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ESTIMATING THE NEW KEYNESIAN IS CURVE FOR BOTSWANA

Mogale M. Ntsosa*

ABSTRACT

Monetary policy in Botswana is premised on the assumption that the impact of policy on output is forward looking. This paper tests the baseline and extended backward and forward looking versions of the New Keynesian IS curve for Botswana. The major finding is that the relationship between output and policy interest rate is backward looking not forward looking. In addition to the policy rate, other variables namely M2, South African demand and the food index determine aggregate demand in Botswana. These findings are robust to structural break tests.

Keywords*: IS curve; New Keynesian Model; backward looking; forward looking; Botswana*

JEL codes*: C2, E31, E52*

1. INTRODUCTION

Monetary policy has real effects on the economy hence it's important to measure its effect. Romer and Romer (1989) found monetary policy shifts to have real and persistent effects. This is corroborated by Bernanke and Blinder (1992) who found that tight policy rate by suppressing credit leads to unemployment in the long-run. This is further confirmed by Leeper *et al.*, (1996) though they found the magnitude of variance in output due to monetary policy shift to be relatively small.

According to Fuhrer (2000) good models must incorporate rational expectations and optimization to accommodate the Lucas (1976) critique. Rational expectations means agents are able to adjust expectations in response to changes in systematic behaviour of other agents like policymakers. Optimization results in structurally sound and stable models as they are derived from agents' maximization of utility or profits. Stable models make it easier to measure improvements in monetary policy overtime. Theoretically, the New Keynesian IS (NKIS) curve, derived from the neoclassical intertemporal Euler equation, incorporates these properties in a forward-looking model that relates output gap to the expected future output gap and ex-ante short-term real interest rate.

* Department of Economics, University of Botswana, Private Bag UB705, Gaborone, Botswana, *E-mail: ntsosamm@mopipi.ub.bw*

Empirically, the fit of NKIS on data has been poor in studies using both a panel of countries (e.g. Stracca, (2010) for Euro area; Goodhart and Hofmann, (2003) for G7; Hafer and Jones, (2008) and country-specific ones (e.g. Hafer *et al*, (2007) for the US; Paradiso *et al*, (2013) for Australia). The interest rate coefficient has been found to be either insignificant or wrongly signed. Several explanations have been put forward. Firstly, Muellbauer (2010) finds a rejection of the consumption Euler equation on aggregate data confirming findings of Campbell and Mankiw (1991). Similarly, Canzoneri et al (2007) find interest rates predicted by the consumption Euler equation to be mostly negatively correlated to policy rates.

Secondly, Ericcson and Irons, (1995) argue that the Lucas critique seems to be relevant theoretically but not empirically for many economic relationships. Estrella and Fuhrer (1998) find dynamic inconsistencies in estimations of purely forward-looking consumption Euler equations. At a theoretical level, forward-looking models show jumps in inflation and output in response to shocks while empirically the responses are hump-shaped. Finally, according to Nelson (2001) the failures are due to simultaneity bias from forward-looking monetary policy, misspecification because of omitted forward elements and misspecification due to omission of other determinants of aggregate demand.

One solution to these problems has been to estimate "hybrid" models that incorporate backward-looking and forward-looking elements, backward-looking and extended models of the IS. The backward-looking aspect is justified on grounds that output and inflation have lagged and persistent responses to monetary policy (Rudebusch, 2002) while forward-looking elements are consistent with monetary policy goals. According to Fuhrer (2000) hybrid models have habit-formation in consumption. Hybrid models are justified theoretically by assuming that a fraction of firms set their prices in a backward-looking fashion (Gali and Gertler, 1999). Extended models are justified on grounds that in addition to interest rates, there are other determinants of aggregate demand (Paradiso *et al,* 2013).

This paper estimates the IS equation for Botswana. The goal is to identify whether the IS curve is backward-looking or forward-looking. The literature on the IS equation concentrates largely on advanced countries while omitting developing countries. Developing countries have different economic structure from that of the developed hence studying them may generate rich information. The types of models estimated here are the hybrid, backward-looking and extended backward-looking models. Models with forward-looking elements are estimated using the generalized method of moments (GMM) while backward-looking models are estimated using least squares. Additional variables on the extended models are growth of monetary aggregates, asset prices, government spending, oil and food prices, the US output gap and the real exchange rate. Stability tests are conducted to establish viability for policy.

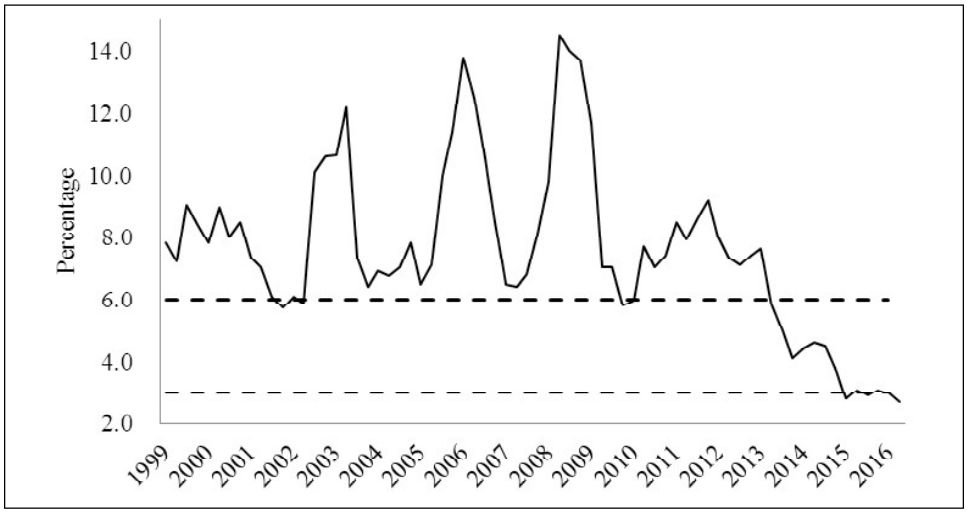
2. MONETARY POLICY IN BOTSWANA

2.1. Inflation rate

According to Setlhare (2013) from 1993 to 1998 the Bank of Botswana's objective was achievement of positive real interest rates while from 1998 price stability was the main objective. In 2002 the Bank began to publicly publish the inflation range of 4 - 6 percent which was later adjusted in 2008 to 3 – 6 percent. The medium term inflation forecast over a 3-year horizon serves as the intermediate target for policy, a departure from the use of commercial bank credit growth. Thus policy is forward-looking and forecast-based in adjusting aggregate demand to meet supply.

However, as Figure 1 shows inflation rate has been above the maximum target of 6 percent prior to the second quarter of 2013 when it fell within the range. Bank of Botswana Annual Report (2014) attributes the decline to declines in international oil and food prices due to capacity underutilization and lack of demand in the global economy. For a mineral-led economy external demand conditions dominate in determination of domestic economic conditions. The persistent failure of monetary policy to meet the inflation objective had prompted Monnane and Kebakile (2006) to question the appropriateness of the monetary policy instrument used to control inflation.

Figure 1: Quarterly inflation rate for Botswana



Source: Bank of Botswana

3. DATA, SPECIFICATION AND METHODOLOGY

3.1. Data

The sample period is from 1999Q1 to 2016Q2[1]. The variables used are the output gap, y, calculated as the percent deviation of actual real GDP from potential

GDP, i.e. $y = 100\,(q - q^{*})$ where q and q^{*} are logs of real GDP and potential GDP respectively. Potential GDP is obtained using the Hodrick-Prescott filter. The output gap is preferred to isolate the business-cycle component of the series (Hafer and Jones, 2008) and it measures aggregate demand pressure. The nominal interest rate (r) is the Bank of Botswana's policy rate defined as the bank rate. The inflation rate (π) is the annualized rate of change of the CPI calculated as $400\,(lnp_{t} - lnp_{t-1})$ where p is the CPI. The real effective exchange rate, represented by *rer*, measures the contribution of external demand on the economy.

The growth rate of real broad money supply ($\Delta m2$) is calculated as the difference between the percentage year-on-year nominal growth of money and the inflation rate. Similarly, the growth rate of share prices, Δdci, is the difference between the percentage year-on-year nominal growth of domestic companies index and the inflation rate. *SA gap* and *US gap* are respectively South African and US output gaps. *oil* and *food* are cyclical components of the natural log of oil and food price indices respectively. The cyclical component of the oil and food prices was extracted using the full sample asymmetric band-pass filter developed by Christiano and Fitzgerald (2003).

The food price index was converted from annual to quarterly using the quadratic-match average method. Since Botswana is an open economy, the variables oil price, food price index, US and South African output gap were chosen to represent external economic conditions. South African gap, US gap and oil prices are sourced from the St Louis' Federal Reserve Bank's FRED database, the real food price index is from FAO while the rest of data is from Bank of Botswana.

Table 1
Descriptive statistics 1999Q1-2016Q2

Variable	*Mean*	*SD*	*Min*	*Max*
r	12.682	2.579	7.5	15.5
π	-7.164	4.61	-26.573	-0.674
rer	102.841	4.695	91.4	112.946
$\Delta m2$	1.964	0.544	0.427	3.314
Δdci	1.968	0.545	0.436	3.326
g	0.422	0.144	0.214	0.740
Bot gap	-0.001	0.04	-0.103	0.086
SA gap	-0.0001	0.012	-0.023	0.029
US gap	-0.0001	0.012	-0.029	0.024
oil	-0.010	13.01	-30.264	38.121
food	-0.228	7.764	-20.788	20.128

Graphs of oil and food gaps are visually similar showing strong correlation. However, food was chosen on the basis that it is less volatile than oil as can be seen from a simple standard deviation in Table 1. Also, graphs of South African gap and US gap are identical but South African gap was preferred because it is less volatile and is Botswana's major trading partner.

3.2. Specification and methodology

According to Fuhrer and Rudebusch (2004) New Keynesian models postulate that current output is largely determined by expectations of future output. This view follows from generalization of the intertemporal Euler equation for consumption stated as:

$$y_t = E_t y_{t+1} - \sigma(r_t - E_t\pi_{t+1}) + \eta_t \quad (1)$$

y_t is the output gap, $E_t y_{t+1}$ is the expectations at time t of future output gap at $t + 1$. r_t is the nominal interest rate at time t, $E_t\pi_{t+1}$ is the expectation at time of next period's inflation. $(r_t - E_t\pi_{t+1})$ is the ex-ante real interest rate which is negatively related to economic activity due to intertemporal substitution in consumption. represents the aggregate demand shock not anticipated by the monetary authority hence is not serially correlated and has a statistical mean of zero.

Following Paradiso *et al.* (2013), the hybrid version of the forward looking IS equation to be estimated is:

$$y_t = \alpha_0 + \Sigma_{i=1}^{4}\alpha_i y_{t-i} + \gamma E_t y_{t+1} + \Sigma_{i=0}^{4}\beta_i(r_{t-i} - E_t\pi_{t-i+1}) + \Sigma_{i=1}^{4}\varphi_i^x x_t + \varepsilon_t \quad (2)$$

x_t is a vector of other variables that may determine aggregate demand namely *g,rer*, $\Delta m2$, Δdci, *SA gap*, *US gap, oil* and *food*. The backward-looking equation is:

$$y_t = \alpha_0 + \Sigma_{i=1}^{4}\alpha_i y_{t-i} + \Sigma_{i=1}^{4}\beta_i(r_{t-i} - \pi_{t-i}) + \Sigma_{i=1}^{4}\varphi_i^x x_{t-i} + \varepsilon_t \quad (3)$$

The estimation strategy is to initially include all the variables in the model with a lag of 4. Then the lag of the least significant variable is reduced until the variable is significant. Further, to avoid multicollinearity, insignificant variables are dropped from the estimated model. According to Paradiso *et al.* (2013) the impact of inflation on output may be negative reflecting impact of changes in prices on real balances. For this reason, the restrictive assumption that inflation's impact on output is strictly positive as the real interest rate restriction suggests is then relaxed. Hence in equations 2.1 and 3.1 the restriction on the coefficient of inflation to equal that of interest rate is relaxed. Thus unconstrained versions of equations 2 and 3 are:

$$y_t = \alpha_0 + \Sigma_{i=1}^{4}\alpha_i y_{t-i} + \gamma E_t y_{t+1} + \Sigma_{i=0}^{4}\theta_i r_{t-i} + \Sigma_{i=0}^{4}\delta_i E_t\pi_{t-i+1} + \Sigma_{i=1}^{4}\varphi_i^x x_t + \varepsilon_t \quad (2.1)$$

$$y_t = \alpha_0 + \Sigma_{i=1}^{4}\alpha_i y_{t-i} + \Sigma_{i=0}^{4}\theta_i r_{t-i} + \Sigma_{i=1}^{4}\delta_i\pi_{t-i} + \Sigma_{i=1}^{4}\varphi_i^x x_{t-i} + \varepsilon_t \quad (3.1)$$

While the nominal interest rate, θ_i is assumed to be strictly negative, δ_i is expected to be either positive or negative.

3.3. Empirical Results

3.3.1. Baseline backward looking IS curve

Following Paradiso *et al.* (2013) both constrained and unconstrained versions of the baseline backward model are estimated using Ordinary Least Squares (OLS). The equations are:

$$y_t = \alpha_0 + \Sigma_{i=1}^{4} \alpha_i y_{t-i} + \Sigma_{i=0}^{4} \beta_i (r_{t-i} - \pi_{t-i}) + \varepsilon_t \quad (4)$$

$$y_t = \alpha_0 + \Sigma_{i=1}^{4} \alpha_i y_{t-i} + \Sigma_{i=1}^{4} \theta_i r_{t-i} + \Sigma_{i=1}^{4} \delta_i \pi_{t-i} + \varepsilon_t \quad (4.1)$$

The results are presented in Table 2. The constrained model shows the real interest rate to be significant at 1% in determining output. In the unconstrained model inflation is negatively related to output while nominal interest rate is insignificant. Normality, serial correlation and heteroscedasticity are not a problem. From the constrained baseline model monetary policy affects the economy in an expected manner. In the unconstrained model nominal interest rate is insignificant while inflation has a negative sign.

Table 2
Estimates of the baseline backward-looking model

	Constrained		*Unconstrained*
α_0	0.02 [2.42]**	α_0	-0.025 [-2.62]***
α_4	0.258 [2.20]**	α_4	-0.247 [-1.46]
β_4	-0.002[-2.99]***		-
	-	δ_1	0.102 [1.16]
	-	δ_2	-0.003 [-3.45]***
$\bar{R}^2$	0.345	$\bar{R}^2$	0.257
JB	0.517	JB	0.183
LM	0.632	LM	0.158
BPG	0.202	BPG	0.627

Notes: ***, **,* denote significance at 1, 5 and 10% levels, respectively. t-statistics are reported in []. *JB* is the Jarque-Bera normality test of residuals. *LM* is the Lagrange Multiplier test for serial correlation. *BPG* is the Breusch-Pagan-Godfrey test for heteroscedasticity. *p*-values are reported for the *JB*, *LM* and *BPG* tests.

3.3.2. Forward looking IS curve

The baseline model may not be structural as it is inconsistent with New Keynesian DSGE models hence a forward-looking hybrid model is estimated using the General Method of Moments. Both the baseline and extended forward looking IS models were estimated. Table 3 presents the extended forward looking IS curve. All the extended variables were insignificant at conventional levels hence were eliminated from the model. Lagged and forward looking variables of output gap are significant at 1% level for both constrained and unconstrained versions. For the constrained model the real interest rate is insignificant. For the unconstrained model nominal interest rate is significant at 5% level with a positive sign. Inflation is significant at 10% level with a positive sign.

The probability of Hansen's (1982) *J*-test shows that the chosen instruments ($y_{t-1}, y_{t-2}, y_{t-3}$, *real interest rate and intercept*) are valid for both constrained and unconstrained versions. Given that the policy variable is either insignificant or has an unexpected sign for the forward looking IS model, it is concluded that monetary policy is ineffective in controlling aggregate demand.

Table 3
Estimates of the forward-looking model - GMM

	Constrained		*Unconstrained*
α_0	-0.004 [-1.12]	α_0	-0.014 [-1.75]*
α_1	0.424 [12.98]***	α_1	0.349 [6.12]***
γ	0.635 [13.81]***	γ	0.704 [11.54]***
β_2	0.0004 [1.16]		-
	-	θ_1	0.008 [2.36]**
	-	δ_4	0.001 [1.88]*
$\bar{R}^2$	0.655	$\bar{R}^2$	0.902
JB	0.194	*JB*	0.883
Prob (J-Stat)	0.680	Prob (J-Stat)	0.635

Notes: ***, **,* denote significance at 1, 5 and 10% levels, respectively. t-statistics are reported in []. *JB* is the Jarque-Bera normality test of residuals. *LM* is the Lagrange Multiplier test for serial correlation. BPG is the Breusch-Pagan-Godfrey test for heteroscedasticity. *p*-values are reported for the *JB*, *LM* and *BPG* tests.

3.3.3. Extended backward looking IS curve

From the preceding it can be concluded that monetary policy in Botswana is not forward looking hence the statement that "…the Bank applies a forward-looking monetary policy strategy in order to achieve medium-term price stability"[2] may be inappropriate. Next is to test if the backward looking model better approximates the impact of monetary policy on aggregate demand. The results are presented in Table 4.

The food index, M2 and the South African GDP gap were found to be significant while the rest of other variables, namely real exchange rate, stock market index and government spending were insignificant hence dropped from

Table 4
Estimates for the extended backward looking model

	Constrained		*Unconstrained*
α_0	-0.065 [-3.25]***	α_0	-0.027 [-1.86]*
α_4	0.409 [5.06]***	α_3	-0.439 [-4.46]***
β_4	-0.007 [-6.40]***		-
	-	θ_1	0.174 [2.46]**
	-	δ_4	0.004 [3.56]***
$\varphi_2^{\Delta M2}$	0.012 [2.16]**	$\varphi_4^{\Delta M2}$	0.029 [2.72]***
φ_1^{SAgap}	1.543 [9.21]***	φ_2^{SAgap}	1.249 [3.12]***
$\varphi_4^{\Delta food}$	-0.002[10.01]***	$\varphi_1^{\Delta food}$	-0.002 [-3.75]***
$\bar{R}^2$	0.736	$\bar{R}^2$	0.630
JB	0.302	JB	0.194
LM	0.816	LM	0.454
BPG	0.912	BPG	0.578

Notes: ***, **,* denote significance at 1, 5 and 10% levels, respectively. t-statistics are reported in []. *JB* is the Jarque-Bera normality test of residuals. *LM* is the Lagrange Multiplier test for serial correlation. *BPG* is the Breusch-Pagan-Godfrey test for heteroscedasticity. p-values are reported for the *JB*,*LM* and *BPG* tests.

the model. From the constrained model, the real interest rate, the food index and the South African gap are significant at 1% significance level while M2 is significant at 5%. All the variables have the expected signs. In the unconstrained model inflation, M2, South African gap and food index are significant at 1% level with expected signs while nominal interest rate is significant at 5% level with a positive sign. The backward looking model performs better than the forward looking model. Except for the wrongly signed nominal interest rate in the unconstrained version, all other variables are significant and have the expected signs. The residuals are normally distributed with no serial correlation and no heteroscedasticity.

3.4. Robustness

Table 5
Quandt-Andrews structural break tests

	Constrained			*Unconstrained*		
Test Statistic	*Break date*	*Value*	*Probability*	*Break date*	*Value*	*Probability*
Max LR *F*-statistic	2005Q2	12.625	0.008***	2008Q4	7.288	0.090*
Max Wald *F*-statistic	2005Q2	12.625	0.008***	2008Q4	7.288	0.090*
Exp LR *F*-statistic	-	3.582	0.007***	-	1.634	0.083*
Exp Wald *F*-statistic	-	3.582	0.007***	-	1.634	0.083*
Ave LR *F*-statistic	-	4.120	0.017***	-	1.915	0.123
Ave Wald *F*-statistic	-	4.120	0.017***	-	1.915	0.123

The backward looking model is further tested for robustness. The Quandt-Andrews test is used to identify multiple structural breaks. Then subsamples accommodating the structural break dates are tested. The Quandt-Andrews is preferred as it tests for one or more unknown structural breakpoints by performing single Chow breakpoint tests at each observation between two dates or observations. The null hypothesis is that there are no breakpoints between two observations. Two statistics; the Likelihood Ratio F-statistic and the Wald F-statistic are calculated. The statistics used are the maximum, average and exponential F-statistic. The validity of the tests is checked using the asymptotic p-values developed by Hansen (1997).

From Table 5 identified structural breakpoints are in 2005 Q2 and 2008Q4. From the maximum statistic the null hypothesis of no break is rejected at 1% significance level for the constrained version while for the unconstrained version it is rejected at 10% significance level. The structural break of 2005 coincides with the devaluation of the Pula by 12.5% and the simultaneous introduction of the crawling peg in May 2005. The breakpoint of 2008 coincides with the impact of the global financial crisis (GFC) on the domestic economy.

The robustness check is conducted using OLS estimation for the following subsamples: before the GFC (1999Q1 - 2008Q2), after the GFC (2009Q2 - 2016Q2) and the crawling peg period (2005Q3 - 2016Q2). The results are presented in Table 6. The real interest rate is significant and has the expected negative sign

Table 6
Robustness

Constrained						Unconstrained					
Global Financial Crisis				Crawling Peg		Global Financial Crisis				Crawling Peg	
	1999Q1-2008Q2		2009Q2-2016Q2		2005Q3-2016Q2		1999Q1-2008Q2		2009Q2-2016Q2		2005Q3-2016Q2
α_0	-0.017	α_0	-0.066	α_0	-0.065	α_0	0.019	α_0	0.009304	α_0	-0.077
	[-0.99]		[-3.47]***		[-3.12]***		[0.48]		[0.68]		[-3.66]***
α_4	0.561	α_1	0.309	α_1	0.367	α_4	0.461	α_4	0.344300	α_1	0.584
	[4.93]***		[1.79]*		[3.16]***		[2.97]***		[3.70]***		[5.12]***
β_1	-0.001	β_1	-0.003	β_4	-0.012		-		-	-	
	[-1.77]*		[-2.89]***		[-6.60]***						
	-		-		-	θ_4	-0.577	θ_4	-0.225	θ_2	-0.081
							[-1.72]*		[-3.94]***		[-1.00]
	-		-		-	δ_2	-0.005	δ_1	0.001	δ_4	0.011
							[-1.22]		[0.79]		[5.75]***
$\varphi_2^{\Delta M2}$	0.021	$\varphi_4^{\Delta M2}$	0.038	$\varphi_4^{\Delta M2}$	0.087	$\varphi_2^{\Delta M2}$	-0.024	$\varphi_1^{\Delta M2}$	-0.008	$\varphi_4^{\Delta M2}$	0.081
	[2.34]**		[9.10]***		[5.45]***		[-0.72]		[-1.25]		[4.92]***
φ_1^{SAgap}	1.351	φ_1^{SAgap}	2.266	φ_2^{SAgap}	1.378	φ_2^{SAgap}	1.887	φ_3^{SAgap}	-0.894	φ_3^{SAgap}	0.946
	[3.00]***		[2.51]**		[3.26]***		[3.79]***		[-2.19]***		[1.91]*
$\varphi_4^{\Delta food}$	0.0003	$\varphi_1^{\Delta food}$	0.001	$\varphi_4^{\Delta food}$	-0.001	$\varphi_2^{\Delta food}$	-0.003	$\varphi_1^{\Delta food}$	0.003	$\varphi_4^{\Delta food}$	-0.001
	[0.23]		[0.92]		[-2.85]***		[1.75]*		[3.55]***		[-2.36]**
$\bar{R}^2$	0.723	$\bar{R}^2$	0.834	$\bar{R}^2$	0.736	$\bar{R}^2$	0.752	$\bar{R}^2$	0.850	$\bar{R}^2$	0.704
JB	0.497	*JB*	0.582	*JB*	0.599	*JB*	0.518	*JB*	0.653	*JB*	0.872
LM	0.633	*LM*	0.213	*LM*	0.542	*LM*	0.662	*LM*	0.398	*LM*	0.198
BPG	0.549	*BPG*	0.472	*BPG*	0.152	*BPG*	0.906	*BPG*	0.738	*BPG*	0.417

Notes: ***, **,* denote significance at 1, 5 and 10% levels, respectively. t-statistics are reported in []. *JB* is the Jarque-Bera normality test of residuals. *LM* is the Lagrange Multiplier test for serial correlation. *BPG* is the Breusch-Pagan-Godfrey test for heteroscedasticity. *p*-values are reported for the *JB, LM* and *BPG* tests

for all the subsamples. The nominal interest rate is significant with the expected sign for the subsamples before and after the GFC while insignificant for the crawling peg period. Inflation is only significant with a positive sign only under the crawling peg period. The rest of the other variables, namely, the M2, South African gap and the food index are mostly significant at conventional levels and have expected signs. There are no problems of serial correlation, heteroskedasticity and non-normal residuals.

4. CONCLUSION

Theoretically the NK-IS curve is purely forward looking. The output gap is determined by expected future output gap and *ex ante* real interest rate. This paper tested whether this relationship is forward looking for Botswana. The findings reject the assertion of forward looking behaviour and strongly suggest the relationship to be backward looking. The period covered is from 1999Q1 – 2016Q2. There are two versions of the model: the constrained version places a restriction on the nominal interest rate-inflation rate relationship to get the real interest rate. This means the inflation rate is restricted to a positive sign. The unconstrained version relaxes the relationship allowing for the inflation rate to assume either a negative or positive sign. According to Paradiso et al (2013) inflation can assume a negative sign, for instance, in some cases inflation can have a negative impact on consumption expenditures.

Baseline and extended versions of the backward and forward looking models were estimated. The baseline relates the output gap to the interest rates while extended versions include other variables that may determine aggregate demand. These are the real exchange rate, changes in M2 and stock market index, government spending to GDP, US and South African output gaps and oil and food indices. The results of the baseline backward looking model show real interest rate to be significant and negatively related to output gap. The unconstrained version shows an insignificant nominal interest rate while inflation is negatively related to output. In the forward looking baseline models the interest rate variables are insignificant.

Since the baseline models are not structural, the extended backward and forward looking models were estimated. In the forward looking models the interest rates were found to be either insignificant (constrained) or positively signed (unconstrained). The added variables were all insignificant. For the extended backward looking model the real interest rate was significant and negative while for the unconstrained model it was significant but positive. Inflation was also significant and positive. South African gap, M2 and food index were significant with expected signs for both versions of the model. Diagnostic checks showed all the models were correctly estimated.

Since the extended backward looking model provided a better fit, it was tested for robustness. Using the Quandt-Andrews structural breakpoint test, two breakpoints were identified in 2005Q2 and 2008Q4. The 2005Q2 breakpoints correspond with a large devaluation of the Pula and introduction of the crawling

peg. The 2008Q4 breakpoint is identified with the onset of effects of the Great Recession on the domestic economy. Three subsamples covering periods before and after the Global Financial crisis and the crawling peg period were tested. In both constrained and unconstrained versions, the interest rate variables were significant at conventional levels with expected signs. Extended variables were mostly significant and of expected signs.

The major conclusion is that the current monetary policy regime that assumes forward looking behaviour has not been effective in controlling aggregate demand. Instead IS curve for Botswana is backward looking and in addition to the policy rate, aggregate demand is determined by M2, food index and South African gap. This conclusion is robust hence it can be reliably used by monetary authorities.

Notes

1. Data like inflation was rebased in September 2016 hence to minimize distortions the period covered was up to 2016Q2.

2 Quoted from the monetary policy framework of Bank of Botswana at http://www.bankofbotswana.bw/index.php/content/2009103009029-policy-framework

References

Andrews, Donald W. K. (1993), "Tests for parameter instability and structural change with unknown change point", *Econometrica*, Vol. 61, pp. 821-56.

Bernanke, Ben S. and Alan, S. Blinder (1992), "The Federal Funds Rate and the Channels of Monetary Transmission", *The American Economic Review*, Vol. 82, pp. 901-921.

Canzoneri, Matthew, Robert Cumby and Behzad Diba (2007), "Euler Equations and money market interest rates: a challenge for monetary policy models. *Journal of Monetary Economics*, Vol. 54, pp. 1863–1881.

Christiano, Lawrence J. and Terry, J. Fitzgerald (2003), "The Band Pass Filter", *International Economic Review*, Vol. 44, pp. 435-465.

Collard Fabrice and Harris Dellas (2012), "Euler Equations and Monetary Policy", *Economics Letters*, Vol. 114, pp. 1–5.

Estrella Arturo and Jeffrey Fuhrer (1998), "Dynamic Inconsistencies: Counterfactual Implications of a Class of Rational Expectations Models."

Fuhrer, Jeffrey (2000), "Habit Formation in Consumption and its Implications for Monetary Policy Models", *American Economic Review*, Vol. 90, pp. 367-390.

Fuhrer Jeffrey and Glenn Rudebusch (2004), "Estimating the Euler Equation for Output", *Journal of Monetary Economics*, Vol. 51, pp. 1133-53.

Gali, Jordi and Mark Gertler, (1999), "Inflation Dynamics: A Structural Econometric Analysis", *Journal of Monetary Economics*, Vol. 44, pp. 195-222.

Hafer, R. W. and Garret Jones, (2008), "Dynamic IS Curves with and without money: an international comparison", *Journal of International Money and Finance*, Vol. 27, pp. 609–16.

Hansen, Lars P. (1982), "Large sample properties of generalized method of moments estimators. Econometrica, 50, 1029–1054.

Hansen, Bruce. E. (1997), "Approximate Asymptotic p-values for Structural Change tests", *Journal of Business and Economic Statistics,* Vol. 15, pp. 60-70.

Linde, Jesper (2001), "The Empirical Relevance of Simple Forward- and Backward-Looking Models: A View from a Dynamic General Equilibrium Model. *Sveriges Riksbank Working Paper Series No. 130*.

Lucas, Robert E. (1976), "Econometric Policy Evaluation: A Critique", *Carnegie-Rochester Conference Series on Public Policy, 7-33*.

Monnane, Monnane and Pinkie Kebakile (2006), "Botswana's Monetary Policy: Time for Debate?" BIDPA Briefing, 2nd Quarter 2006.

Paradiso, Antonio, Saten Kumar and B. Bhaskara Rao (2013), "A New Keynesian IS Curve for Australia: Is it Forward Looking or Backward Looking?" Applied *Economics*, Vol. 45, pp. 3691-3700.

Quandt, Richard E. (1960) "Tests of the Hypothesis that a Linear Regression System Obeys Two Separate Regimes", *Journal of American Statistical Association*, Vol. 55, pp. 324-30.

Romer, Christina, D. and D. H. Romer, (1989), "Does Monetary Policy Matter? A New Test in the Spirit of Friedman and Schwartz", (in: Olivier J. Blanchard and Stanley Fischer, eds., *NBER Macroeconomics Annual*,), Cambridge, MA: MIT Press.

Rudebusch, Glenn, (2002), "Assessing Nominal Income Rules for Monetary Policy with Model and Data Uncertainty", *Economic Journal*, Vol. 112, pp. 401–32.

Stracca, Livio, (2010) "Is the New Keynesian IS Curve Structural?", *European Central Bank Working Paper Series No. 1236.* Frankfurt: Germany.