Pakistan Economic and Social Review
Volume 55, No. 1 (Summer 2017), pp. 119-157

ESTIMATING MONETARY POLICY REACTION FUNCTION OF STATE BANK OF PAKISTAN

GHULAM SAGHIR AND WASEEM SHAHID MALIK*

Abstract. A near consensus in the contemporary monetary economics is that monetary policy can achieve its objectives more precisely if it is designed as a rule rather than discretion. The objective of this paper is to estimate monetary policy reaction function. For this purpose, Taylor type rules and McCallum rules are estimated using quarterly data of Pakistan economy over the period 1993 Q3 to 2013 Q2. Both types of rules have been modified by incorporating exchange rate management and interest rate smoothing as policy objectives. Moreover, we have found recursive estimates of the parameters to sort out policy inconsistency. We have also looked into the issue of nonlinearity of the monetary policy reaction function with regards to output gap and inflation rate assuming asymmetric preferences of monetary authority. We find that monetary authority in Pakistan does not follow Taylor rule as coefficient of output gap is negative and statistically insignificant and the coefficient of inflation rate, though statistically significant, is far below the benchmark value suggested by Taylor (1993). State Bank of Pakistan (SBP) is found to involve in exchange rate management and interest rate smoothing and this result is robust to different modifications in the Taylor rule. The parameters of output gap, inflation rate and differenced exchange rate, in the reaction function, are not stable over time and vary over the business cycle and across different inflationary regimes. The variation in the

*The authors are respectively Assistant Professor at Business School, University of Central Punjab, Lahore-Pakistan and Assistant Professor at School of Economics, Quaid-i-Azam University, Islamabad-Pakistan.
Corresponding author e-mail: ghulam.saghir@ucp.edu.pk

coefficient of output gap is found countercyclical while the coefficient of inflation rate follows the same pattern with respect to inflationary regimes. Coefficients of exchange rate and lagged interest rate remain almost stable. The threshold value of output gap is found 2.5% below which the response of interest rate to output gap fluctuations is positive but above which the response is insignificant. The threshold rate of inflation is found at 6% and coefficient of output gap is found positive only in high inflationary regime while the coefficients of inflation rate and exchange rate are significant only in low inflationary regime. Monetary authority responds to currency depreciation more strongly when interest rate is low compared to that when it is high. Moreover, the response of interest rate to output gap is significant only if currency depreciation is below threshold (estimated at 0.68) while response to exchange rate is significant only if there is high speed of depreciation (above threshold). The results are robust to inclusion of fiscal deficit in the Taylor rule. In Pakistan, fiscal deficit negatively affects interest rate which is because of the borrowing of government from State Bank of Pakistan (SBP) for budgetary support. In a modified version of the Taylor rule, interest rate is found to negatively respond to changes in growth rate of real GDP. Growth rate of monetary base negatively depends on the difference between nominal GDP growth rate and its average value indicating countercyclical response at the part of monetary authority. Moreover, growth rate of money exhibits strong inertia and is negatively related to currency depreciation. The coefficients in the McCallum rule too are not stable during the sample period. The coefficients of growth rate of nominal GDP and exchange rate are not stable over time, while the parameter capturing inertia is stable over the sample period. The response of monetary growth rate to nominal GDP growth rate and to exchange rate are significant only when nominal GDP is above its threshold value and/or when currency depreciates at higher rate.

Keywords: Nonlinear Taylor Rule, McCallum Rule, Threshold Inflation Rate, State Bank of Pakistan

JEL classification: E52, E58

I. INTRODUCTION

The prime objective of monetary policy is to stabilize some aggregate measure of prices along with stabilizing real economic activity and financial sector. Optimal monetary policy rules can help to achieve these objectives. The term optimal monetary policy is used in the conventional meaning of successfully stabilizing inflation around a low average level and with some concern for real stabilization in terms of stable economic activity.

In formulating monetary policy rule an important issue is the choice of appropriate variables to target. The vector of choice variables may include measures of real activity, prices, and relative price of the currency. The output gap may be taken as a measure of real activity but at the same time real GDP growth rate is an alternative choice. It should be noted however that maintaining a high growth rate in the long run is not possible through continuous lose monetary policy. For the prime objective of price stability, different aggregate measures of prices like CPI, WPI, GDP deflator, and weighted average of prices of commodities in core basket, can be a target. However, the most of the central banks in the world use inflation rate, rather than the price level, as a policy target. Similarly, for relative price of a currency, nominal spot exchange rate, nominal effective exchange rate or real effective exchange rate can be used. Furthermore, the choice of variables to be included in the rule also depends on whether or not the policy maker is forward-looking. In case of forward-looking policy, only future forecasts of the target variables appear on right hand side of the rule. But with backward-looking behavior, only lagged values are included.

Another issue in this regard is functional form of the reaction function. In one setting, just like Taylor (1993), monetary policy instrument can be formulated as linear function of the target variables. But at the same time this would be inappropriate if there are regime shifts in the history of monetary policy, (see for instance Leeper 2005)1. The choice of monetary policy instrument is yet another issue to be addressed. Besides the academic discussion regarding price level indeterminacy in

[1] For details on regime shifts see Hamilton (1989)

New Classical literature, most of the countries in the world are now using short term interest rate as operational target2.

For the case of Pakistan, there is good number of studies available on money-inflation relationship but the number is limited in case of rule based monetary policy. Qayyum (2006) identifies significant role of money in explaining inflation variability. Chaudhary and Choudhary (2006) find that inflation is imported rather than monetary phenomenon. Khan and Schimmelpfennig (2006) find inflation as monetary phenomenon in the long run but government support prices play significant role in the short run. Omer and Saqib (2009) conclude that Quantity Theory of Money does not hold in Pakistan as velocity is not constant. Agha et al (2005) find that interest rate channel along with credit channel and asset price channel are active in Pakistan, while Khan and Qayyum (2007) find that exchange rate channel and supply side shocks, compared to demand side shocks, play more important role. For the rule based policy, to our knowledge, there are only two studies that, based on simulation analysis, suggest adoption of rule, (for details see Malik and Ahmad 2010, and Tariq 2010)3. However, both the studies take interest rate as monetary policy instrument and assume backward looking behavior of monetary policy. Moreover, the output gap and the inflation rate are taken as target variables. Malik (2007) identifies, however, five objectives - output stabilization, price stability, exchange rate management, interest rate smoothing, and minimizing trade deficit - of monetary policy in Pakistan. However, it is only positive analysis and normative analysis needs further investigation.

In Pakistan the Taylor rule has been estimated by Malik and Ahmed (2010) and Tariq (2010) but a reaction function with monetary base as policy instrument, like the McCallum rule, has not been estimated. Moreover, both the studies do not deal with the issue of policy consistency despite the fact that policy reversal has been observed most of the times in the history of Pakistan. Another area where empirical

---

[2] For discussion on price level indeterminacy see Sargent and Wallace (1975)

[3] There are, however, studies available that discuss the issue of inflation targeting in Pakistan. For details see Moinuddin (2009), Khalid (2006), Felipe (2009), Sinclair (2009), Akbari and Rankaduwas (2006), Bokil and Schimmelpfennig (2005), among others

literature, with regards to Pakistan economy, lacks is the nonlinearity of rules. There is only one study, Ahmed and Malik (2011) that highlight nonlinear aspect of monetary policy reaction function of Pakistan. However, even that study does not investigate the optimality of nonlinear Taylor rule. The underlying study contributes to the empirical literature of Pakistan by filling this literature gap and setting objectives accordingly.

In this context, the objective of the study is regarding positive analysis of monetary policy in Pakistan. More specifically, the objective is to estimate monetary policy reaction function with regard to Pakistan's economy. Keeping in view the existing literature with reference to Pakistan's economy, the focus is more on nonlinear specification along with focusing on different target variables and policy instruments. More specifically, we considered alternative measures of target variables, like the output gap, the GDP growth rate, the inflation rate, the lagged interest rate, and the exchange rate. This has been done for both monetary policy instruments - interest rate and monetary base - and two types of functional forms - linear and non-linear. Policy consistency, through parameters stability in the reaction function, is also investigated.

For achieving these objectives, we have estimated various types of monetary policy reaction functions for Pakistan by using quarterly data over the period 1993Q3 to 2012 Q2. For policy consistency, recursive estimates of the parameters in the reaction function are found.

The study finds that State Bank of Pakistan has not been following the Taylor rule and Taylor principle is not satisfied. There is strong inertia found in the monetary policy instrument and exchange rate significantly explains changes in interest rate. Policy, throughout the sample period, has not been consistent as parameters in the policy reaction function are found to be unstable. Nonlinearity has been observed in the reaction function, over the business cycle[4], with respect to coefficients of the inflation rate and the exchange rate. The threshold for the output gap is found to be 2.5% and policy behavior is found to be

[4] Output gap is used as a measure of business cycle in Pakistan as no formal data is available. Positive values of output gap indicate boom while negative values indicate recession in the economy.

different, with respect to this threshold, regarding the output gap and the exchange rate. Similarly, the threshold rate of inflation is found to be about 6%5 and policy behavior changes at this threshold with respect to the output gap, the inflation rate, and the exchange rate. Moreover, the results of McCallum rule are according to theory and are in conformity with the results of Taylor rule, to the extent that exchange rate management is significant determinant of policy instrument and strong inertia is also found in it. The McCallum rule also exhibits nonlinearity with respect to GDP growth rate and exchange rate. Finally, regarding normative analysis, it has been found that Taylor (1993) rule can significantly perform well in an estimated model for Pakistan economy and nonlinearity in the reaction function does not improve the performance of the rule.

Rest of the study proceeds as follows. In the first step linear Taylor-type rules are estimated with four specifications, results of which are given in section 2. Then Taylor rule is extended in two directions: one with the lagged values of all independent variables and in the second, forward-looking Taylor rule is estimated. Results of these two extended rules are explained in section 3. The Taylor Rule is also estimated with a modification that stabilization of real GDP growth rate, instead of the output gap, is assumed an objective of monetary policy. Results of this modified Taylor rule are explained in section 4. Being a developing country, most of the time, policy reversal is observed in Pakistan. Hence section 5 deals with the parameters stability of the Taylor rules. To investigate, whether or not the monetary authority in Pakistan exhibits opportunistic behavior, non-linear Taylor rules are also estimated and results are given in section 6. Another objective of this section is to explore whether there exist threshold values for target variables beyond which monetary authority alters its behavior. The next three sections present results of McCallum rules: section 7 deals with the linear McCallum rules; section 8 present results of parameter stability in the McCallum rule; results of nonlinear McCallum rule are elaborated in

[5] The threshold inflation rate is lower than the average inflation rate (8.68%) during the sample period. The lower value of threshold is found because of the low inflation rates during 1998 to 2003 when economy was in recession. Moreover, it is the rate at which policy maker changes its behavior keeping in view the current values of output gap, exchange rate, lagged interest rate etc.

section 9 and finally concluding remarks and policy recommendations are given in section 10.

II. LINEAR TAYLOR RULES

In line with the first objective of the study, in the first step, four specifications of linear Taylor rule are estimated. As benchmark, the first specification is the standard Taylor rule in which the short term interest rate responds to deviations of actual output from potential level and that of inflation from the target.

Results in the second column of Table 1 (Rule 1) show that monetary authority in Pakistan does not follow Taylor rule. The coefficient of the output gap is negative and statistically insignificant. Moreover, the coefficient of the inflation rate, though statistically significant, is far below the benchmark value (1.5, in Taylor 1993)6 and even does not satisfy the Taylor principle (the coefficient is greater than 1). Adjusted R-square is quite low which show the presence of objectives of monetary policy in Pakistan other than output and price stability. As the variables are non-stationary at level, therefore, there is a risk of getting spurious results. However, if the variables are cointegrated then OLS estimates are super consistent (Enders 2009). The ADF (Augmented Dickey Fuller) statistics along with the probability value at the bottom of the column show that the variables are cointegrated and thus results of the model are not unreliable because of non-stationarity of the data.

Durbin-Watson is too low which might be an indication of the presence of autocorrelation. However, autocorrelation is not the only cause of low value of Durbin-Watson; there might be the problem of misspecified dynamics in the model. More specifically Sargan suggested testing the misspecified dynamics if Durbin-Watson is low and recommended modeling of autocorrelated errors only if dynamics of the model are properly specified (Thursby 1981). Therefore, we have used Likelihood ratio test to investigate whether the low Durbin-Watson value is because of autocorrelated errors or it is because of missing variables from the equation.

---

[6] In some studies this benchmark value is taken as 0.5 (Adema, 2003). According to our formulation this value is taken as 1.5.

Under the null hypothesis that errors of the Taylor rule equation are autocorrelated, we find the value of likelihood ratio as 12.46 which is significant at 1%. Hence, we reject the null hypothesis of autocorrelated errors in favor of the alternate hypothesis that the Taylor rule equation is not properly specified for the case of Pakistan and there are missing dynamics from the equation that cause low value of Durbin-Watson indicating that the interest rate smoothing might be one of the objectives of monetary policy in Pakistan.

TABLE 1

Results of Linear Taylor Rules

	Rule 1	**Rule 2**	**Rule 3**
Constant	6.58	7.35	0.57
	(0.00)	(0.00)	(0.16)
Y	-0.03	0.12	0.12
	(0.86)	(0.54)	(0.03)
Inf	0.39	0.21	0.03
	(0.00)	(0.09)	(0.39)
i(-1)			0.89
			(0.00)
d(er(-1))		0.78	0.29
		(0.02)	(0.00)
Adjusted R-square	0.19	0.24	0.93
DW Statistic	0.12	0.20	1.57
LM Statistic	60.99	54.46	5.87
	(0.00	(0.00)	(0.21)
LR Stats	12.46		
	(0.00)		
ADF of resids	-2.06	-1.92	-6.48
	(0.04)	(0.05)	(0.00)

* y denotes output gap, inf denotes inflation rate i(-1) is lagged interest rate, and d(er(-1)) is the lagged differenced exchange rate. Probability values are given in parentheses.

In the next step we have estimated modified versions of the standard Taylor rule so that the correct form of the monetary policy reaction function can be specified and other objectives of monetary policy can be

sorted out. In this regard, the Taylor rule is augmented with the lagged difference of exchange rate7. Results in the third column of Table 1 (Rule 2) show that, in Pakistan, exchange rate stabilization is preferred over inflation and output gap stabilization. Coefficient of lagged differenced exchange rate is positive and statistically significant indicating that the local currency depreciation in current period leads to tightening of monetary policy in the future periods. Interestingly, the coefficient of output gap turned to positive when lagged differenced exchange rate is added in the Taylor rule. Significance of the coefficient of differenced exchange rate in Taylor rule indicates that the previous version of the rule (Rule 1) was misspecified. So that version was subject to the omitted variable bias and the estimate of the coefficient of output gap was downward biased as the correlation coefficient between lagged differenced exchange rate and output gap is negative. However, the change of sign is not so critical, as output gap remains insignificant before and after inclusion of exchange rate in the model.

Adjusted R-square is somewhat higher compared to that in the standard Taylor rule specification but still it is quite low. Moreover, inclusion of exchange rate did not improve the value of Durbin-Watson statistic indicating incomplete dynamics of the model and pointing to motive of interest rate smoothing at the part of State Bank of Pakistan. The ADF statistics of residuals show that the variables of the model are cointegrated.

Finally, both the lagged differenced exchange rate and lagged interest rate are incorporated in the Taylor rule: results are given in the last column of table 1 (Rule 3). This specification gives reasonably different results compared to those of the previous two specifications. The coefficient of lagged interest rate is quite high (0.89) indicating significant inertia in the monetary policy operating instrument. The coefficient of exchange rate is still positive and statistically significant but is lower than its value in the previous specification. This indicates that lagged values of the exchange rate and the interest rate are positively correlated. However, the long run coefficient is 2.64. Moreover, the coefficient of output gap in this case is positive and statistically

[7] Exchange rate is defined as the Pak-Rupees price of one US dollar.

significant and its long run value is quite high8. The coefficient of inflation rate is close to zero and is statistically insignificant. This coefficient, before inclusion of lagged interest rate, was statistically significant but it turned out insignificant when we included lagged interest rate as one of the regressors. Actually, changes in interest rate, driven by monetary policy, transmit into output and inflation rate after a time lag. So lagged (current) interest rate is associated with the current (future) inflation rate. Therefore, inclusion of lagged interest rate made the coefficient of inflation rate insignificant. Moreover, the coefficients of equation without lagged interest rate are interpreted as long run coefficients while those of the dynamic model are related to short run. The long run coefficient of inflation rate is significant but that for short run is insignificant. So, it can be concluded that inflation rate and interest rate, in Pakistan, are associated in the long run but they are not related to each other at quarterly frequency and coefficient of inflation rate in the equation of interest rate is insignificant once the effect of last quarter's interest rate is controlled.

The adjusted R-square has improved considerably and it shows that most of the variation in the interest rate is determined by its own history. The ADF statistics of residuals show that the variables of the model are cointegrated. The value of Durbin-Watson has also improved a lot. As the model now contains lagged dependent variable as one of the regressors, Durbin-Watson test cannot be used for autocorrelation. Therefore, we have used Lagrange Multiplier (LM) test for detection of autocorrelation in the error term. The LM stats is quite low with high (greater than 10%) probability value indicating that autocorrelation is removed after incorporating lagged interest rate in the model. This version of the Taylor rule portrays the policy behavior of SBP much better.

It can be concluded from the results of this section that, in Pakistan, the interest rate smoothing and the exchange rate stability get priority over the output gap and price stability. Interest rate is predominantly dependent on its own lagged values and the three target variables (output gap, inflation rate, and exchange rate) explain little variation in the

---

[8] The coefficient of output gap is 0.12 in the dynamic model (with lagged interest rate as regressor). With value of coefficient of lagged interest rate 0.89, the long run value of coefficient of output gap is 1.09.

interest rate. It is worth mentioning that Taylor principle is satisfied in none of the specifications.

III. MODIFIED TAYLOR RULES

MODIFICATION WITH RESPECT TO TYPE OF DATA USED

At the time of deciding on monetary policy instrument data that is required for Taylor rule is actually not available to policy makers. More specifically, the data on output and inflation rate are available only at the end of the period but monetary policy decision is taken at the start of the period and revised most of the times during the period9. So Taylor rule is modified by incorporating fourth lagged values of the output gap and inflation rate instead of contemporaneous values. Results of this specification (Table 2) are in conformity with those found in the previous section. Lagged interest rate has coefficient which is close to one and the exchange rate and the output gap have positive and statistically significant coefficients along with insignificant coefficient of inflation rate. Adjusted R-square is considerably high and LM stats indicate no autocorrelation up to the fourth lag. ADF statistics indicate that the variables of the model are cointegrated and results of the regression are not spurious.

TABLE 2

Results of Modified Linear Taylor Rule

	Backward Looking	Forward Looking
Constant	1.26	-0.19
	(0.00)	(0.39)
Y	0.19	0.15
	(0.00)	(0.00)
Inf	0.02	0.06
	(0.55)	(0.02)

[9] Data on GDP is available at the end of each year and inflation rate is published on monthly basis. Target for M2 is set at the start of each fiscal year and currently Monetary Policy Committee decides on discount rate after every two months. Moreover data on GDP is revised after one year and final data is published after two years.

	Backward Looking	Forward Looking
i(-1)	0.82	0.92
	(0.00)	(0.00)
d(er(-1))	0.32	0.36
	(0.00)	(0.00)
Adjusted R-square	0.94	0.93
DW Statistic	1.55	1.41
LM stats	5.63	
	(0.23)	
ADF of resids	-6.59	-4.99
	(0.00)	(0.00)

For backward-looking rule, y is lagged output gap, inf is lagged inflation rate. For forward-looking rule, y and inf are, respectively, future expected values of output gap and inflation rate. Probability values are given in parentheses. LM stands for Lagrange Multiplier

Another issue in formulating monetary policy is the transmission lags: monetary policy decisions that are taken today can affect the economy only after certain time period. In this context monetary policy should be forward-looking. Instead of reacting to current values of the output gap and the inflation rate, the central bankers design monetary policy keeping in view the future forecast of these variables. To investigate this issue in Pakistan we have estimated Taylor rule by incorporating future expected values of inflation and output gap and estimated the model through Generalized Method of Moments (GMM). Results in table 2 indicate that all the variables in the rule are statistically significant and have theoretically right sign. Interestingly, the coefficient of inflation rate turned significant in this forward-looking Taylor rule. This result coupled with the one found for backward looking model indicates that SBP is backward looking for the case of output and is forward looking in case of inflation rate. SBP regularly publish inflation forecast at quarterly frequency. The forecast of output is not available and is difficult to forecast. Therefore, it is feasible for SBP to take policy decisions on the basis of future forecast of inflation rate but for the case of output it can at best be reactionary. Indeed, reacting to future forecasted changes in inflation rate is desirable because transmission of monetary policy involves time lags. The magnitude of this coefficient is still low compared to the value of this coefficient that is required by the satisfaction of Taylor principle. The magnitude of the coefficient of

inflation is 0.06, which after adjustment is 0.75 for the long run (less than 1).

Results of this section confirm those of the last section that Taylor rule is not followed by the State Bank of Pakistan and Taylor principle is satisfied in none of the specifications.

LINEAR TAYLOR RULE WITH REAL GDP GROWTH RATE AS TARGET VARIABLE

Results obtained so far show that Taylor rule does not fit the Pakistani data well and interest rate smoothing and exchange rate stability are preferred, in policy choices, to inflation and output stabilization and Taylor principle is violated in almost all of the specifications of linear and nonlinear Taylor rules. Therefore, to further investigate the monetary policy reaction function we have modified the Taylor rule in such a way that real GDP growth rate, instead of the output gap, is taken as target variable. Again three specifications of this modified rule are estimated; results are given in Table 3.

TABLE 3

Results of Taylor Rule with GDP Growth

	Rule 1	**Rule 2**	**Rule 3**
Constant	9.72	9.69	0.28
	(0.00)	(0.00)	(0.63)
Y	-0.57	-0.53	-0.01
	(0.00)	(0.00)	(0.86)
Inf	0.32	0.24	0.08
	(0.00)	(0.01)	(0.01)
i(-1)			0.89
			(0.00)
d(er(-1))		0.50	0.21
		(0.09)	(0.03)
Adjusted R-square	0.34	0.36	0.93

	Rule 1	**Rule 2**	**Rule 3**
DW Statistic	0.41	0.42	1.44
LM stats	49.45	46.64	6.86
	(0.00)	(0.00)	(0.14)
ADF of resids	-2.77	-2.83	-6.09
	(0.00)	(0.00)	(0.00)

* y denotes real GDP growth rate, inf denotes inflation rate i(-1) is lagged interest rate, and d(er(-1)) is the lagged differenced exchange rate.

In the first specification, the interest rate is regressed on real GDP growth rate and the inflation rate. Results in the second column of table 3 (Rule 1) show that monetary authority adopts pro-cyclical policy: the coefficient of GDP growth rate is negative indicating that higher growth rate leads to easing of monetary policy. This result seems consistent with the historical facts. In the aftermath of September 11, 2001 foreign exchange inflow made expansion in the stock of money which put downward pressure on the interest rate. SBP did not try to reverse the situation and kept monetary policy in expansionary mode as at that time economy was recovering from recession that started in late 1990s. However, after 2007 inflation reached above 20 % per year and real GDP growth rate was just positive. SBP was in dilemma of controlling inflation vs. expansion of business activity. Therefore, it did not lower interest rate despite the fact that real GDP growth rate was almost zero.

The coefficient of the inflation rate is positive and statistically significant but it is still far below 1 (requirement of Taylor Principle to be satisfied); the benchmark value for the satisfaction of Taylor principle. Moreover, the adjusted R-square and Durbin-Watson statistics are quite low indicating that there are target variables other than GDP growth rate and inflation rate that are part of monetary policy reaction function in Pakistan. Therefore, we extended this linear and modified Taylor rule in two ways; the reaction function is first augmented by lagged differenced exchange rate and then by lagged interest rate.

The third column of Table 3 show that results regarding the coefficients of GDP growth rate and the inflation rate are robust and do not change after incorporating exchange rate as an extra target variable.

Improvement in adjusted R-square and Durbin-Watson statistics is negligible. The coefficient of exchange rate is positive but it is significant only at 10% level of significance. This result confirms the results of all the specifications we have estimated so far that exchange rate stabilization is one of the objectives of monetary policy in Pakistan. In the last specification, the interest rate is regressed on the inflation rate, the exchange rate, the GDP growth rate, and the lagged interest rate. Results in the last column of Table 3 show that once lagged interest rate is included as one of the regressors, coefficient of GDP growth rate does not remain significant. Changes in interest rate, driven by monetary policy, transmit into output and inflation rate after a time lag. So, changes in interest rate provide incentive for private investors to change their investment decision, thereby affecting the future GDP growth rate. Therefore, inclusion of lagged interest rate made the coefficient of GDP growth rate insignificant10. The coefficient of lagged interest rate is 0.89 and adjusted R-square is 0.93. Again it is found that interest rate in Pakistan is predominantly determined by its own past values which indicates motive of interest rate smoothing at the part of SBP. Moreover, Durbin-Watson stats improved and the LM stats show that there is no autocorrelation up to fourth lag in the final version of the rule.

IV. (IN)STABILITY OF PARAMETERS IN THE TAYLOR RULES

In Pakistan many times policy reversal has been observed which was either due to change of the government or because economy was subject to external shocks. For instance, at the end of 1990s, tight monetary policy was in place but after September 11, 2001 due to inflow of foreign exchange monetary policy went into expansionary mode. That expansionary stance was not because of the recession in the economy at that time; rather it was because of foreign exchange inflow and resultant increase in money supply. In this context stability of the parameters in estimated Taylor rule has been investigated. For this purpose, Rule 3 from section 2 has been selected in which interest rate responds to the

[10] It is noteworthy that the regression results of the last (generalized) specification are not subject to the problem of multicollinearity. Rather, the results of the first and second models (rule 1 and 2) are subject to omitted variable bias.

output gap, the inflation rate, lagged differenced exchange rate and lagged interest rate. Recursive estimates of that specification have been found by estimating the rule in first sub-sample, 1993Q3 to 1997Q4, and then extending the sample by including one extra observation each time. The parameters' estimates, so found, are then plotted in Figure 1 to find the evidence of policy reversal.

Pakistan Economy was in expansionary phase during 2003 through 2007. During this period the coefficient of the output gap remained negative and it starts increasing in 2008 when contraction of the business activity started. The coefficient of output gap is thus found moving counter cyclically around its long run average value. The coefficient of inflation moves on a path that is mirror image of the path of the coefficient of output gap. During the expansionary phase of the economy, the coefficient of inflation was above its average value while during contractionary phase it was below average. However, it is worth noting that during contraction that started in 2008, inflation rate was high – a period of stagflation. In that period, the coefficient of inflation rate was quite low. This was due to the fact that inflation rate, in that period, touched local maxima but SBP did not increase interest rate due to stagflation in the economy and real interest rate became negative. The coefficient of lagged interest rate remained around 0.85 and no clear pattern has been observed except that the inertia effect was high in high inflationary regime of 2008 to 2010.

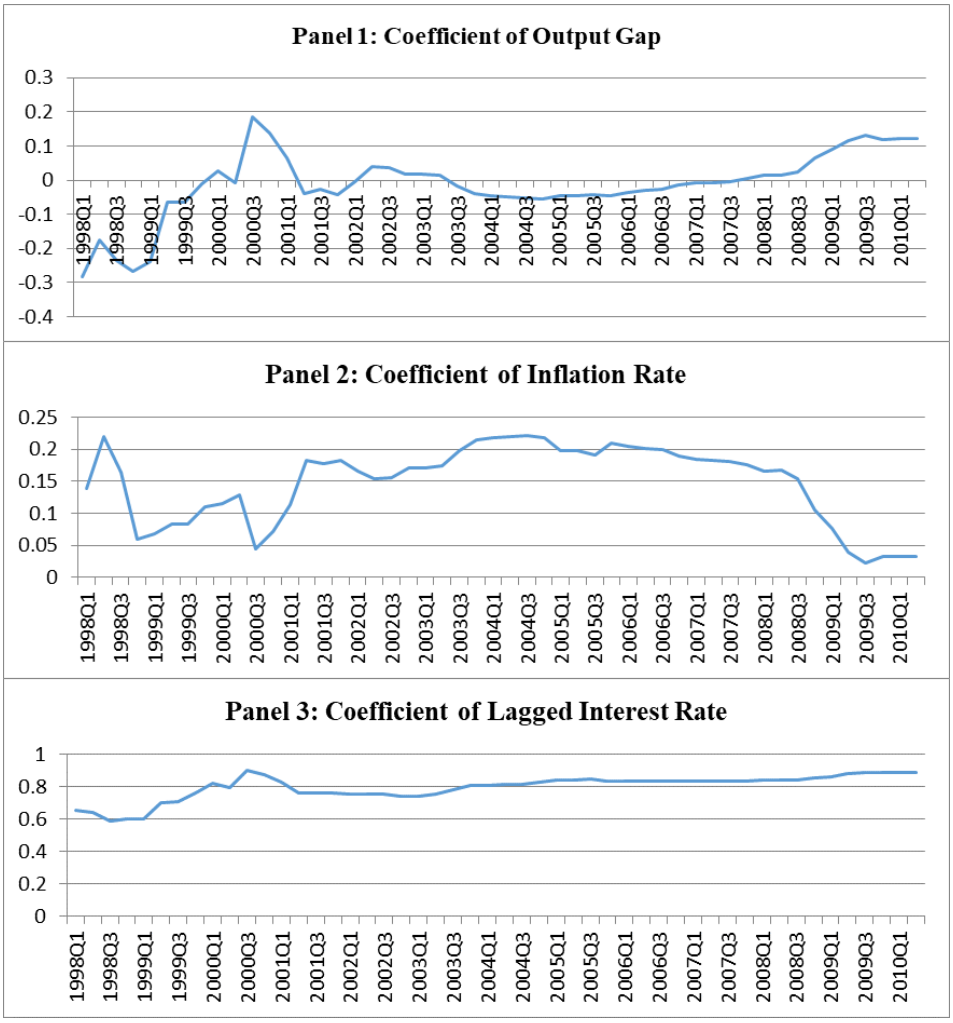
The coefficient of exchange rate was stable and high during the expansionary phase of the economy and low and somewhat volatile during the contractionary phase. Moreover, this coefficient was low when exchange rate depreciation was high and the coefficient was high in the period when exchange rate depreciation was low. Again after 2008, the coefficient of differenced exchange rate started decreasing; currency depreciated at a very fast pace but SBP did not raise interest rate to that extent because of the fear of slowing down the economic activity.

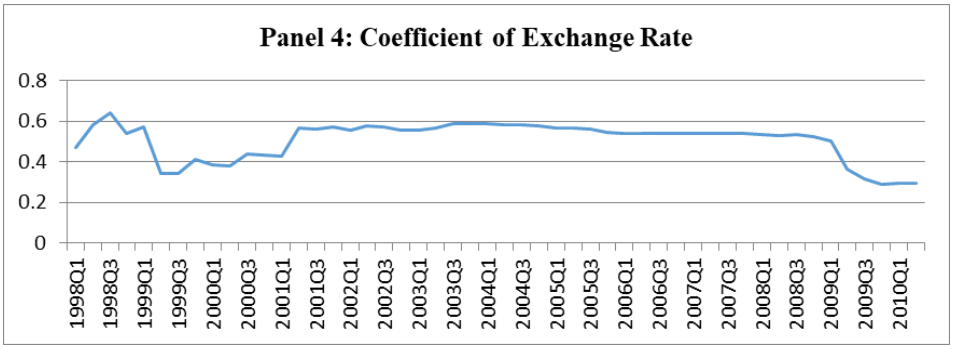
These findings highlight that the coefficients of output gap, inflation rate and exchange rate did not remain stable during the sample period and fluctuation of the coefficients depend on business activity, inflationary regime and the high or low values of the exchange rate depreciation.

These results motivated us to investigate the non-linear Taylor rule for Pakistan.

Figure 1

Recursive Estimates of Parameters in the Taylor Rule





V. NONLINEAR TAYLOR RULES

Policy makers may respond to state of the economy in a nonlinear way. More specifically, the coefficients of the target variables in one regime may differ from those in other regimes. For instance, policy makers' preferences may differ in boom and recession or in high and low inflationary regimes. We have used threshold regression for estimating nonlinear policy reaction function. Threshold values of output gap, inflation rate, exchange rate, and interest rate are estimated and then policy behavior above and below the threshold values of these variables are estimated. In all nonlinear specifications of the Taylor rule, Durbin-Watson statistic is low and LM test indicate the presence of autocorrelation which is not removed even if we include 5 lags of the dependent variable. So, for this section, instead of losing so many degrees of freedom by incorporating too many lags, we used the Newey-West standard errors. The problem of autocorrelation may cause biasness in the estimates of standard errors of the coefficients, which makes the results unreliable. The use of corrected standard errors for autocorrelation and heteroscedasticity can solve the problem of reliability of results.

NONLINEARITY WITH RESPECT TO ECONOMIC ACTIVITY

A dummy variable with values 1 for boom (positive output gap) and 0 for recession (negative output gap) is constructed and then assuming zero value of the output gap as threshold, four specifications of Taylor rule are estimated, the results of which are given in table 4. In each of the specifications one of the target variables is multiplied with dummy variable so that policy behavior regarding that variable can be estimated in boom and recessionary regimes. It is interesting to note that in all of

the four specifications adjusted R-square is above 0.9, Durbin-Watson statistic is above 1.57, the coefficient of lagged interest rate is about 0.9 and the coefficient of lagged differenced exchange rate is about 0.3. Hence the result that there is strong inertia in the interest rate and interest rate positively respond to currency depreciation is found robust. In the Rule 1 it is found that policy response regarding business activity is same in boom and recession as the coefficient of output gap is statistically insignificant in both states of the economy. Results of Rule 2 show that the interest rate positively responds to the inflation rate only in boom. But this response is weak as the null hypothesis that this coefficient is zero can be rejected only with 90% confidence. Moreover, Taylor principle is still not satisfied as the value of response coefficient of inflation is less than 1. The hypothesis that response coefficient of inflation is same in two states of the economy can only be rejected with 90% confidence. Results of Rule 3 show that the extent of interest rate smoothing does not vary over the business cycle. Finally, the results in last column of table 4 show that response coefficient of exchange rate is higher in boom than that in recession. However, this difference is not statistically significant. Overall it can be concluded that policy behavior is not altered if we consider zero value of output gap as threshold.

It might be possible however, that policy maker has a threshold value of the output gap that is different from zero. To investigate this issue, we have estimated threshold value of the output gap in the policy reaction function and it is found 2.5%. Results of Rule 1 with this threshold value of the output gap indicate that interest rate positively and significantly respond to output gap only if the latter is below its threshold value. In the long run the coefficient of the output gap, when it is below threshold value, is estimated at 1.45. Hence policy maker responds to the output gap in a manner that is consistent with the prescription of Taylor rule only if there is slowdown in the business activity and when economic activity is flourishing then focus is shifted from the output gap to other objectives. The coefficients of inflation rate and lagged interest rate are same no matter output gap is above or below the threshold. Although, the magnitudes are somewhat different in two regimes (both coefficients are higher in magnitude when there is low growth period) but the difference is not statistically different as indicated by the F-stats at the bottom of the table. In the fourth specification we found asymmetric response of

interest rate to exchange rate in two states of the economy. The coefficient of exchange rate is positive only when output gap is below threshold value, otherwise it is negative.

TABLE 4

Results of Nonlinear Monetary Policy Reaction Function
(Nonlinearity w.r.t Output Gap)

Threshold Value of Output Gap	**Rule 1**		**Rule 2**		**Rule 3**		**Rule 4**	
	0	**2.5**	**0**	**2.5**	**0**	**2.5**	**0**	**2.5**
C	0.47	0.67	0.35	0.62	0.53	0.67	0.56	0.65
	(0.49)	(0.18)	(0.51)	(0.21)	(0.30)	(0.25)	(0.25)	(0.20)
Y			0.04	0.17	0.05	0.18	0.11	0.17
			(0.55)	(0.01)	(0.55)	(0.02)	(0.03)	(0.00)
π	0.04	0.03			0.03	0.03	0.03	0.03
	(0.35)	(0.66)			(0.46)	(0.49)	(0.34)	(0.43)
R(-1)	0.89	0.89	0.89	0.90			0.88	0.90
	(0.00)	(0.00)	(0.00)	(0.00)			(0.00)	(0.00)
DER	0.30	0.28	0.35	0.27	0.34	0.27		
	(0.03)	(0.04)	(0.01)	(0.04)	(0.01)	(0.06)		
y*Dum	0.15	0.04						
	(0.27)	(0.66)						
y*(1-Dum)	0.09	0.16						
	(0.52)	(0.02)						
π*Dum			0.08	-0.02				
			(0.06)	(0.63)				
π*(1-Dum)			0.01	0.03				
			(0.74)	(0.36)				
R(-1)*Dum					0.92	0.84		
					(0.00)	(0.00)		
R(-1)*(1-Dum)					0.86	0.90		
					(0.00)	(0.00)		
DER*Dum							0.50	-1.98
							(0.00)	(0.03)

Threshold Value of Output Gap	**Rule 1**		**Rule 2**		**Rule 3**		**Rule 4**	
	0	**2.5**	**0**	**2.5**	**0**	**2.5**	**0**	**2.5**
DER*(1-Dum)							0.27	0.28
							(0.02)	(0.02)
Adjusted R-square R-square	0.93	0.93	0.94	0.94	0.94	0.94	0.94	0.94
DW Statistic	1.57	1.59	1.70	1.60	1.61	1.60	1.63	1.69
LM stats	17.64	15.40	20.19	14.71	19.04	15.50	14.88	14.91
	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)
F stats	0.11	1.12	2.95	1.89	2.22	2.58	1.27	3.97
	0.74	0.29	0.09	0.17	0.14	0.11	0.26	0.05

y denotes output gap, inf denotes inflation rate i(-1) is lagged interest rate, and d(er(-1)) is the lagged differenced exchange rate. F-stats is calculated with the null hypothesis that coefficient of a target variable is same above and below threshold value. Dum is the dummy variable which has value 1 when output gap is above threshold value and zero otherwise.

It is noteworthy that there is high R-square in each specification of nonlinear Taylor rule but coefficients are not significant in all of the models. This may be due to the problem of multicollinearity. We therefore, used Variance Inflation Factor (VIF) to formally test the multicollinearity problem. Results in table show that for all of the regressors VIF is considerably lower than the benchmark value of 10. So, multicollinearity is not the cause of the problem. A possible explanation of high R-square combined with insignificant coefficients can be the strength of association between interest rate and its lagged values. To test this, we regressed interest rate only on lagged interest rate and interestingly, the R-square was found 0.91. Hence, in a regression with lagged interest rate as a regressor, R-square will be above 0.91 no matter the coefficients of other regressors are significant or not.

NONLINEARITY WITH RESPECT TO INFLATION RATE

In this step two regimes are separated on the basis of threshold inflation rate. The high inflationary regime is the one with inflation rate above threshold and the low inflationary regime is the one with inflation rate below threshold inflation rate. Results in table 5 indicate that the threshold inflation rate is found 6.02%. Again four specifications of the

nonlinear Taylor rule are estimated: in each specification dummy variable, with value 1 for inflation rate above threshold, is multiplied by one of the target variables.

TABLE 5

Results of Nonlinear Taylor Rule (Nonlinearity w.r.t Inflation Rate)

	Rule 1	**Rule 2**	**Rule 3**	**Rule 4**
C	0.33	-0.17	0.19	0.07
	(0.62)	(0.77)	(0.73)	(0.89)
Y		0.21	0.19	0.08
		(0.00)	(0.01)	(0.09)
π	0.04		0.08	0.13
	(0.33)		(0.12)	(0.00)
R(-1)	0.89	0.89		0.87
	(0.00)	(0.00)		(0.00)
DER	0.31	0.25	0.25	
	(0.02)	(0.04)	(0.06)	
y*Dum	0.19			
	(0.11)			
y*(1-Dum)	0.06			
	(0.67)			
π*Dum		0.08		
		(0.07)		
π* (1-Dum)		0.34		
		(0.02)		
R(-1)*Dum			0.86	
			(0.00)	
R(-1)*(1-Dum)			0.96	
			(0.00)	
DER*Dum				-0.05
				(0.71)

	Rule 1	**Rule 2**	**Rule 3**	**Rule 4**
DER*(1-Dum)				0.69
				(0.00)
Adjusted R-square	0.94	0.94	0.94	0.95
DW Statistic	1.57	1.44	1.45	1.46
F stats	0.81	7.21	4.35	2.56
	(0.37)	(0.01)	(0.04)	(0.00)

y denotes output gap, inf denotes inflation rate i(-1) is lagged interest rate, and d(er(-1)) is the lagged differenced exchange rate. F-stats is calculated with the null hypothesis that coefficient of a target variable is same above and below threshold value. Dum is the dummy variable which has value 1 when inflation rate is above threshold value (6.02%) and zero otherwise. Probability values are given in parentheses

Results in Table 5 show that in all four specifications adjusted R-square is above 0.9, Durbin-Watson statistic is about 1.5, the coefficient of lagged interest rate is about 0.9 and the coefficient of exchange rate is about 0.3. Moreover, the F-statistics show that coefficients of all the target variables other than that of the output gap are not equal in two inflationary regimes. Results in the second column of the table indicate that the coefficient of output gap is positive and statistically significant only if economy is in high inflationary regime. But the coefficient of inflation rate is significant in both regimes. However, this coefficient in high inflationary regime has a value which is close to zero and Taylor principle is satisfied only in low inflationary regime. This is because SBP does not increase interest rate to that extent when inflation crosses certain threshold value. For instance, after 2007 inflation jumped to historical high rates (above 25%) but SBP increased policy rate to just 15%. Inertia in the interest rate has almost same coefficient values in two regimes; however, these coefficients are statistically different. Similarly, it is found that SBP increases interest rate in response to currency depreciation only if there is low inflationary regime.

NONLINEARITY WITH RESPECT TO LAGGED INTEREST RATE AND EXCHANGE RATE

Nonlinearity in the Taylor rule is also investigated with respect to lagged interest rate. Time period when the interest rate is above threshold value is the high interest rate regime and vice versa. Threshold value of interest

rate, above and below which policy behavior is expected to be different, is found 7.45%. Results in Table 6 show that adjusted R-square, Durbin-Watson statistics, the coefficient of inflation rate and the coefficient of exchange rate are same as those found in the case of nonlinearity with respect to the inflation rate. Again, as F-statistics show, response coefficients of all the target variables except that of output gap are significantly different in two different regimes of interest rate. Response of the interest rate to the output gap is significant only if interest rate is already high in the economy. On the other hand, the response of interest rate to inflation rate is significant only when the interest rate is already low. Similarly, it is found that inertia in interest rate is more prevalent when interest rate is low. Finally, monetary authority responds to currency depreciation more strongly when interest rate is low compared to that when it is high.

F-statistics in the last four columns of Table 6 signify that nonlinearity with respect to exchange rate is significant only when the dummy variable, with value 1 for exchange rate depreciation above threshold estimated at 0.68, is multiplied with exchange rate. Response of interest rate to currency depreciation is stronger when magnitude of currency depreciation is high. One of the explanations of this result is that, in Pakistan, central bank intervenes in the foreign exchange market, through foreign exchange reserves, to stop currency depreciation. But when depreciation is high and persistent and foreign exchange reserves are low then central bank focus on other instruments, like increase in interest rate, to stabilize exchange rate.

TABLE 6

Results of Nonlinear Taylor Rule
(Nonlinearity w.r.t Interest Rate and Exchange Rate)

	Nonlinearity w.r.t Interest Rate				Nonlinearity w.r.t Exchange Rate			
	Rule 1	*Rule 2*	*Rule 3*	*Rule 4*	*Rule 1*	*Rule 2*	*Rule3 3*	*Rule 4*
C	0.50	-0.22	-0.05	0.36	0.51	0.76	0.67	0.56
	(0.41)	(0.77)	(0.94)	(0.40)	(0.36)	(0.20)	(0.26)	(0.30)
Y		0.12	0.17	0.10		0.16	0.14	0.15
		(0.00)	(0.00)	(0.02)		(0.00)	(0.01)	(0.00)
π	0.03		0.03	0.05	0.04		0.03	0.02

	Nonlinearity w.r.t Interest Rate				Nonlinearity w.r.t Exchange Rate			
	Rule 1	*Rule 2*	*Rule 3*	*Rule 4*	*Rule 1*	*Rule 2*	*Rule3 3*	*Rule 4*
	(0.39)		(0.44)	(0.09)	(0.30)		(0.57)	(0.64)
R(-1)	0.89	0.96		0.90	0.89	0.89		0.90
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)		(0.00)
DER	0.31	0.29	0.31		0.26	0.27	0.27	
	(0.01)	(0.02)	(0.01)		(0.05)	(0.05)	(0.08)	
y*Dum	0.15				0.01			
	(0.02)				(0.96)			
y*(1-Dum)	0.05				0.16			
	(0.58)				(0.01)			
π*Dum		0.03				0.04		
		(0.47)				(0.33)		
π*(1-Dum)		0.16				-0.01		
		(0.08)				(0.78)		
R(-1)*Dum			0.94				0.91	
			(0.00)				(0.00)	
R(-1)*(1-Dum)			1.12				0.87	
			(0.00)				(0.00)	
DER*Dum				0.18				0.41
				(0.10)				(0.00)
DER*(1-Dum)				0.89				0.12
				(0.00)				(0.43)
Adjusted R-square R-square	0.93	0.94	0.94	0.94	0.94	0.94	0.94	0.94
DW Statistic	1.55	1.70	1.72	1.73	1.62	1.61	1.68	1.63
F stats	0.76	4.07	6.08	9.25	2.22	2.73	2.48	3.81
P value	0.39	0.05	0.02	0.00	0.14	0.10	0.12	0.06

y denotes output gap, inf denotes inflation rate i(-1) is lagged interest rate, and d(er(-1)) is the lagged differenced exchange rate. F-stats is calculated with the null hypothesis that coefficient of a target variable is same above and below threshold value. For second to fourth columns Dum is the dummy variable which has value 1 when interest rate is above threshold value (7.45%) and zero otherwise. For last three columns Dum is the dummy variable which has value 1 when exchange rate is above threshold value (0.68%) and zero otherwise.

VI. LINEAR MCCALLUM RULES

As stated earlier the objective of this study is not just estimation of Taylor rule. Rather the objective is to find the monetary policy reaction function that closely approximates the behavior of central banker in Pakistan. For that purpose, different types of policy reaction functions are estimated; one of those is the McCallum rule in which monetary base is the monetary policy instrument which responds to deviation of nominal GDP growth rate from its long run average.

It can be seen from Table 7, column 2 (Rule 1) that monetary base negatively and significantly responds to nominal GDP growth rate. So central bank contracts money whenever inflation rate is high and/or business activity is in boom. Durbin-Watson statistics show that error term is serially uncorrelated so monetary authority does not seem to smooth monetary base. However, adjusted R-square is considerably low which show that monetary base is dependent on factors other than nominal GDP growth. Therefore, we have extended McCallum rule by incorporating lagged differenced exchange rate and lagged growth rate of monetary base. Results in the third column show that exchange rate is significant determinant of monetary base; currency depreciation leads to slowdown in monetary expansion. This result is consistent with the one found in Taylor rule that currency depreciation leads to monetary tightening through increase in interest rate.

Finally, results in the last column highlight the importance of inertia in monetary growth rate. It is found that once the monetary growth rate is higher due to whatever reason, the central bank tries to counter it by decreasing the rate of monetary expansion in the future. It is worth mentioning that adjusted R-square does not improve much even in this specification. Hence monetary base is dependent on factors other than nominal GDP growth rate and exchange rate. However, the low R-square is because the dependent variable is in differenced form. The LM stats show that there is no autocorrelation in the errors of this last specification.

TABLE 7

Linear McCallum Rule

	Ru1e 1	Ru1e 2	Ru1e 3
Constant	0.13	0.14	0.19
	(0.00)	(0.00)	(0.00)
GDPG	-0.29	-0.38	-0.48
	(0.09)	(0.03)	(0.00)
D(ER(-1))		-0.01	-0.01
		(0.05)	(0.02)
MOYG			-0.43
			(0.00)
Adjusted R Square	0.03	0.07	0.24
DW Statistic	1.65	1.66	1.52
LM stats	10.14	11.66	4.32
	(0.04)	(0.02)	(0.28)

GDPG is real GDP growth rate, D(ER(-1)) is lagged differenced exchange rate, M0YG is growth rate of monetary base.

VII. STABILITY OF PARAMETERS IN THE MCCALLUM RULE

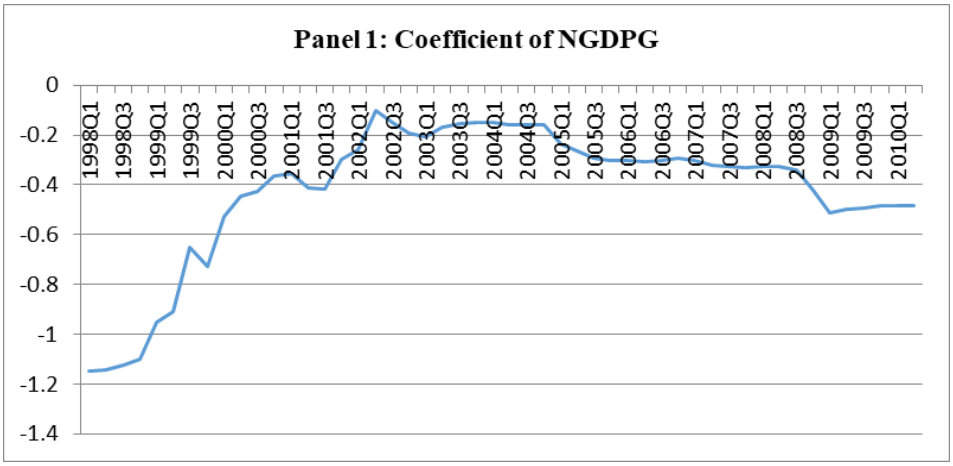
As explained earlier policy reversal can be observed in the history of monetary policy in Pakistan. So we have found recursive estimates of the third specification of McCallum rule in which monetary growth rate depends on nominal GDP growth rate, exchange rate and lagged values of monetary growth rate. For this purpose, first sample is selected from 1993Q3 to 1997Q4 and then one observation is increased in each next sample. Estimates of parameters so obtained are then plotted which are shown in Figure 2.

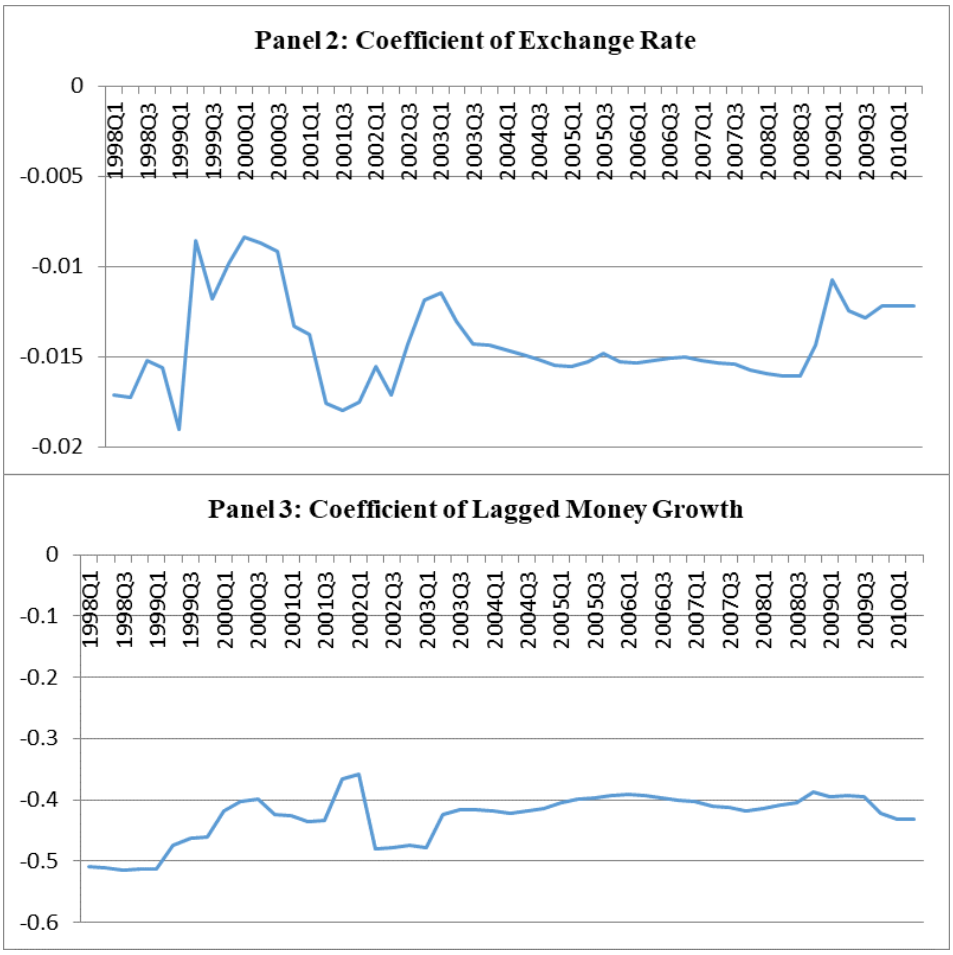
It can be seen from results in the first panel of Figure 2 that the coefficient of nominal GDP growth rate is not stable over time. More

specifically this coefficient initially increases till 2002 and then it continuously decreases. Speed of decrease in the coefficient increases sharply at the end of 2008 and then after one year it became stable. This movement in the coefficient can be attributed to business cycle fluctuation, movement in the inflation rate and fluctuation in the monetary growth rate. For instance, inflation rate and monetary growth rate are negatively related with the coefficient of nominal GDP growth. Second panel of figure 2 show that coefficient of exchange rate in the McCallum rule is positively related to exchange rate. This coefficient increased in 1999, decreased in 2001 and again increased in 2009; exchange rate also moved in a similar way. The coefficient of lagged monetary growth rate remained almost stable throughout the sample period (Panel 3). However, this coefficient increased after 2001 due to monetary expansion.

Figure 2

Recursive Estimates of Parameters in the McCallum Rule





VIII. NONLINEAR MCCALLUM RULE

We have estimated four specifications of McCallum rule. Two dummy variables are constructed for this purpose; first dummy variable has value 1 whenever nominal GDP growth rate was above its threshold and second dummy variable has value 1 when exchange rate was above threshold. These two dummy variables are then multiplied by nominal GDP growth rate and exchange rate. Again in these nonlinear McCallum rules Newey-West standard errors are used to find probability values.

In the first two specifications first dummy variable is multiplied by nominal GDP growth rate and exchange rate. Results in column 2 and 3

of table 8 show that the effects of nominal GDP growth rate and exchange rate on monetary growth rate are significant only when nominal GDP is above its threshold value i.e. there is boom in business activity and/or there is high inflationary regime. This result is opposite to conventional wisdom that government intervention through monetary policy is justified in recessions with low inflation and not in booms with high inflation rate11. Results in the last two columns of table 8 show that the negative response of monetary growth rate to nominal GDP growth rate and exchange rate is significant only when currency depreciates at higher rate (above threshold value). Results also show that adjusted R-square does not exceed 0.3 even in the nonlinear model.

TABLE 8

Results of Nonlinear McCallum Rule

	NGDPG Dummy		ER Dummy	
	Rule 1	Rule 2	Rule 1	Rule 2
Constant	0.19	0.20	0.19	0.20
	(0.00)	(0.00)	(0.00)	(0.00)
NGDPG		-0.58		-0.46
		(0.01)		(0.02)
D(ER(-1))	-0.02		-0.01	
	(0.00)		(0.00)	
M0G(-1)	-0.49	-0.45	-0.43	-0.43
	(0.07)	(0.12)	(0.12)	(0.13)
Dum*NGDPG	-0.88		-0.69	
	(0.00)		(0.00)	
(1-Dum)*NGDPG	0.10		-0.21	
	(0.91)		(0.43)	
Dum*D(ER(-1))		-0.02		-0.01
		(0.00)		(0.00)

[11] For discussion on this issue see Scarth (1996), chapter 4.

	NGDPG Dummy		ER Dummy	
	Rule 1	Rule 2	Rule 1	Rule 2
(1-DUM)* D(ER(-1))		-0.00		-0.01
		(0.70)		(0.00)
Adjusted R-square R-square	0.30	0.24	0.26	0.24
DW Statistic	1.64	1.50	1.67	1.45
F stats	5.60	0.99	2.49	0.53
P value	0.02	0.32	0.12	0.47

NGDPG is nominal GDP growth rate, D(ER(-1)) is lagged differenced exchange rate, M0G(-1) is the lagged value of monetary growth rate. Dum, for columns 2 and 3, is dummy variable which has value 1 when nominal GDP growth rate is above threshold value and zero otherwise. Dum, for columns 4 and 5, is dummy variable which has value 1 when exchange rate is above threshold value and zero otherwise. Probability values are given in parentheses.

IX. INTEREST RATE DETERMINATION WITH BUDGET DEFICIT

Finally, we have estimated the equations in which interest rate is determined as a linear combination of target interest rate set by the SBP and the fiscal deficit. The first specification in this regard is the augmented version of the standard Taylor rule in which the short term interest rate responds to deviations of actual output from potential level, that of inflation from the target and logarithm of fiscal deficit.

Results in the second column of Table 1 (Rule 1) show that monetary authority in Pakistan does not follow Taylor rule. The coefficient of the output gap is negative and statistically significant. Moreover, the coefficient of the inflation rate, though statistically significant, is far below the benchmark value (1.5) and even does not satisfy the Taylor principle. The coefficient of fiscal deficit is positive, greater than 1, and is statistically significant. This shows that higher budget deficit leads to high interest rate which confirms that the effect of borrowing from commercial banks outweigh the effect of borrowing from central bank. However, the adjusted R-square is quite low which indicates the importance of factors, other than output gap, inflation rate, and fiscal deficit in determining the value of interest rate in Pakistan.

Moreover, the Durbin-Watson is too low which might be an indication of the presence of autocorrelation. However, autocorrelation is not the only cause of low value of Durbin-Watson; there might be the problem of mis-specified dynamics in the model. Hence, results of this specification might be misleading due to mis-specified dynamics and/or the presence of autocorrelated errors.

In rest of the three specifications the coefficient of output gap is significant and is positive. Moreover, the magnitude of this coefficient is quite high when it is adjusted for the long run. The coefficient of inflation in all specifications is positive and statistically significant. However, this coefficient has lower values and Taylor principle is not satisfied. It is found that SBP has strong preference of interest rate smoothing as the coefficient of lagged interest rate is very high and is statistically significant. Finally, the coefficient of differenced exchange rate is also positive and statistically significant indicating that the e exchange rate management is a policy objective of SBP. The coefficient of fiscal deficit is negative in last three specifications indicating that borrowing from SBP dilutes the monetary policy stance taken by SBP.

The equation of interest rate, when fiscal deficit is included, fits the data much better than different versions of Taylor rule without fiscal deficit. This shows that fiscal deficit plays important role in determining interest rate in Pakistan. So any attempt, at the part of monetary authority, to control prices or stabilize output will not prove fruitful unless fiscal discipline is maintained. This needs monetary and fiscal coordination, in the absence of which both policies may affect the target variables in opposite directions.

TABLE 9

Results of Interest Rate Equation with Fiscal Deficit

	Rule 1	Rule 2	Rule 3	Rule 4
Constant	-17.52	5.65	4.75	4.56
	(0.01)	(0.02)	(0.03)	(0.03)
Y	-0.31	0.16	0.18	0.14
	(0.06)	(0.00)	(0.00)	(0.01)

	Rule 1	Rule 2	Rule 3	Rule 4
Inf	0.29	0.11	0.04	0.02
	(0.00)	(0.00)	(0.30)	(0.51)
i(-1)		0.99	0.98	1.24
		(0.00)	(0.00)	(0.00)
i(-2)				-0.26
				(0.06)
Log(FD)	1.89	-0.54	-0.42	-0.39
	(0.00)	(0.01)	(0.04)	(0.04)
d(er(-1))			0.25	0.23
			(0.02)	(0.02)
Adjusted R-square	0.55	0.97	0.97	0.97
DW Statistic	0.68	1.26	1.19	1.56
LM Statistic	19.09	6.87	8.69	6.36
	(0.00)	(0.14)	(0.07)	(0.17)

* y denotes output gap, inf denotes inflation rate i(-1) is lagged interest rate, and d(er(-1)) is the lagged differenced exchange rate. Log(FD) is the logarithm of fiscal deficit. Probability values are given in parentheses.

X. CONCLUSION AND POLICY RECOMMENDATIONS

The first objective of this paper is to estimate monetary policy reaction function. For this purpose, Taylor type rules and McCallum rules are estimated using quarterly data on Pakistan economy. Both types of rules have been modified by incorporating exchange rate management and interest rate smoothing as policy objectives. Moreover, the estimated values of parameters, in the rule, may not represent true behavior of monetary policy against all changes in the state of economy during the whole sample period, as the estimated values represent only average behavior. If different policy options are adopted in different conditions, with respect to business activity and inflation rate, then parameters of the rule do not remain stable over time. We have, therefore, found recursive

estimates of the parameters to sort out policy inconsistency. Finally, nonlinearity in the rules have been introduced with respect to the output gap and the inflation rate assuming monetary authority reacts differently, to the state of economy, above and below the threshold values of output gap and/or inflation rate.

SUMMARY OF FINDINGS

Results found in the study are summarized in the following.

- Monetary authority in Pakistan does not follow Taylor rule as the coefficient of output gap is negative and statistically insignificant and the coefficient of inflation rate, though statistically significant, is far below the benchmark value (1.5). Moreover, Taylor principle is not satisfied as the coefficient of inflation rate is also less than 1.
- There is strong preference of central bank towards exchange rate management and interest rate smoothing. Inertia in interest rate is found to be high and the result that interest rate positively responds to changes in exchange rate is robust to different specifications of the rule.
- Results of backward-looking Taylor rule are almost same as those found in case of forward-looking Taylor rule. The only difference is that the coefficient of inflation rate is statistically significant in forward-looking specification but not in the other one.
- Coefficient of output gap moves in opposite direction to business cycle movements: it is low during expansions and high in the slumps. Coefficient of inflation rate is high in low inflationary period but low in high inflationary regime. Coefficient of exchange rate and that of lagged interest rate are almost stable throughout the sample period but the former became low when currency depreciated at a higher speed, at the end of the sample period.
- Response coefficients do not vary much over the business cycle when positive output gap is defined as boom and negative as recession. However, the response to output gap varies at a threshold value of output gap, which is found 2.5%. The response

of interest rate to output gap is positive only when output gap is below this threshold value. The coefficients of inflation rate and lagged interest rate do not vary across two regimes but the coefficient of exchange rate is positive only when output gap is below threshold value.

- Threshold rate of inflation is found about 6%. The coefficient of output gap is positive only in high inflationary regime while the coefficients of inflation rate and exchange rate are significant only in low inflationary regime. An interesting result is that Taylor principle is satisfied only in low inflationary regime and the response coefficient is close to zero when the inflation rate is above threshold. This result is consistent with Iftikhar (2012).
- Response of the interest rate to the output gap is significant only if lagged interest rate is above threshold (found 7.45%) but that to inflation rate is significant only when the lagged interest rate is below threshold. Moreover, monetary authority responds to currency depreciation more strongly when interest rate is low compared to that when it is high.
- The response of interest rate to the output gap is significant only if currency depreciation is below threshold (estimated at 0.68) while response to exchange rate is significant only if there is high speed of depreciation (above threshold).
- Fiscal deficit puts downward pressure on interest rate which is because a significant part of deficit is financed through borrowing from SBP.
- In the modified Taylor rule it is found that interest rate negatively responds to real GDP growth rate in static version while this response becomes insignificant in dynamic version of the rule. The modification in the rule does not alter the result that interest rate smoothing and exchange rate management are the two preferred objectives of SBP.
- Growth rate of monetary base negatively depends on the difference between nominal GDP growth rate and its average value indicating countercyclical response at the part of monetary authority. Moreover, growth rate of money is lowered by SBP

whenever local currency depreciates. Finally, monetary growth rate significantly depends on its previous values.

- Coefficients in the McCallum rule do not remain stable during the sample period. Coefficient of growth rate of nominal GDP is not constant, however, it is not clear whether this variation is because of change in the state of economic activity or is it because of change in inflationary regime. The coefficient of exchange rate is also not stable and co-varies with exchange rate. The inertia coefficient is stable over the sample period.
- The effect of nominal GDP growth rate and that of exchange rate on monetary growth rate are significant only when nominal GDP is above its threshold value i.e. there is boom in business activity and/or there is high inflationary regime. Moreover, the negative response of monetary growth rate to nominal GDP growth rate and to exchange rate is significant only when currency depreciates at higher rate (above threshold value).

POLICY RECOMMENDATIONS

Based on these findings this study makes some policy recommendations. Monetary authority should focus more on price stability and stabilization of economic activity and less on interest rate smoothing and exchange rate stability. Inclusion of lagged interest rate and currency depreciation in the reaction function is helpful in keeping financial sector and international trade stable. But stability of financial and external sectors is justified if it improves social welfare. Therefore, the interest rate smoothing and exchange rate management can be incorporated into the policy reaction function only if social welfare is not compromised.

SUGGESTIONS FOR FUTURE RESEARCH

More research is needed to find appropriate method of modeling nonlinearity. For instance, nonlinearity in the monetary policy reaction function can be modeled as Smooth Transition Regression (Teräsvirta 1994) in which switching from one monetary policy regime to the other is supposed to be gradual. Similarly, threshold regression models (Chan 1993; Hansen 1997) can be modified assuming switching from one regime to the other a discrete but Markov Process. Then the simulation

analysis for nonlinear Taylor rules can be conducted with the appropriate form of nonlinearity regarding monetary policy reaction function.

REFERENCES

Adema, Y., 2003. A Taylor rule for the euro area based on quasi-real time data, Netherlands Central Bank, Research Department.

Agha, Asif Idrees., Noor Ahmed, Yasir Ali Mubarik, and Hastam Shah. (2005). "Transmission Mechanism of Monetary Policy in Pakistan", SBP-Research Bulletin, Vol 1, No. 1, 2005.

Ahmad A. Maqsood, and Wasim S Malik (2011) "The Economic of Inflation, Issues in the Design of Monetary Rule, and Monetary Policy Reaction Function in Pakistan" The Lahore Journal of Economics, Vol. 16, September, 215-232.

Akbari, A. H. and Rankaduwa, W. (2006), "Inflation Targeting in a Small Emerging Market Economy: The Case of Pakistan", SBP-Research Bulletin, Vol. 2, No. 1, pp. 169-190.

Bokil, M. and A. Schimmelpfennig (2005). "Three Attempts at Inflation Forecasting in Pakistan." IMF Working Paper No. 05/105. Washington, D.C.: IMF.

Chaudhary, Muhammad Aslam, and Munir A. S. Choudhary (2006). "Why The State Bank of Pakistan Should Not Adopt Inflation Targeting." SBP Research Bulletin, Vol.2, No. 1: 195-209.

Felipe J. (2009). "Does Pakistan Need to Adopt Inflation Targeting? Some Questions", SBP Research Bulletin, Vol. 5, No. 1, May, 2009.

Hamilton, James (1989). A new approach to the economic analysis of non-stationary time series and the business cycle. Econometrica, 57, 357-384.

Iftikhar., Zainab (2012). Is State-Contingent Response of State Bank of Pakistan Asymmetri? M.Phil Thesis. Quaid-i-Azam University, Islamabad.

Khalid, A. M. (2006), Inflation Targeting the Best Policy Choice for Emerging Economics? A Survey of Emerging Market Experiences and Lessons for Pakistan", SBP-Research Bulletin, Vol. 2, No. 1, pp. 145-165.

Khan, Mohsin, and Axel Schimmelpfenning (2006). "Inflation in Pakistan: Money or Wheat?" SBP-Research Bulletin, Vol.2, No.1: 213-234.

Khan Sajawal & abdul Qayyum, 2007. Measures of Monetary Policy Stance: The Case of Pakistan, PIDE-working Papers 2007:39, Pakistan Institute of Development Economics.

Malik, W. Shahid and Ahmed (2010), "Taylor Rule and the Macroeconomic Performance in Pakistan". The Pakistan Development Review, Vol.49, No.1

Malik, W.Shahid (2007), "Monetary Policy Objectives in Pakistan: An Empirical Investigation", PIDE Working Papers 35.

Moinuddin (2009). "Choice of Monetary Policy Regime: Should SBP Adopt Inflation Targeting." SBP Working Paper Series, No.19.

Omer and Saqib, 2009. "Monetary Targeting in Pakistan: A Skeptical Note", SBP Research Bulletin Vol. 5, NO. 1, May 2009.

Qayyum, A. (2006), "Monetary, Inflation, and Growth in Pakistan" The Pakistan Development Review, Vol. 45, No. 2, pp. 203-212.

Sargent, T.J., and N. Wallace (1975), "Rational Expectations, the Optimal Monetary Instrument, and the Optimal Money Supply Rule", Journal of Political Economy 83:241-254.

Sinclair P. (2009). "The Why and Wherefores of Controlling Inflation", SBP Research Bulletin, Vol. 5, No. 1, May, 2009.

Tariq, Muhammad (2010). "The Effect of Monetary Policy Rules on Welfare and Business Cycle in an Open Economy Framework", Ph.D. Thesis. Federal Urdu University of Arts, Science and Technology Islamabad.

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