An Analysis of the State Bank of Pakistan Monetary Policy Reaction Function in an Open Economy Taylor Rule Framework

Muhammad Tariq
Abdul Wali Khan University Mardan
Shahid Jan Kakakhel
Islamia College University Peshawar

Abstract
This paper presents an empirical study of the monetary policy of Pakistan during the period 1973 to 2015. For this purpose, a Taylor rule-based monetary policy reaction function of State Bank of Pakistan has been analyzed. Specifically, it has been investigated, whether the State Bank of Pakistan using a Taylor rule-based monetary policy, targets only interest rate? Or it also targets real exchange rate by adopting an open economy Taylor rule based policy. The study used Hodric Prescott Filter method for removing the long run trend from data and making it stationary. After that ordinary least squares method and Wald test has been used for the estimation of results. First results have been computed for the full sample period of the study during the period 1973-2015. After that, results has been estimated for the sub sample periods (i.e. three exchange rate regimes periods) during 1973-1981, 1982-1999 and 2000-2015. The full sample period results showed a systematic reaction of the State Bank of Pakistan to exchange rate fluctuations. However, the subsample analysis conditional on historical changes of the exchange rate regimes provides a different picture of the monetary policy management in Pakistan. A time-varying attention placed by SBP to inflation and output gaps fluctuations is uncovered by our subsample investigation.
Keywords: Taylor rule, Real exchange rate, Backward looking model, F-statistic

In 1993, John B. Taylor presented a paper entitled "Discretion versus Policy Rules in Practice". In this paper Taylor presented a monetary policy rule. The rule was explaining the mechanism of targeting the interest rate in a small closed economy by the monetary authorities. The basic idea of the rule was that the monetary authorities can use interest rate as an instrument for bringing the economy towards equilibrium position when output and inflation diverts from its settled targets (Krugman, 1996; Wren and Leith, 2015). The rule explains that if output and inflation deviates 1% from their targeted levels, the monetary authority brings 1% and 1.5% increase in the nominal interest rate for stabilizing these variables and vice versa. Taylor (1993) suggested that the coefficients of both the variables i.e. output gap and inflation must be greater than zero i.e. i.e. $a_y>0$ and $a_\pi>0$. Otherwise the monetary policy will be ineffective.

Furthermore Taylor (1994) mentioned that the weights of the restrictions imposed on the model are not strict and its values are dependent on the macroeconomic structure and degrees of openness of an economy. Peersman and Smets (1998) and Malik and Ahmed (2010) also tested the Taylor Rule (TR) empirically and referring it is a schematic tool which the help the monetary authorities in the stabilization of macroeconomic aggregates in a better way.

Interest rate functions in an economy in through several channels. On one side changes in it affect the market interest rates which in turn influence saving and lending rates for individuals and firms. On the other hand a rise in the interest rate decreases the aggregate demand for money through decreased money supply in the economy which helps in keeping the inflation in control and the domestic goods become more competitive in the world market. This strengthens the domestic currency value by increasing the flow of foreign exchange reserves in the home country. However, in an open economy, the conduct of monetary policy is not similar to the conduct of monetary policy as in a closed economy. Hence, limiting monetary policy to only inflation and output[1] gaps might not work well without taking into account the role of some other macroeconomic variables i.e. real exchange rate, money supply, trade balance etc. Mishkin (2000) mentioned that inflation control, output growth, employment, stability of interest rate and exchange rate are the general objectives of the monetary policy in most of the economies. Chang (2000) conducted study for analyzing the reaction of macroeconomic aggregates to interest rate and exchange rate fluctuations. All these studies concluded that keeping exchange rate in the monetary policy mandate increases the success of monetary policy. These views are also supported by Svensson (1998), Setlhare (2002), Batini *et al.* (2001) Eichengreen,

[1]Output gap is the difference between actual and potential GDP i.e. Y–Y*. If the difference between the two is positive, it will bring increase in the interest rate for covering inflationary gap. In contrast a negative difference will bring decrease in the interest rate for covering deflationary gap. Ball (1997), stated that Taylor rule in which central bank reacts to inflation and output gap is optimal. Claridaet al (1998) suggested that the central banks in the United States, Germany and Japan all partly respond to output gap. Gerlas& Smets (1999) using a Taylor rule included output gap in their monetary policy model, concluded that output gap works as a thermometer for inflation and reacting to it is optimal.

(2004), Shambaugh (2004), Thomas and Schorfheide (2007) and Parsley & Popper (2009) in their studies.

"Exchange rate provides additional aggregate demand and supply transmission channels for the conduct of monetary policy in an economy. On one side a change in it influences the relative prices of domestic and foreign goods which in turn affect the domestic and foreign demand for domestic goods. Moreover, depreciation directly affects the domestic currency prices of imported goods which raise domestic inflation. Indirectly, exchange rate by affecting the prices of imported inputs influences the nominal wages which in turn affect the cost of production and leads to domestic inflation". Now the question is what the State Bank of Pakistan(SBP) follows whether a closed economy Taylor Rule where its objective is to cover only output and inflation gaps or an open economy Taylor Rule where it also reacts to real exchange rate in its monetary policy strategy. This question has been answered in this paper.

Research Problem

In Pakistan a number of studies have been conducted for examining the monetary policy mandate of the State Bank of Pakistan. However, the research dimension of those studies was different and limited. For example Malik (2007) conducted a VAR analysis for computing a loss function consisting of various variables. The study concluded that interest rate is affected by nominal exchange rate, trade deficit, output and inflation. Similarly, Malik and Ahmed (2010) empirically examined the optimality of the Taylor rule based monetary policy against discretionary policy in the achievement of the macroeconomic objectives. It is concluded that State Bank of Pakistan is not following the simple Taylor rule in its monetary policy strategy. Fatima and Malik (2015) investigated the suitability of the nonlinear Taylor rule function to Pakistani data and concluded that SBP followed a nonlinear monetary policy reaction function. Other studies are form Zaidi & Zaidi (2011), Tahir (2013) etc.

There are several contributions of this study. First, unlike the previous studies it investigates the monetary policy reaction function of the State Bank of Pakistan where its reacts to real exchange rate movement by following an open Economy Taylor Rule framework. Moreover, examining the monetary policy reaction function under the three different exchange rate regimes is another distinction of this study. Moreover, this study used de-

trended data series obtained through Hodric Prescott filter technique for dealing with the objectives of the study.

Real exchange rate and monetary policy

Real exchange rate is a broad summary measure of the prices of one country's goods and services against other countries currencies. According to Chinn (2006) the real exchange rate plays a key role in the models of an open economy. And its role in the determination of major macroeconomic variables cannot be underestimated. Moreover, the sampling period of the study was categorized into three sub sample periods i.e. 1973-1981, 1982-1999 and 2000-2015. Hence, for the purpose of empirical analysis, real exchange rate has been used against nominal exchange rate. Because the real exchange rate is also fluctuating under the fixed exchange rate system. However, here this change will be caused only by the inflation differential between the domestic and foreign countries.

Literature Review

In the literature a number of studies can be found out on the role of exchange rate in the monetary policy. Taylor (1999b) explained that all the central banks in the market economies show their response to fluctuations in exchange rate. He also mentioned that keeping exchange rate alongwith interest rate in policy format; it makes the monetary policy more effective. Similar conclusions were also derived by Batini et al (2001), Setlhare (2002), Thomas and Schorfheide (2007) and Parsley and Popper (2009).

Similarly, Svensson (2000) described in his research work that real exchange rate brings into focus additional direct and indirect channels to the monetary authorities. Eichengreen (2004) conducted an empirical study for Korea and concluded that exchange rate addition in the monetary policy actions highlighted the additional direct and indirect transformation channels. And with the inclusion of exchange rate the monetary policy of the central bank of Korea became more effective.

Taylor (2001) analyzed the relationship between exchange rate and interest rate under the different monetary policy systems i.e. monetary policy regime of floating exchange rate, rule based monetary policy and inflation targeting monetary policy. The study concluded that exchange rate inclusion helps in the stabilization of interest rate. Dennis (2003) conducted a study for Australian economy also found a support for Taylor (2001) findings and

reached to similar conclusion. However, unlike them, Leitmo and Soderstrom (2005) didn't find any support for their results.

Bask (2006) developed a three version Taylor rule based monetary policy model for testing the role of exchange rate in the monetary policy. The study concluded that if the central banks keep contemporary exchange rate in the monetary policy targets, they showed reaction to it. However, the central banks didn't show any response to lag exchange rate.

Hsing (2009) conducted a study for testing the of central banks of four countries namely Indonesia, Malaysia, Thailand and Philippines to real exchange rate in its Taylor Rule based monetay policy reaction functions. The study used quarterly data over the period 1993Q1 to 2007Q2. It was concluded that the central banks of Phillipines and Thailand showed a negative reactions to movements in current real exchange rate and positve response to lagged real exchange rate fluctuations. Furthermore, it was found out that the central banks of other two countries i.e. Malaysi and Indonesia didnt show any response to both current and lagged real exchange rate. However, it was found out that all the central banks of selected four countries showed positive reaction to inflation and output gap. It was suggested that these countries should follow a modified and extended Taylor rule function for making monetary policy more effective to achieve the settled goals.

Ghatak and Moore (2011) conducted a comparative study of the Taylor rule and McCallum rule functions for selected European Union countries. The study concluded that the inclusion of exchange rate alongwith interest rate is important for making the monetary policy more effective. The study also questioned the reliability of the Taylor rule for these countries.

Lueangwilai (2012) applied a Bayesian Maximum Liklehood estimation model for investigating the monetary policy mechanism of the central bank of a small open economy Thailand under an inflation targeting environment. The time period of the study was from 2000 to 2011. He used various types of monetary policy rules i.e. contemporaneous, backward looking and forward looking. He also included exchange rate as a dominant factor in his model. The study concluded that contemporaneous monetary policy rule reacting to both inflation and exchange rate movements "well characterized the policy rate set by the Bank of Thailand".

Guney (2016) carried out a research work for examining the role of inflation and output uncertainties in the monetary policy framework of the central bank of Turkey by using data over the

period 2002 to 2014. The findings of the study suggested that following a forward looking policy approach the major objectives of the central bank of Turkey were to control inflation and growth fluctuations.

MacDonald & Popiel (2017) estimated the effects of unconventional monetary policy in a small open economy of Canada. They used the data from 1995-2015 and used recently proposed shadow interest rate to take into account unconventional monetary policy at the zero lower bound. The estimated structural autoregressive model for Canada and US monetary policies as a foreign shock and found that during the period of zero lower bound period, Canadian unconventional monetary policy raises output by 0.013% per month on average. On the other hand, US unconventional monetary policy increases Canadian output by 0.127% per month on average. The study found that the usefulness of domestic unconventional monetary policy displays a strong positive spillover effects.

Verstraete and Suchanek (2017) investigated the effects of monetary policy on Canadian firms. Their study demonstrated the consequences of monetary policy on (1) how business perspective are affected by monetary policy (2) business sentiment, as captured by survey data, has sense for monetary policy decision in Canada. The study employed Bank of Canada's quarterly Business Outlook Survey for the period of 2001-2016. The results showed that tight monetary policy with a lag, hinder business activity and price pressure.

Arwatchanakarn (2017) used quarterly data from 1997Q3 to 2014Q4 and found that the monetary policy reaction functions of the central bank of Thailand showed more response to exchange rate. However, he further concluded that interest rate and monetary aggregates played dominant role in the monetary policy transmission mechanism against the exchange rate.

Saadat etal. (2017) evaluated the significance of Taylor rule for the central bank of Iran. They employed a descriptive-analytical research method for the achievement of the objectives of the study. The study concluded that Taylor rule was a highly effective and flexible rule helped in reducing the output gap and controlling inflation in Iran.

Nyumuah (2018) estimated the empirical analysis of monetary policy reaction function for Ghana.The study employed macroeconomic data for the period of 2002-2012. The study opted for dynamic ordinary least squares to estimate the monetary

response function and found that the central bank follow a backward-looking Taylor rule. The study further concluded that the central bank laid less emphasize on policy rule and focused more on past inflation relative to current expected inflation. Furthermore, the study concluded that the Bank of Ghana pursue inflation targeting monetary policy and assigned key role to exchange rate in output stabilization.

Taguchi and Wanasilp (2018) conducted a study for analyzing the monetary policy reaction function of the central bank of Thailand. The policy reaction function illustrated the central bank followed an inflation targeted monetary policy where it also responds to exchange rate fluctuations during the study period. Froyen and Guender (2018) carried out a comparative analysis of different inflation targeting monetary policy functions. The study concluded that "inclusion of the real exchange rate in Taylor rules and, second, it is sufficient to improve the performance of Taylor rules relative to optimal policy. Gains are substantial because a small weight on real exchange rate fluctuations makes optimal policy less aggressive".

3. Empirical Model of the Study

The empirical model of the present study is based on the conceptual framework of Taylor Rule (1993). The general form of the rule is given in equation (1) as below.

$$i_t = \pi_t + r^*_t + a_\pi(\pi-\pi^*) + a_y(y_t-y^*_t) \quad (1)$$

Whereas, ($a_\pi>0$ $a_y>0$)

Equation (1) is called the Taylor Rule function presented by John B. Taylor in 1993. The equation shows a closed economy Taylor rule monetary policy function of the central bank where the monetary authority is using nominal interest rate for targeting inflation and output gaps. In the model i_t refers to nominal interest rate, π_t and π^* are the actual and target inflation rates, r^*_t stands for the equilibrium level of the real interest rate in the long run and y_t are y^*_t are the actual and potential output levels. Whereas, he imposed two constraints on the model i.e. $a_\pi>0$ $a_y>0$ which is called the Taylor principle.

Now because the aim of the present study is to empirically examine the monetary policy reaction function of the State Bank of Pakistan. Hence, for this purpose the Taylor rule has been extended and modified. First for analyzing the State Bank of Pakistan monetary policy reaction function in a closed economy setup the following Taylor rule model has been used.

$i^g{}_t = \gamma_1 + \gamma_\pi \pi^g{}_t + \gamma_y Y^g{}_t + \varepsilon i^g{}_t$ (2)

Constraint ($\gamma_y>0$, $\gamma_\pi>0$, $z = 0$, $q^g{}_t = 0$)

Equation 2 is the modified form of the basic Taylor rule function. Here $i^g{}_t$ is the nominal interest rate gap, $\pi^g{}_t$, is the inflation gap and $Y^g{}_t$ stands for output gap. Where γ_1 is the intercept, γ_π and γ_y are the relevant coefficients and $\varepsilon i^g{}_t$ is the error term. Moreover, different constraints have been imposed on the model. $\gamma_y>0$ and $\gamma_\pi>0$ are the restrictions on coefficients of inflation and output. $q^g{}_t = 0$ means that the real exchange rate is excluded from the model. Z is used as a vector for all other variables in the model and $z = 0$ means that all other variables are also excluded from the model. Here, it is assumed that the State Bank of Pakistan is restricted its focus only on two objectives and does not show any response to other variables.

After that for examining the monetary policy reaction function of the State Bank of Pakistan under the different exchange rate regimes followed by the State Bank of Pakistan some more restrictions have been imposed on the model. For the managed float exchange rate period and floating exchange rate period the model given in equation 2 has been used. However, for a fixed exchange rate period equation 2 has been further modified and few more restrictions have been imposed on it. Equation 3 shows the empirical model of the study for fixed exchange rate period.

$${}^c i^g{}_t = \gamma_2 + \gamma_\pi \pi^g{}_t + \gamma_y Y^g{}_t + \varepsilon i^g{}_t \quad (3)$$

Constraint ($\gamma_y\neq0$, $\gamma_\pi\neq0$, $z = 0$, $q^g{}_t = 0$)

In equation 3 ${}^c i^g{}_t$ shows that a restriction "c" has been imposed on the movement of interest rate. C stands for "constant" and it shows that interest rate will remain constant during the fixed exchange rate period. Moreover, the constraints $\gamma_y \neq 0$, $\gamma_\pi \neq 0$ imposed on the model shows that SBP does not react to movement (i.e. increase or decrease) in the inflation and output gaps.

After that for testing the Taylor rule monetary policy reaction of the SBP in a small open economy framework, the following model given in equation has been used.

$$i^g{}_t = \gamma_3 + \gamma_\pi \pi^g{}_t + \gamma_y Y^g{}_t + \gamma_q q^g{}_t + \varepsilon i^g{}_t \quad (4)$$

Constraint ($\gamma_y>0$, $\gamma_\pi>0$, $z = 0$)

Equation 4 shows an extended form of 2 in two aspects. One more variable $q^g{}_t$ stands for the real exchange rate has been included in the model. Moreover, the restriction $q^g{}_t = 0$ imposed on equation 2 has been relaxed now. Which shows that following an open economy model the SBP is now also shows reaction to exchange rate movements along with other targeted objectives. Furthermore,

testing the open economy Taylor rule reaction function under the managed float and floating exchange rate systems the model presented in equation 4 has been used. However, for testing the Taylor rule under the fixed exchange rate period the following equation given in equation 5 has been used.

$$^{c}i^{g}{}_{t} = \gamma_4 + \gamma_\pi \pi^{g}{}_{t} + \gamma_y y^{g}{}_{t} + \gamma_q q^{g}{}_{t} + \varepsilon i^{g}{}_{t} \quad (5)$$

Constraint ($\gamma_y \neq 0, \gamma_\pi \neq 0, \gamma_q \neq 0 \;\; z = 0$)

The above equation is a calibrated form

Equation 5 shows a modified form of the Taylor rule function under the fixed exchange rate period where the State Bank of Pakistan does not bring any increase or decrease in the nominal exchange rate if there is any change in the inflation, output or real exchange rate. Moreover, the restriction $z = 0$ shows that the monetary policy reaction function is restricted to only these three variables. And all other variables represented by a proxy "z" have been excluded from the model.

Finally for analyzing the monetary policy reaction function of the State Bank of Pakistan a backward[2] looking Taylor rule model has been used which is showing by equation 6 as follows.

$$i^{g}{}_{t} = \gamma_0 + \sum_{t=1}^{j} \gamma_{\pi,j} \pi^{g}{}_{t-j} + \sum_{t=0}^{k} \gamma_{q,k} q^{g}{}_{t-l} + \gamma_y (y^{g}{}_{t}) + \gamma_z (z) + \varepsilon i^{g}{}_{t} \quad (6)$$

Constraint ($\gamma_y > 0, \gamma_\pi > 0$) Here $j = 1, \ldots 2, , k = 0, \ldots 2$

Equation (6)[3] is shows the backward looking model of the study where lagged variables showing by the sigmas have also been included in the model and all the restrictions are relaxed. In the model z has been used as a vector for other variables i.e. trade balance and money supply. The constraint ($\gamma_y > 0, \gamma_\pi > 0$) is still imposed on the model for making sure that the model satisfy the Taylor principle. The main objective here is to test the open

[2]Backward looking models are used by many researchers. Fuhrer (2000) suggested that backward-looking models perform better than forward looking models because of its better explanation of the empirical data. Estrella and Fuhrer (1999) argued that when a shift in regime occurs the backward looking models performs better and remained more stable than the forward-looking models. Charles et al. (2000) suggested that the monetary authority should follow a monetary policy based on backward looking framework when the response of nominal interest rate is optimal to past inflation rates.

[3] The model used in this paper is not a pure backward looking model. It is a calibrated backward looking model where some variables are also included contemporaneously for making this research work different from the previous works which only includes lag values of the variables in their backward looking models.

economy Taylor Rule function of the SBP in a backward looking open economy framework.

4. Results and Discussion

The estimation results has been given in table 1, table 2 and table 3 respectively. In table 1 estimated results for closed economy Taylor Rule model has been given. Here results have been computed both for the full sample period and sub sample periods. Various constraints are imposed on the models i.e. ($\gamma_y>0$, $\gamma_\pi>0$, $z = 0$, $q^g_t = 0$) and ($\gamma_y\neq0$, $\gamma_\pi \neq 0$, $z = 0$, $q^g_t = 0$) and ($\gamma_y>0$, $\gamma_\pi>0$) for estimating the closed economy Taylor Rule model. After that it has been investigated whether State Bank of Pakistan showing response to exchange rate movements in its Taylor rule based monetary policy or not? The restriction on real exchange rate has been relaxed and it is included in the model. The purpose was to extend the closed economy Taylor Rule monetary policy model to an open economy framework where the State Bank of Pakistan responds to real exchange rate. Here, some new constraints have been imposed on the model i.e.($\gamma_y>0$, $\gamma_\pi>0$, $z = 0$) and ($\gamma_y \neq0$, $\gamma_\pi \neq 0$, $z= 0$).

Finally, the results given in the table 3 showed two more improvements in the model. First, lagged variables for both inflation and real exchange rate has been included in the model. And two more variables money supply and trade balance has also been added to the model. The objective behind the inclusion of the lagged variables was to test the State Bank of Pakistan Taylor Rule based monetary policy in a backward looking framework for Pakistan economy. Here the results are only computed for the full sample period which is showing by the constraint i.e. ($\gamma_y>0$, $\gamma_\pi>0$).

Table. 1: Regression Results of Simple Taylor Rule Model

Dependent Variable :i^g_t

Newey-West HAC Standard Errors and Covariance test has been applied[4]

Sample Size/s	**1973-2015**	**1973-1981**	**1982-1999**	**2000-2015**
Independent Variables	Coefficients (Std.Errors) (1)	Coefficients (Std.Errors) (2)	Coefficients (Std.Errors) (3)	Coefficients (Std.Errors) (4)
π^g_t	0.100408* (0.051557)	0.050951 (0.043115)	0.094838 (0.140330)	0.642373** (0.076222)

[4]Newey-West HAC(Heteroskedasticity and Autocorrelation Consistent) is used for getting more reliable results and for overcoming the problems of serial correlation and heteroskedasticity in the residuals.

Y^g_t	0.232530**	0.144606**	0.211821*	0.361946**
	(0.070003)	(0.051461)	(0.104691)	(0.079901)
R Squared Values	0.427	0.637	0.323	0.834
Adjust. R-Squared	0.384	0.514	0.236	0.777
F Statistic	11.902	5.191	3.542	14.673
Probability (F-Stat)	0.000	0.051	0.053	0.0042
Durbin Watson Stat.	1.232	2.011	1.640	1.562

- Asterisks "*****" , "******" , "*******" shows 90%, 95%, and 99% confidence level.
- Intercept turned insignificant hence it is dropped out from all the models.

In table 1 the estimation results for the closed economy Taylor Rule model has been presented. The results of the full sample period showed that both inflation and output gaps showed positive relationship with the interest rate. However, the coefficients values of both the inflation and output are different against what indicated by Taylor. This shows that for a developing economy like Pakistan, a 1% increase in both π^{gt} and Y^g_t put a greater influence on i^g_t. The R-Squared value is 0.42 which showed that 42% variation in the interest rate is explained by the inflation and output. Moreover, the Durbin Watson Statistic value is 1.23 which indicated the serial correlation in the data of the model. These values of both R-Squared and Durbin Watson statistic showed the weak explanatory power of the model and pointed towards the inclusion of additional variables in the model to overcome the model misspecification problem.

Similarly, in column 2, 3 and 4 results for the sub sample periods has been given. The results of the fixed exchange rate period given in column 2 showed inflation remained insignificant and output gap turned significant. Similar results has also been obtained in column 3 i.e. managed float period where again output remained significant and inflation turned insignificant. In contrast, from the floating period results given in column 4 it is clear that both inflation and output showed a positive and significant relationship with the interest rate. This result of the floating exchange rate period is according to expectation showing the reaction of the State Bank of Pakistan in case of deviation of inflation and output from their targets. However, the R-Squared value is only 0.83 and Durbin Watson statistic value is 1.56 which showed the weak

explanatory power of the model and indicating the inclusion of additional variables in the model.

Table.2: Regression Results of Taylor Rule Model with Real Exchange Rate
Dependent Variable :i^g_t
Newey-West HAC Standard Errors and Covariance test has been applied

Sample Size/s	**1973-2015**	**1973-1981**	**1982-1999**	**2000-2015**
Independent Variables	Coefficients (Std.Errors) (1)	Coefficients (Std.Errors) (2)	Coefficients (Std.Errors) (3)	Coefficients (Std.Errors) (4)
π^g_t	0.142579**	0.090586	0.051735	0.621865***
	(0.059423)	(0.091928)	(0.168679)	(0.085465)
y^g_t	0.225575***	0.147402**	0.256488**	0.393833**
	(0.070403)	(0.052642)	(0.097919)	(0.125635)
q^g_t	0.101824*	0.078050	0.103590	-0.097109
	(0.050829)	(0.113785)	(0.062068)	(0.136093)
R Squared Values	0.462	0.655	0.432	0.841
Adjust. R-Squared	0.410	0.433	0.315	0.743
F Statistic	9.402	3.074	3.631	8.694
Probability (F-Stat)	0.000	0.133	0.043	0.015
Durbin Watson Stat.	1.215	2.046	1.484	1.582

- Asterisks "*****" , "******" , "*******" shows 90%, 95%, and 99% confidence level.
- Intercept turned insignificant hence it is dropped out from all the models.

The estimated results given in table 1 showed that State bank of Pakistan didn't restrict its monetary policy to a closed economy Taylor rule. For this purpose an extended version of the Taylor rule has been estimated. The results are given in table 2. Table 2 showed the estimated results of the Taylor Rule function (with real exchange rate) both for the full sample period and sub sample periods. The main objective here was to test the Taylor Rule based reaction function of the State Bank of Pakistan (SBP) after including real exchange rate in it. The full sample period results given in column 1 of table 2 showed all variables inflation, output and real exchange became significant with the expected signs. Moreover, after including the real exchange rate in the model, the coefficients signs of inflation increased both in terms of size and

significance level. These results showed that SBP reacts of real exchange rate in its Taylor Rule based monetary policy. The R-squared value is 0.46 and DW statistic value is 1.21 which shows weak reliability of the results.

Similarly, like table 1 result for all the exchange rate system periods has also been computed. These sub sample periods results showed that inflation remained insignificant in both the fixed sample and managed float periods. However, for the floating period it became significant. Moreover, output gap remained significant for all the sub sample periods. However, real exchange rate remained insignificant for all the sub sample periods.

It is concluded form the above results that State bank of Pakistan is following an extended version of the Taylor Rule based monetary policy where it also reacts to movements in real exchange rate. It is also clear that the SBP monetary policy is constant on different exchange rate regimes.

Table.3: Regression Results of a Backward Looking Taylor Rule based monetary policy reaction function

looking open economy framework

Dependent Variable :i^g_t

Method : Ordinary Least Squares

Newey-West HAC Standard Errors and Covariance test has been applied

Sample Size/s	**1973-2015**	**1973-2015**	**1973-2015**
Independent Variables	Coefficients (Std.Errors) (1)	Coefficients (Std.Errors) (2)	Coefficients (Std.Errors) (3)
π^g_t	0.231054*	0.251154**	0.131664*
	(0.113202)	(0.118047)	(0.066244)
π^g_{t-1}	0.249520*	0.184376**	0.103659*
	(0.082657)	(0.084466)	(0.060486)
π^g_{t-2}	0.113816**	0.091813**	0.135778**
	(0.041047)	(0.031595)	(0.049187)
π^g_{t-3}	0.173636**	0.133803***	…….
		(0.038305)	
	(0.041350)		
y^g_t	0.101093***	0.085940**	0.104000***
		(0.039008)	(0.026322)
	(0.054535)		
q^g_t	0.178207**	0.166111**	0.114960**
		(0.072300)	(0.049152)
	(0.068691)		
q^g_{t-1}	0.117591*	……..	0.108078**

	(0.060293)		(0.042812)
q^g_{t-2}	0.161092**	0.129639**	0.127683***
	(0.047176)	(0.049245)	(0.041925)
i^g_{t-1}	……..	0.242366**	……..
		(0.098244)	
tb^g_t	……..	……..	-7.60E-06***
			(1.49E-06)
m^g_t	……..	……..	0.082478***
			(0.018119)
R Squared Values	0.736	0.766	0.862
Adjust. R-Squared	0.657	0.673	0.815
F Statistic	8.443	8.376	16.690
Probability (F-Stat)	0.000	0.000	0.000
Durbin Watson Stat.	1.330	1.703	2.472

- Asterisks "*****" , "******" , "*******" shows 90%, 95%, and 99% confidence level.
- The results in the table are better results obtained against the previous results which is supported the Wald test.
- Intercept, foreign exchange reserves, US GDP and US interest rate are dropped out from the model after turning insignificant.

The estimation results presented in table 2 indicated that all the variables in the model for the full sample period remained significant with the inclusion of the real exchange rate in the model. However, the values of R-Squared and Durbin Watson statistic showed that additional variables need to be included in the model to overcome the weak explanatory power and missing variables issue in the model. Therefore, two more variables trade balance and money supply has been included in the model. Also lagged values of all the variables are also added in the model. All the results computed are given in table 3. The results showed that all the variables (i.e. contemporaneous and lagged) remained significant in the model given in column 1, column 2 and column 3 respectively. However, lagged value of the interest rate remained insignificant in the final result given in column 3 of the table. Moreover, in column 3 trade balance and money supply remained significant contemporaneously. The coefficient of the trade balance was negative showing that an increase in it will improve the terms of trade and will ultimately brings reduction in the interest rate. Similarly, the positive sign of money supply showed that increase in it will increase interest rate via channel of inflation. Moreover,

the results showed that output gap turned significant at current level and showed expected sign. Inflation remained significant at current level and at lag 1 & 2. Real exchange rate remained significant at current level and lag 1 & 3. The R-Squared value was 0.86 and Durbin Statistic value remained 2.47 showing the overall goodness of the model and absence of serial correlation in the data. F/Wald test also supported these results as shown in table 4 as follows.

Table.4 *Wald/F test for Overall Significance of Regressors*

Independent Variables	F-Statistic
$\pi^g_t, \pi^g_{t-1}, \pi^g_{t-2}, \pi^g_{t-3}, y^g_{t,}, q^g_t, q^g_{t-1}, q^g_{t-2}$	17.33**
$\pi^g_t, \pi^g_{t-1}, \pi^g_{t-2}, \pi^g_{t-3}, y^g_{t,}, q^g_t, q^g_{t-1}, q^g_{t-2}, i^g_{t-1}$	14.60**
$\pi^g_t, \pi^g_{t-1}, \pi^g_{t-2}, y^g_t, q^g_t, q^g_{t-1}, q^g_{t-2}, tb^g_t, m^g_t$	25.04**

- Asterisks "*" , "**" , "***" shows 90%, 95%, and 99% confidence level.

The Wald test has been used to investigate the overall significance of all the models estimated and given in table 3 above. The results are given in table 4. The results showed the robustness of the results and highlighted the overall significance of the models.

Conclusion

The aim of the present study was to empirically examine the monetary policy of the State Bank of Pakistan in both a closed economy and open economy Taylor rule based framework. The basic objective of the study was to investigate whether the State Bank of Pakistan targets only interest rate or it also responds to real exchange rate movements. For estimating the results first Hodric Prescott filter method has been applied for removing the trend from the data and to work only with the cyclical components of the data. After that Ordinary Least Squares method and Wald test has been used. Both a full sample period i.e. 1973 to 2015 and a sub sample periods i.e. 1973-1981, 1982-1999 and 2000-2015 has been conducted. The findings of the study were that the State Bank of Pakistan monetary policy was not confined to closed economy Taylor rule. But its monetary policy framework was based on an open economy Taylor rule where it also reacts to real exchange rate fluctuations alongwith interest rate. Furthermore, the results computed for the different sub periods depicted that that the monetary policy of Pakistan remained constant on the various exchange rate systems followed by the central bank time to time in the country. And "across systems differences" are found out irrespective of the monetary policy mandate of State Bank of Pakistan. These results suggested that the inclusion of the real exchange rate in the Taylor Rule function strengthens the

effectiveness of the monetary policy in targeting output and inflation gaps for the stabilization of the economy.

References

Arwatchanakarn, P. (2017). Structural vector autoregressive analysis of monetary policy in Thailand. *Sociology Study*, *7*(3), 133-145.

Ball, L., (1997). Efficient Rules for Monetary Policy. reserve bank of New Zealand, Wellington *Discussion paper* G97/3.

Bask, M. (2006). Should one augment the Taylor rule with an exchange rate term? *Helsinki Center of Economic Research Discussion Paper No*. 135.

Batini,N., Harrison, R. and Millard, P.S. (2001). Monetary policy rules for an open economy. *bank of England working paper series*, *ISSN*.1368 5562.

Chang, S.H. (2000). Estimating the monetary policy reaction function for Taiwan: a VAR model. *International Journal of Applied Economics 2*(1), 50-61.

Charles T. Carlstrom, T.C. and Fuerst, S.T. (2000). Forward looking versus backward looking Taylor rules. *Working Paper No. 00-09*.

Clarida, R., Gali, J., and Gertler, M. (1998). Monetary policy rules in practice. Some international evidence. *European Economic Review 42*, 1033 1068.

Dennis, R. (2003). Exploring the role of the exchange rate in monetary policy in Australian monetary policy. *Economic Record*, *79*, 20-38.

Eichengreen, B., (2004). Monetary and exchange rate policy in Korea: assessments and policy issues. *CEPR Working Paper Series, No. 4676.*

Estrella, A. and Fuhrer, C. (1999). Are deep parameters stable? The Lucas critique as an empirical testable hypothesis. *Federal Reserve Bank of Boston, Working Papers, No. 99-4*.

Fatima, M. and Malik, W. S. (2015). Choice of functional form in the nonlinear Taylor rule: The case of Pakistan. *Pakistan Economic and Social Review*, *53*(2), 225-250.

Froyen, R. T. and Guender, A. V. (2018). The real exchange rate in Taylor rules: A re-assessment. *Economic Modeling*, *https://doi.org/10.1016/j.econmod.2018.03.011*.

Fuhrer, C. J. (2000). Habit formation in consumption and its implications for monetary policy models. *American Economic Review*, *90*(3).

Gerlac, S., and Smets., F. 1999). Econometric methods for monetary policy: output gaps and monetary policy in the EMU area. *European Economic Review 43*, 801-812.

Ghatak, S. and Moore, T. (2011). Monetary policy rules for transition economies: an empirical analysis. *Review of Development Economics, 15*(4), 714-728.

Hodrick, R. J. and Prescott, E. C. (1981). Postwar US business cycles: an empirical investigation. *NBER Working Paper No. 451*.

Hsing, Y. (2009). Is the monetary policy rule responsive to exchange rate changes? The case of Indonesia, Malaysia, the Philippines, and Thailand. *International Review of Economics, 56*(2): 123–132.

Krugman, P. (1996). Stable prices and fast growth: just say no. *The Economist, August 31, 15-18. http://pages.stern.nyu.edu/~nroubini/NYT/krugeconairu.htm*.

Lueangwilai, K. (2012). Monetary policy rules and exchange rate uncertainty: a structural investigation in Thailand. *Procedia Economics and Finance, 2*, 325 334.

MacDonald, M. and Popiel, M. K. (2017). The Effects of Unconventional Monetary Policy in a Small Open Economy of Canada. *IMF Working Paper No WP/17/268*.

Malik, S. W. (2007). Monetary policy objectives in Pakistan: an empirical investigation. *PIDE Working Papers No. 35.*

Malik S.W. and Ahmed M.A. (2010). The Taylor rule and the macroeconomic performance in Pakistan. *The Pakistan Development Review, 49*(1), 37-56.

Mishkin, S. F. (2000). Inflation targeting in emerging market countries. *American Economic Review, 90*, 105-109.

Nyumuah. (2018). An Empirical analysis of the monetary policy reaction function. *International Journal of Economics and Finance, 10*(3).

Parsley, D. and Popper, H. (2009). Evaluating exchange rate management: an application to Korea. Hong Kong Institute for Monetary Research HKIMR, *Working Paper No. 28*.

Peersman, G. and Smets, F. (1998). The Taylor rule: a useful monetary policy guide for the ECB? *Paper Presented at the Bank of Italy Workshop on Monetary Policy of the ESCB: Strategic and Implementation Issues, 6-7.*

Setlhare, L. (2002). Empirical foundations of monetary policy in Botswana. Unpublished Dissertation, University of Manitoba.

Shambaugh, C. J. (2004). The effects of fixed exchange rates on monetary policy. *Quarterly journal of Economics, 119*(1), 301-352.

Svensson(2000). Open economy inflation targeting. *Journal of International Economics, 50*, 1555-183.

Svensson, E.O.L.(1998). Inflation Targeting as a Monetary Policy Rule. *Paper Presented at the Conference on Monetary Policy Rules in Stockholm, 12-13.*

Taguchi, H. and Wanaslip, M. (2017). Monetary policy rule and its performance under inflation targeting: the evidence of Thailand. *MPRA Paper No. 83544.*

Tahir, N. (2013). 145 Forward-Looking and Backward-Looking Taylor Rules: Evidence from Pakistan. The Lahore Journal of Economics, 18(2).

Taylor, B.J. (1993). Discretion versus Policy Rules in Practice. *Carnegie-Rochester Conference Series on Public Policy. 39*, 195-214.

Taylor, J. B.(1994). The inflation/output variability trade off revisited. Goals, Guidelines, and Constraints Facing Monetary Policymakers, *The Federal Reserve Bank of Boston Conference, Series. 38*, 21-38.

Taylor, J. B. (1999b). The robustness and efficiency of monetary policy rules as guidelines for interest rate setting by the European central. *Journal of Monetary Economics, 43*(3), 655-679.

Taylor, J. B. (2001). The Role of the exchange rate in monetary policy rules. *Policy Implications of Macroeconomic Research, 91*(2).

Thomas, A. L. and Schorfheide, F. S. (2007). Do central banks respond to exchange rate movements. *Journal of Monetary Economics, 54* (4), 1069-1087.

Verstraete, M. and Suchanek, L. (2017). Understanding monetary policy and its effects: evidencefrom Canadian firms using the business outlook survey. *Bank of Canada Staff Working Paper 2017-24.*

Wren, L. S. and Leith C. (2015). Interactions between monetary and fiscal policy rules. *The Economic Journal,110* (462), 93-108.

Zaidi, A. K., & Zaidi, I. (2011). Rethinking the Monetary Policy Framework of the State Bank of Pakistan. *SBP Research Bulletin, 7*(1).

Appendix: A

Data and Variables Description

The present study used time series yearly data over the period 1973 to 2015. In addition for conducting a sub sample analysis based on the various exchange rate systems the study time period has been categorized into three sub periods i.e. 1973-1981, 1982 to 1999 and 2000 to 2015. The division of the sub time periods is based on the fixed, managed float and floating exchange rate systems followed by the State Bank of Pakistan during the study period. Historically, Pakistan adopted a fixed exchange rate regime from 1947 to 7th January 1982, managed from 8th January 1982 and floating exchange rate regime from 19th May 1999 onwards. However, in the present study annual data has been used, hence for the purpose of this study we have used these time periods from 193 to 1981, 1982 to 1999 and 2000 to 2015.

The details are given in table A1 as follows

Table A1: ***Variables Description***

Variables	Definition	Computation	Symbol
Interest Rate	Average annual money call rate	$i^g_t = i_t - i^*_t$ stands for the interest rate gap. It has been computed by taking a subtraction of the actual interest rate (i_t) and targeted interest rate (i^*_t).	i^g_t
Inflation Rate	Average annual percentage change in consumer price index	$\pi^g_t = \pi_t - \pi^*_t$ shows the inflation gap. It is computed by taking a difference of the actual inflation rate(π_t) and targeted inflation rate(π^*_t)	π^g_t
Gross Domestic Product	Gross Domestic Product in million of Pakistani rupees	$y^g_t = y_t - y^*_t$ is output gap which is the difference between actual GDP(y_t) and potential GDP(y^*_t). Before the application of HP filter log real GDP has been computed after converting nominal GDP in real form by using 1976 as a base period and multiplied it with 100.	y^g_t,
Exchange Rate	Nominal Exchange Rate of Pakistan rupee vs USA dollar	$q^g_t = q_t - q^*t$ shows the real exchange rate which is the difference between the actual and targeted exchange rate. First nominal exchange rate has been converted into real exchange rate form	q^g_t

		by defining real exchange rate as nominal exchange rate of Pak Rupee vs US dollar. And it is multiplied with the ratio of the foreign to domestic price level (RER = q(CPI^{usa} / CPI^{pak}). For converting RER into growth terms log of it has been taken.	
Money Supply Growth Rate	Money supply of Pakistan in million of rupees	$m^g_t = m_t - m_t^*$ is domestic money supply gap which is the deviation of actual(m_t) and targeted(m_t^*) money supply growth rates.	m^g_t
Trade Balance	Exports minus Imports of Pakistan in million of rupees	$tb^g = tb_t - tb^*_t$ = is trade balance gap which is computed by taking the difference between actual(tb_t) and targeted(tb^*_t) trade balance. For computation trade balance is converted into real form.	tb^g
Consumer Price Index of Pakistan	----------	----------	CPI^{pk}
Consumer Price Index of USA	----------	----------	CPI^{usa}

Data Sources: Economic Survey of Pakistan Various Issues, State Bank of Pakistan and International Financial Statistics.

Eviews Software has been used for analysis of the data.