our study, we make a similar application of this logic yet in context of capturing concavities and convexities which could possibly exist in the Swazi Phillips curve. Note that a concave (convex) Phillips curve implies that as an economy strengthens (weakens) inflation becomes more sensitive to output adjustment and hence the cost of fighting inflation is assumed to be greater during economic expansions (recessions).

The NARDL-in-levels transformation of regression (5) can be specified as:

$$\Delta \pi_t = \rho \pi_{t-1} + \lambda^{neg} X_t^{neg} + \lambda^{pos} X_t^{pos} + \sum_{j=1}^{p-1} (\eta_j^{pos} \Delta x_{t-j}^{pos} + \eta_j^{neg} \Delta x_{t-j}^{neg}) + error \quad (8)$$

The traverse between short-run disequilibrium and the new long-run steady state of the system can be estimated through the following cumulative dynamic multipliers:

$$M_h^{pos} = \sum_{j=0}^n \frac{\partial \pi_{t+j}}{\partial X_t^{pos}}, M_h^{neg} = \sum_{j=0}^n \frac{\partial \pi_{t+j}}{\partial X_t^{neg}}, \quad h = 0, 1, 2 \dots \quad (9)$$

Where  $M_h^{pos}$  and  $M_h^{neg} \rightarrow \beta^{pos}$  and  $\beta^{neg}$ , respectively as  $h \rightarrow \infty$ . Note that the long-run coefficients are computed as  $\beta^{pos} = -(\lambda^{pos}/\rho)$  and  $\beta^{neg} = -(\lambda^{neg}/\rho)$ , respectively, with the nonlinear error correction term is computed as  $\xi_{t-1} = GDP_t - \beta^{pos} X_h^{pos} - \beta^{neg} X_h^{neg}$ . Moreover, Shin et al. (2014) suggest the testing of three hypothesis in order to validate asymmetric cointegration effects within the specified N-ARDL model. The first is an extension of the non-standard bounds based F-test of Pesaran et al. (2001) which is used to test for overall asymmetric cointegration relations, namely:



$H_{01}: \rho = \lambda^+ = \lambda^- = 0$  (10)

The second hypothesis tests for long-run asymmetric effects in which the null hypothesis of no long-run asymmetric effects is tested as:

$H_{02}: \rho = \beta^+ = \beta^-$  (11)

The final hypothesis tests for short-run asymmetric effects whereby the null hypothesis of no short-run asymmetric effects is tested as:

$H_{03}: \eta^+ = \eta^-$  (12)

Note that the latter two null hypotheses of “no long-run” and “no short-run” asymmetric effects can be evaluated by relying on standard Wald tests. Furthermore, conventional diagnostic tests are to be performed on the regression residuals such as tests for normality, serial correlation, heteroscedasticity and correct functional form.

4. Data and Empirical Results

4.1. Empirical Data, Descriptive Statistics, and Unit Root Tests

The data used in our study has been retrieved from the World Bank online statistical database on an annual basis over the period 1991 to 2016 and consists of the inflation in consumer prices (i.e.,  $\pi$ ), unemployment as a percentage of total labour force (i.e.,  $U$ ), GDP growth rates (i.e.,  $gdp$ ) and the Rand/Dollar nominal exchange rate (i.e.,  $ER$ ) which is used to proxy supply shocks as in Phiri (2016). Further note that the Swazi Lilangeni is pegged one-for-one with the South African Rand which, in turn, is sensitivity to international supply shocks and this justifies the use of this variable as a proxy for supply shocks in Eswatini. Also recall that in order to estimate our empirical Phillips curve specifications requires the construction of two additional variables, namely, the ‘unemployment-gap’ (i.e.,  $U\_gap$ ) and ‘output-gap’ (i.e.,  $Y\_gap$ ) variables. The extraction of these “gap” vari-

Table 1  
Descriptive Statistics and Unit Root Tests

|                        | 1-sided HP filter |            |            |            | 2-sided HP filter |            | Corbae-Oularis filter |             |            |
|------------------------|-------------------|------------|------------|------------|-------------------|------------|-----------------------|-------------|------------|
| Panel A:               | $\pi$             | unemp      | ER         | unemp_gap  | gdp_gap           | unemp_gap  | gdp_gap               | unemp_gap   | gdp_gap    |
| Descriptive statistics |                   |            |            |            |                   |            |                       |             |            |
| Mean                   | 7.89              | 24.65      | 7.09       | 0.05       | -0.19             | 3.07E-16   | -9.27E-15             | 3.75E-16    | -1.71E-16  |
| Std. dev.              | 2.91              | 2.31       | 2.98       | 0.91       | 1.19              | 0.98       | 1.50                  | 1.26        | 1.12       |
| J-B (p-value)          | 0.31              | 0.24       | 0.44       | 0.53       | 0.95              | 0.98       | 0.81                  | 0.44        | 0.56       |
| Panel B:               |                   |            |            |            |                   |            |                       |             |            |
| Unit root tests        |                   |            |            |            |                   |            |                       |             |            |
| ADF                    | 3.71**            | -0.93      | 0.44       | -1.68      | -4.03***          | -2.29      | -4.32***              | -7.40***    | -10.14***  |
| (intercept)            | (-6.69)***        | (-3.97)*** | (-3.19)**  | (-4.20)*** | (-4.93)***        | (-4.61)*** | (-5.79)***            | (-9.69)***  | (-22.9)*** |
| ADF                    | -4.31**           | -1.79      | -1.99      | -1.93      | -3.86**           | -2.25      | -4.17**               | -8.49***    | -9.93***   |
| (trend)                | (-6.54)***        | (-3.86)**  | (-3.25)*   | (-4.15)*** | (-4.69)***        | (-4.51)*** | (-5.58)***            | (-9.45)***  | (-27.7)*** |
| PP                     | -3.71**           | -1.11      | 0.44       | -1.84      | -3.27**           | -2.43      | -3.83***              | -1.97       | -2.18      |
| (intercept)            | (-10.44)***       | (-3.98)*** | (-3.16)**  | (-4.21)*** | (-10.7)***        | (-4.62)*** | (-11.85)***           | (-2.09)     | (-2.44)    |
| PP                     | 4.15**            | -2.06      | -1.37      | -2.07      | -3.18             | -2.39      | -3.63**               | -1.95       | -2.28      |
| (trend)                | (-10.03)***       | (-3.86)**  | (-3.22)    | (-4.15)*** | (-10.4)***        | (-4.52)*** | (-11.33)***           | (-2.09)     | (-2.30)    |
| DF-GLS                 | -3.76***          | -0.93      | 0.64       | -1.74      | -4.16***          | -2.23      | -4.05***              | -9.38       | -6.03***   |
| (intercept)            | (-6.83)***        | (-3.65)*** | (-3.27)*** | (-4.30)*** | (-4.38)***        | (-4.38)*** | (-5.00)***            | (-16.47)*** | (-18.1)*** |
| DF-GLS                 | -4.47***          | -1.72      | -2.34      | -1.99      | -4.14***          | -2.29      | -4.42***              | -7.14***    | -9.19***   |
| (trend)                | (-6.74)***        | (-3.92)*** | (-3.42)**  | (-4.34)*** | (-4.74)***        | (-4.60)*** | (-5.76)***            | (-9.82)***  | (-14.5)*** |

Note: Notes: significance codes \*\*\* – 1%, \*\* – 5% and \* – 10%. Unit root test statistics for first differences reported in parentheses (). Optimal lag selection of models determined by minimization of Schwarz information criterion.

ables has been the subject of much contention, and to ensure robustness of our analysis we employ three filters to this end. The first two filter are the one-sided and two-sided HP filters, respectively, with the later providing ex post estimates of the “gap” based on all information and the former providing real estimates of the gap. However, these HP filters have been severely criticized on the premise of suffering from ‘end-point problems’ hence prompting us to employ the frequency-domain (FD) filtering process discussed in Corbae and Oularis (2006) which overcomes these deficiencies by minimizing distortions in the data generating process (DGP) of the series.

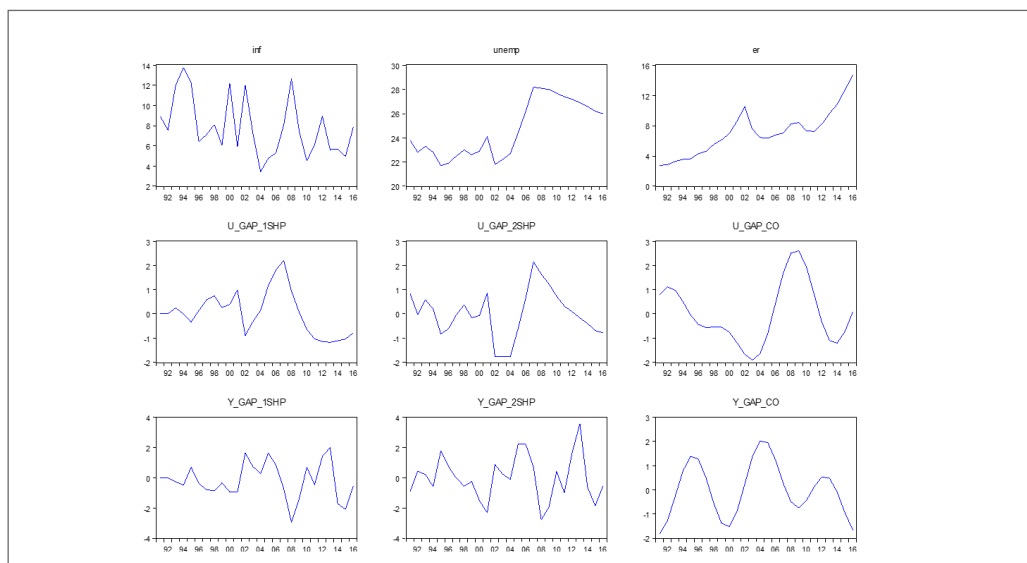
The descriptive statistics of the utilized time series are reported in Panel A of Table 1, whilst their time series plots are provided in Figure 3. Panel B of Table 1 reports the outcome of the ADF, PP and DF-GLS unit root tests as performed on the levels and first difference transformations of the time series variables. Collectively, these results indicate that the observed inflation, unemploy-

ment, unemployment-gap and output gap series are both levels stationary process whereas the unemployment and unemployment gap variables are first difference stationary variables. The realization of the time series data being a mixture of  $I(0)$  and  $I(1)$  variables implies that conventional cointegration methods such as the Engle & Granger (1987) and Johansen (1991) approaches would not methodologically suffice in modelling cointegration relations amongst the time series. Hence our decision to rely on the N-ARDL framework is well justified.

#### 4.2. Empirical Results from Traditional Phillips Curve Specification

Table 2 presents the results from estimating the tradition Phillips curve and for control purposes, we also report estimates from the linear ARDL specification. As can be observed from panel B, the results obtained from the linear ARDL model are quite encouraging, in the sense of finding a theoretically-correct negative and significant coefficient estimate in the short-run. How-

**Figure 3**  
Time Series Plots of Variables



Note: Definitions of variables. inf – inflation; unemp – unemployment; er-exchange rates; U\_GAP\_1SHP-unemployment gap from one-sided HP filter; U\_GAP\_2SHP-unemployment gap from two-sided HP filter; U\_GAP\_CO-unemployment gap from C-O filter; Y\_GAP\_1SHP-unemployment gap from one-sided HP filter; U\_GAP\_2SHP-unemployment gap from two-sided HP filter; U\_GAP\_CO-unemployment gap from C-O filter;

ever, as evident in Panel A, the linear short-run trade-off is not translated into the long-run steady state as the coefficient on the long-run parameter is insignificant. We note that these findings are consistent with those previously presented by Khumalo and Eita (2015) for similar Swazi time series. Further note that the bounds test statistic for cointegration effects and the diagnostic tests reported in Panels C and D, respectively, provide sufficient evidence for linear cointegration amongst the series and vouch for well-behaved error terms, correct functionality and regression stability.

On the other hand, the regression estimates obtained from the N-ARDL regression estimates are less optimis-

tic as none of the obtained short-run or long-run estimates reported in Panels A and B are statistically significant. Moreover, the Wald test for long-run asymmetry reported in Panel C is insignificant hence ruling out the possibility of any long-run asymmetries in the traditional Phillips curve. And even though the F-test for asymmetric cointegration, the Wald test for short-run asymmetric effects, as well as the diagnostic tests and stability analysis from Panel D all produce favourable findings, the regressions are meaningless in the absence of significant coefficient estimates. Collectively, our results in Table 1 infer at least a linear, short-run trade-off between inflation and unemployment for the Swazi Kingdom.

**Table 2**

*Regression of Inflation on Unemployment*

|                             | Linear ARDL |         | Nonlinear ARDL |         |
|-----------------------------|-------------|---------|----------------|---------|
|                             | ARDL(1,0)   |         | N-ARDL(2,1,1)  |         |
| Panel A: Long-run estimates | Coefficient | p-value | Coefficient    | p-value |
| U                           | -0.29       | 0.37    |                |         |
| U+                          |             |         | 0.12           | 0.74    |
| U-                          |             |         | 0.87           | 0.25    |
| Panel B:                    |             |         |                |         |
| Short-run estimates         |             |         |                |         |
| $\Delta U$                  | -1.16       | 0.07*   |                |         |
| $\Delta U+$                 |             |         | -0.91          | 0.20    |
| $\Delta U-$                 |             |         | -1.21          | 0.17    |
| ectt-1                      | -0.81***    | 0.00    | -1.08***       | 0.00    |
| Panel C:                    |             |         |                |         |
| Cointegration tests         |             |         |                |         |
| F-test                      | 5.04**      |         | 4.53**         |         |
| Wald-LR                     |             |         | 0.13           |         |
| Wald-SR                     |             |         | 3.77**         |         |
| Panel D: Diagnostic tests   |             |         |                |         |
| $\chi^2_{NORM}$             | 1.89        | 0.39    | 0.27           | 0.87    |
| $\chi^2_{SC}$               | 2.09        | 0.15    | 0.77           | 0.48    |
| $\chi^2_{HET}$              | 0.50        | 0.62    | 0.95           | 0.49    |
| $\chi^2_{FF}$               | 0.25        | 0.80    | 0.47           | 0.65    |

Notes: significance codes \*\*\* – 1%, \*\* – 5% and \* – 10%. P-values are reported in parentheses (). The regression have been estimated using Newey-West coefficients. Optimal lag selection of models determined by minimization of Schwarz information criterion.

### 4.3. Empirical Results from New Classical Phillips Curve Specifications

Tables 4 and 5 report the empirical results for the unemployment-gap and the output-gap based Phillips curve and as before, we report both the linear ARDL and N-ARDL regression estimates. Further note that we present a total of six estimated regressions in each of the Tables, which are representative of the linear ARDL and N-ARDL models performed for the three filters (i.e., one-sided HP, two-sided HP and C-O filters) used to extract the 'gap' variables. Focusing on Panel A, we find the correct negative and statistically significant coefficients for three models. The first two are the linear and nonlinear ARDL models estimated with gap variables extracted from the one-sided HP filter and the third is the nonlinear ARDL model with gap variables derived from the conventional two-sided HP filter. Note that concerning the N-ARDL results, the model based on the one-sided HP filter argues for a traditional convex, unemployment-based Phillips curve in the short-run (i.e.,  $U\_gap+ > U\_gap-$ ) as found in Turner (1995), Clark et al. (1996), Debelle and Laxton (1997), Laxton et al. (1999) and Nell (2006, 2018) whilst the two-sided HP filter argues for a concave, short-run Phillips curve as found in Stiglitz (1997) and Eisner (1997). However, judging from the long-run estimates recorded in Panel B, only the N-ARDL model with gap variables derived from the one-sided HP filter produces a significant negative coefficient on the  $U\_gap+$  variable. This result implies that over the long-run, the Phillips curve is of a concave shape which is in line with the findings presented by Stiglitz (1997) and Eisner (1997).

The results obtained from the output gap specification are not as concrete as those found for the unemployment-gap version and can be summarized by two relevant findings. The first is from the short-run coefficients reported in Panel A, in which the  $Y\_gap+$  variable extracted from the two-sided HP filter for the N-ARDL model produces the correct positive and statistically significant estimate. The second is from the long-run coefficients reported in Panel B, in which the  $Y\_gap+$  series extracted from the one-sided HP filter similarly produces a positive and significant estimate. Both these results argue for a concave output-gap based Phillips curve specification which is consistent with argument for stabilization policies

to be implemented during expansionary cycles to prevent the overheating of the economy. These arguments are re-iterated in the works of Turner (1995), Clark et al. (1996), Debelle and Laxton (1997), Laxton et al. (1999) and Nell (2006, 2018). Further re-enforcing the validity of our findings are the positive statistics obtained for corresponding tests for asymmetries, regression diagnostics and stability analysis presented in Panels C and D.

### 4.4. Empirical Results from The Triangular Phillips Curve Specifications

As a final empirical exercise, we estimate Gordon's (1989, 1990, 1997) triangular Phillips curve version for both the unemployment-gap and output gap specifications. Starting with the results from the triangular, unemployment-gap version reported in Table 5, the short-run estimates found in Panel A point to correct negative and significant estimates for both ARDL and N-ARDL models estimated with gap variables extracted from the one-sided HP filter as well as the linear ARDL model estimated with two-sided HP gap variables. Note that the significant coefficient for the N-ARDL model is on the  $U\_gap+$  variable hence arguing for a concave unemployment-gap based Phillips curve specification. However, we also note that none of the estimated coefficients on the supply shock variable is significant over the short-run. And even though the supply shock variable for the long-run reported in Panel B produces the correct positive and significant estimate for the N-ARDL with two-sided HP filter gap variables, the remaining long-run coefficients are either statistically insignificant or produce the wrong sign throughout all estimated regressions. And with the exception of the models estimated with the C-O filter-based gap variables, the associated Wald tests for short-run and long-run asymmetries fail to find significant asymmetries, which further cast doubt on the validity of these estimates.

In turning to the empirical results of the triangular, output gap Phillips curve specification reported in Table 6, we are quick to note that only the N-ARDL model estimated with gap variables derived from the C-O filter produce encouraging findings. As can be observed from the short-run and long-run estimates reported in Panels A and B, respectively, all variables including the supply-shock variables produce the

**Table 3**  
*Regression of Inflation on Unemployment Gap*

|                                    | one-sided HP       |                    | Two-sided HP       |                    | C-O                |                    |
|------------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
|                                    | ARDL<br>(1,0)      | N-ARDL<br>(2,0,1)  | ARDL<br>(1,1)      | N-ARDL<br>(1,1,1)  | ARDL<br>(1,0)      | N-ARDL<br>(1,1,0)  |
| Panel A:<br>Long-run<br>estimates  |                    |                    |                    |                    |                    |                    |
| U_gap                              | 0.92<br>(0.02)**   |                    | 1.19<br>(0.12)     |                    | 0.64<br>(0.37)     |                    |
| U_gap+                             |                    | -1.03<br>(0.03)*   |                    | 0.51<br>(0.10)     |                    | 0.39<br>(0.45)     |
| U_gap-                             |                    | -0.28<br>(0.38)    |                    | 1.13<br>(0.00)***  |                    | 0.94<br>(0.10)     |
| Panel B:<br>Short run<br>estimates |                    |                    |                    |                    |                    |                    |
| $\Delta\pi$                        |                    | 0.49<br>(0.01)**   |                    |                    |                    |                    |
| $\Delta U\_gap$                    | -1.60<br>(0.04)*   |                    | -0.59<br>(0.36)    |                    | 0.49<br>(0.29)     |                    |
| $\Delta U\_gap+$                   |                    | -1.56<br>(0.05)*   |                    | -2.05<br>(0.09)*   |                    | 0.35<br>(0.45)     |
| $\Delta U\_gap-$                   |                    | -3.75<br>(0.00)*** |                    | -1.02<br>(0.07)*   |                    | 0.85<br>(0.11)     |
| ect(-1)                            | -0.79<br>(0.00)*** | -1.51<br>(0.00)*** | -0.83<br>(0.00)*** | -1.52<br>(0.00)*** | -0.76<br>(0.00)*** | -0.91<br>(0.00)*** |
| Panel C:<br>Cointegration<br>tests |                    |                    |                    |                    |                    |                    |
| F-test                             | 4.99*              | 5.83**             | 6.22**             | 5.83**             | 7.01**             | 6.11**             |
| Wald-LR                            |                    | 5.94**             |                    | 0.58               |                    | 2.64               |
| Wald-SR                            |                    | 8.48***            |                    | 12.85***           |                    | 0.20<br>(0.66)     |
| Panel D:<br>Diagnostic tests       |                    |                    |                    |                    |                    |                    |
| $\chi^2_{NORM}$                    | 0.97<br>(0.62)     | 0.28<br>(0.87)     | 1.02<br>(0.60)     | 4.09<br>(0.10)     | 2.30<br>(0.32)     | 1.94<br>(0.38)     |
| $\chi^2_{SC}$                      | 0.30<br>(0.74)     | 0.66<br>(0.53)     | 0.31<br>(0.74)     | 0.40<br>(0.68)     | 0.02<br>(0.98)     | 0.91<br>(0.42)     |
| $\chi^2_{HET}$                     | 0.41<br>(0.75)     | 1.64<br>(0.20)     | 0.87<br>(0.47)     | 1.09<br>(0.41)     | 0.14<br>(0.87)     | 0.84<br>(0.49)     |
| $\chi^2_{FF}$                      | 0.01<br>(0.99)     | 0.57<br>(0.58)     | 0.05<br>(0.96)     | 0.06<br>(0.95)     | 0.02<br>(0.98)     | 1.21<br>(0.24)     |
| CUSUM                              | S                  | S                  | S                  | S                  | S                  | S                  |
| CUSUMSQ                            | S                  | S                  | S                  | U                  | S                  | U                  |

Notes: significance codes \*\*\* – 1%, \*\* – 5% and \* – 10%. P-values are reported in parentheses (). The regressions have been estimated using Newey-West coefficients. Optimal lag selection of models determined by minimization of Schwarz information criterion.

**Table 4**  
Regression of Inflation on Output Gap

|  | one-sided HP       |                     | two-sided HP       |                    | C-O                |                    |
|--|--------------------|---------------------|--------------------|--------------------|--------------------|--------------------|
|  | ARDL<br>(1,0)      | N-ARDL<br>(1,1,0,0) | ARDL<br>(1,0)      | N-ARDL<br>(2,1,1)  | ARDL               | N-ARDL             |
| <b>Panel A:</b><br>Long-run estimates  |                    |                     |                    |                    |                    |                    |
| Y_gap                                  | -0.41<br>(0.56)    |                     | -0.35<br>(0.40)    |                    | -0.63<br>(0.32)    |                    |
| Y_gap+                                 |                    | 1.21<br>(0.06)*     |                    | -0.80<br>(0.01)**  |                    | -0.84<br>(0.17)    |
| Y_gap-                                 |                    | -0.82<br>(0.14)     |                    | -0.43<br>(0.21)    |                    | -0.28<br>(0.63)    |
| <b>Panel B:</b><br>Short run estimates |                    |                     |                    |                    |                    |                    |
| $\Delta\pi(-1)$                        |                    |                     | 0.24<br>(0.32)     |                    |                    |                    |
| $\Delta Y\_gap$                        | -0.31<br>(0.55)    |                     | -0.17<br>(0.59)    |                    | 0.64<br>(0.44)     |                    |
| $\Delta Y\_gap+$                       |                    | 0.35<br>(0.66)      |                    | 0.84<br>(0.04)*    |                    | 0.72<br>(0.49)     |
| $\Delta Y\_gap-$                       |                    | -0.80<br>(0.12)     |                    | -1.51<br>(0.00)*** |                    | 0.14<br>(0.90)     |
| Ect(-1)                                | -0.75<br>(0.00)*** | -0.97<br>(0.00)***  | -0.77<br>(0.00)*** | -0.97<br>(0.00)*** | -0.85<br>(0.00)*** | -1.03<br>(0.00)*** |
| <b>Panel C:</b><br>Cointegration tests |                    |                     |                    |                    |                    |                    |
| F-test                                 | 6.64**             | 5.51**              | 4.60*              | 3.83*              | 4.43**             | 4.48**             |
| Wald-LR                                |                    | 7.12***             |                    | 6.54**             |                    | 0.20               |
| Wald-SR                                |                    | 10.89***            |                    | 7.65***            |                    | 0.22               |
| <b>Panel D:</b><br>Diagnostic tests    |                    |                     |                    |                    |                    |                    |
| $\chi^2_{NORM}$                        | 2.44<br>(0.30)     | 1.72<br>(0.42)      | 2.18<br>(0.34)     | 1.07<br>(0.58)     | 2.56<br>(0.28)     | 1.94<br>(0.38)     |
| $\chi^2_{SC}$                          | 0.06<br>(0.94)     | 0.99<br>(0.39)      | 0.01<br>(0.99)     | 0.96<br>(0.40)     | 0.38<br>(0.69)     | 2.41<br>(0.12)     |
| $\chi^2_{HET}$                         | 0.31<br>(0.74)     | 1.77<br>(0.18)      | 1.29<br>(0.29)     | 0.41<br>(0.84)     | 0.99<br>(0.39)     | 0.92<br>(0.45)     |
| $\chi^2_{FF}$                          | 0.03<br>(0.98)     | 1.43<br>(0.17)      | 0.77<br>(0.45)     | 2.29<br>(0.04)*    | 1.38<br>(0.18)     | 1.23<br>(0.23)     |
| CUSUM                                  | S                  | S                   | S                  | S                  | S                  | S                  |
| CUSUMSQ                                | S                  | S                   | S                  | S                  | S                  | S                  |

Notes: significance codes \*\*\* – 1%, \*\* – 5% and \* – 10%. P-values are reported in parentheses (). The regression have been estimated using Newey-West coefficients. Optimal lag selection of models determined by minimization of Schwarz information criterion.

correct positive estimates which are all significant at the 1 percent critical level. Upon closer inspection of our results, we note that the  $Y_{gap+}$  estimates are of larger value than the  $Y_{gap-}$  counterparts, hence implying a form of concavity within the output-gap based Phillips curve. Recall that these findings imply that policymakers should be cautious of overheating the economy during economic expansions and should not test the limits of expansionary policies. This is clearly a counterargument to that proposed by Stiglitz (1997) and Eisner (1997). Further strengthening the validity of our findings are the significant test-statistics for asymmetric cointegration as well as for short-run and long-run asymmetries found in Panel C. Similarly, the failure to detect non-normality, serial correlation, heteroscedasticity and incorrect functional form, as reflected in the diagnostic tests reported in Panel C of Table 5, also validates the reliability of our empirical results.

## 6. Conclusion

Against the lack of empirical evidence on the possibility of a Phillips curve trade-off for the Swazi kingdom, our study sought to fill this empirical hiatus. To this end we estimate (a) traditional, (b) new classical, and (d) triangular versions of the Phillips curve using the nonlinear ARDL model applied to data collected between 1991 and 2016. For control purposes we also provide estimates from the linear ARDL model. We are able to find evidence of linear short-run Phillips curve for the traditional specification whilst for the New Classical and triangular forms of the Phillips curve, we find that nonlinear specifications best describes the time series data. What is particular interesting is our discovery of “concave-type” nonlinearity for both the unemployment-gap and output-gap specifications and these findings have different yet interconnected policy implications. In our case, the concave unemployment-gap implies that a worsening of the economy reflected by a positive deviation of unemployment from its natural rate will be met with reduced inflation whilst a countermovement of unemployment below its natural rate bears no impact on the inflation rate. On the other hand, the dynamics from the concave output-gap Phillips curve implies that changes in the output-gap move

in the same direction as inflation, more so when economic growth exceeds its potential. This latter finding highlights the need for policymakers to be forward looking and act accordingly upon inflationary pressures.

In assembling policy recommendations for Swazi policymakers, we come up with the following. Firstly, we advise Swazi monetary authorities to be concerned with stabilizing policies and judging from the concavity observed in the output-gap based Phillips curve policymakers are cautioned on the risk of overheating of the economy during upswings of the business cycle. In the event that the economy recovers from its current recessionary period, policymakers should proceed cautiously as the economy reaches and surpasses its potential output level. In further contextualizing our findings, our concave unemployment-gap Phillips curve accounts for the decrease in Swazi inflation experienced over the last decades which were an outcome of worsening labour markets as reflected by the widening of the unemployment gap above its natural rather than a deliberate effort of policymakers. Therefore, over the medium-to-long term we firstly encourage Swazi policymakers to develop the necessary institutions to enhance the independence, credibility and transparency of monetary policy conduct and its pursuit of price stability. These monetary developments can be coupled with microeconomic structural reforms which can include adopting less stringent laws on minimum wage and allowing for insider-outsider or efficiency wage bargaining. However, given the significance of supply shocks through the exchange rate as well as the Kingdoms dependency on South Africa for trade revenues, monetary authorities are not advised to cease their currency dependence of the Swazi Lilangeni on the South African Rand.

Lastly, we acknowledge three shortcomings of our current study which can be improved on in future studies. Firstly, instead of using of single-equation approach to model the Phillips curve, future studies may consider the structural vector autoregressive (SVAR) or dynamic Stochastic General Equilibrium (DSGE) which provide a further advantage of allowing the researcher to predict the consequences of policy actions on the macroeconomy. Secondly,

Table 5

*Regression of Inflation on Unemployment Gap and Supply Shocks*

|                                    | one-sided HP       |                     | two-sided HP       |                     | C-O                |                     |
|------------------------------------|--------------------|---------------------|--------------------|---------------------|--------------------|---------------------|
|                                    | ARDL<br>(1,1,0)    | N-ARDL<br>(1,1,0,0) | ARDL<br>(2,1,1)    | N-ARDL<br>(1,1,1,0) | ARDL<br>(1,0,0)    | N-ARDL<br>(1,0,2,0) |
| Panel A:<br>Long-run<br>estimates  |                    |                     |                    |                     |                    |                     |
| U_gap                              | 0.46<br>(0.19)     |                     | 0.21<br>(0.63)     |                     | 0.52<br>(0.42)     |                     |
| U_gap+                             |                    | 0.32<br>(0.13)      |                    | 1.03<br>(0.03)*     |                    | 0.434<br>(0.48)     |
| U_gap-                             |                    | 1.16<br>(0.13)      |                    | 1.88<br>(0.00)***   |                    | 1.55<br>(0.07)*     |
| ER                                 | -0.29<br>(0.27)    | 0.18<br>(0.38)      | -0.55<br>(0.00)*** | 1.88<br>(0.00)***   | -0.19<br>(0.42)    | 0.48<br>(0.21)      |
| Panel B:<br>Short run<br>estimates |                    |                     |                    |                     |                    |                     |
| $\Delta\pi(-1)$                    |                    |                     | 0.39<br>(0.07)*    |                     |                    |                     |
| $\Delta U\_gap$                    | -2.01<br>(0.02)**  |                     | -2.06<br>(0.02)**  |                     | 0.43<br>(0.36)     |                     |
| $\Delta U\_gap+$                   |                    | -6.47<br>(0.00)***  |                    | -1.21<br>(0.30)     |                    | 0.39<br>(0.32)      |
| $\Delta U\_gap+(-1)$               |                    |                     |                    | -0.05<br>(0.94)     |                    |                     |
| $\Delta U\_gap-$                   |                    | 1.19<br>(0.11)      |                    |                     |                    | 1.40<br>(0.04)*     |
| $\Delta ER$                        | -0.26<br>(0.26)    | 0.18<br>(0.38)      | 0.15<br>(0.73)     | 0.22<br>(0.44)      | -0.15<br>(0.41)    | 0.43<br>(0.22)      |
| ect(-1)                            | -0.89<br>(0.00)*** |                     | -1.33<br>(0.00)*** | -1.11<br>(0.00)***  | -0.81<br>(0.00)*** | -0.90<br>(0.00)***  |
| Panel C:<br>Cointegration<br>tests |                    |                     |                    |                     |                    |                     |
| F-test                             | 4.05*              | 4.15*               | 4.67**             | 5.06**              | 5.01*              | 4.70**              |
| Wald-LR                            |                    | 9.20***             |                    | 1.16                |                    | 3.81*               |
| Wald-SR                            |                    | 8.17***             |                    | 9.91***             |                    | 0.16                |
| Panel D:<br>Diagnostic tests       |                    |                     |                    |                     |                    |                     |
| $\chi^2_{NORM}$                    | 0.57<br>(0.75)     | 0.76<br>(0.83)      | 1.52<br>(0.77)     | 1.05<br>(0.59)      | 2.23<br>(0.33)     | 1.93<br>(0.38)      |
| $\chi^2_{SC}$                      | 0.14<br>(0.87)     | 0.04<br>(0.97)      | 0.41<br>(0.67)     | 0.10<br>(0.91)      | 0.59<br>(0.56)     | 0.23<br>(0.80)      |
| $\chi^2_{HET}$                     | 0.44<br>(0.78)     | 0.72<br>(0.61)      | 0.31<br>(0.92)     | 0.95<br>(0.49)      | 0.01<br>(0.99)     | 0.88<br>(0.50)      |
| $\chi^2_{FF}$                      | 1.59<br>(0.13)     | 1.07<br>(0.30)      | 1.66<br>(0.12)     | 1.84<br>(0.08)*     | 1.51<br>(0.15)     | 1.59<br>(0.13)      |
| CUSUM                              | S                  | S                   | S                  | S                   | S                  | S                   |
| CUSUMSQ                            | U                  | S                   | S                  | S                   | S                  | S                   |

Notes: significance codes \*\*\* – 1%, \*\* – 5% and \* – 10%. P-values are reported in parentheses (). The regression have been estimated using Newey-West coefficients. Optimal lag selection of models determined by minimization of Schwarz information criterion.



**Table 6***Regression of Inflation on Output Gap and Supply Shocks*

|                                    | one-sided HP       |                     | two-sided HP       |                     | C-O                |                     |
|------------------------------------|--------------------|---------------------|--------------------|---------------------|--------------------|---------------------|
|                                    | ARDL<br>(1,0,0)    | N-ARDL<br>(1,1,0,0) | ARDL<br>(1,0,0)    | N-ARDL<br>(1,0,0,0) | ARDL<br>(1,0,0)    | N-ARDL<br>(1,1,2,2) |
| Panel A:<br>Long-run<br>estimates  |                    |                     |                    |                     |                    |                     |
| Y_gap                              | -0.47<br>(0.50)    |                     | -0.45<br>(0.27)    |                     | -0.84<br>(0.16)    |                     |
| Y_gap+                             |                    | -1.22<br>(0.07)*    |                    | -0.44<br>(0.32)     |                    | 1.64<br>(0.00)***   |
| Y_gap-                             |                    | -0.83<br>(0.17)     |                    | -0.11<br>(0.83)     |                    | 1.16<br>(0.00)***   |
| ER                                 | -0.26<br>(0.30)    | -0.01<br>(0.97)     | -0.29<br>(0.24)    | 0.26<br>(0.43)      | 0.34<br>(0.13)     | 0.96<br>(0.00)***   |
| Panel B:<br>Short run<br>estimates |                    |                     |                    |                     |                    |                     |
| $\Delta Y\_gap$                    | -0.39<br>(0.48)    |                     | -0.22<br>(0.48)    |                     | 0.71<br>(0.37)     |                     |
| $\Delta Y\_gap+$                   |                    | 0.36<br>(0.69)      |                    | -0.04<br>(0.93)     |                    | 7.69<br>(0.00)***   |
| $\Delta Y\_gap-$                   |                    | -0.80<br>(0.13)     |                    | -0.27<br>(0.57)     |                    | 5.38<br>(0.00)***   |
| $\Delta ER$                        | -0.22<br>(0.27)    | -0.01<br>(0.97)     | 0.48<br>(0.33)     | 0.62<br>(0.26)      | 0.53<br>(0.29)     | 0.98<br>(0.01)**    |
| Ect(-1)                            | -0.83<br>(0.00)*** | -0.97<br>(0.00)***  | -0.83<br>(0.00)*** | -0.90<br>(0.00)***  | -0.90<br>(0.00)*** | -1.29<br>(0.00)***  |
| Panel C:<br>Cointegration<br>tests |                    |                     |                    |                     |                    |                     |
| F-test                             | 5.08**             | 3.96*               | 3.97**             | 3.43*               | 3.79*              | 5.80***             |
| Wald-LR                            |                    | 1.54                |                    | 0.10                |                    | 6.08***             |
| Wald-SR                            |                    | 2.84                |                    | 0.12                |                    | 37.11***            |
| Panel D:<br>Diagnostic tests       |                    |                     |                    |                     |                    |                     |
| $\chi^2_{NORM}$                    | 2.36<br>(0.31)     | 1.73<br>(0.42)      | 1.94<br>(0.38)     | 1.29<br>(0.52)      | 2.39<br>(0.30)     | 0.70<br>(0.71)      |
| $\chi^2_{SC}$                      | 1.25<br>(0.31)     | 0.94<br>(0.41)      | 1.08<br>(0.36)     | 0.06<br>(0.94)      | 3.44<br>(0.05)*    | 0.31<br>(0.90)      |
| $\chi^2_{HET}$                     | 0.09<br>(0.97)     | 1.54<br>(0.23)      | 0.26<br>(0.86)     | 1.49<br>(0.24)      | 0.32<br>(0.81)     | 1.38<br>(0.29)      |
| $\chi^2_{FF}$                      | 2.76<br>(0.01)     | 1.41<br>(0.18)      | 2.11<br>(0.05)*    | 0.16<br>(0.87)      | 0.56<br>(0.58)     | 0.50<br>(0.62)      |
| CUSUM                              | S                  | S                   | S                  | S                   | S                  | S                   |
| CUSUMSQ                            | S                  | S                   | S                  | S                   | S                  | S                   |

Notes: significance codes \*\*\* – 1%, \*\* – 5% and \* – 10%. P-values are reported in parentheses (). The regression have been estimated using Newey-West coefficients. Optimal lag selection of models determined by minimization of Schwarz information criterion.

future studies can consider a disaggregated analysis of the Phillips curve either for different categories of unemployment and different sectors of output productivity. Lastly, different measure of inflation expectations can be used in future analysis as the Phillips curve may hold differently across various strata of the society.

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