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THE SPECIFICATIONS AND TESTING OF NON MODIFIED AND MODIFIED LINEAR TAYLOR RULES: A TIME SERIES ANALYSIS OF INFLATION TARGETING IN PAKISTAN

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ABSTRACT

Purpose: *This study has tested the various specifications of linear Taylor rule of inflation targeting in Pakistan. Linear Taylor rules with and without modification have been examined.*

Design/Methodology/Approach: *Short term interest rates i.e., Treasury bill of maturity 3 months, 6months and 12 months for the period of 2005q1 to 2019q3 have been used. OLS and GMM methods are applied.*

Findings: *Findings exhibit that the State Bank of Pakistan is not following Taylor rule and the Taylor principle is not satisfying in Pakistan. Results show that SBP is not preferring exchange rate management over output gap and inflation stability. This result is robust in all specifications except for GMM estimation of a forward-looking version of the Taylor rule which shows a significant positive impact of differenced lagged Exchange Rate. Interest rate smoothing is an important determinant of short-term interest rates. Real GDP is found negative and significant when replacing with output gap in Taylor rule. This paper also evaluates the important influence of fiscal deficit in Taylor rule to determine short-term interest rates in Pakistan.*

Implications/Originality/Value: *The study suggests that flexible inflation targeting may be adopted to control inflation in Pakistan so that exchange rate management and interest rate smoothing may also be considered. SBP should be autonomous in its decision making. Moreover, fiscal deficit may be financed through taxes.*

Keywords: *Treasury bill, Taylor rule, inflation targeting, output gap, Real GDP growth rate, Fiscal deficit, Exchange rate*

JEL Classification: *E31, E43, E52, E58*

1. Introduction

Inflation targeting is a monetary policy framework associated with quantitative targets or target ranges for one or more horizon of the inflation rates. A low and stable inflation rate is the primary long-run goal of the central bank (Bernanke et al., 1999). Inflation targeting is a powerful tool to achieve price stability under some circumstances as compared to any other monetary policy framework. The dominance of price stability does not mean that central banks ignore other monetary policy objectives. In inflation targeting, central banks have considerable discretion in achieving price stability but and other goals cannot be ignored (Berg and Jonung, 1999).

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Inflation targeting is not a rule but a monetary policy framework to work in a constrained discretion environment. Inflation targeting is easy to understand, flexible and best for central bank accountability, and it provides awareness on inflation cost. Price stability is the major goal of the central banks and other goals are subordinated (Bernanke et al., 1999 and Mishkin, 2004). However, inflation targeting without a suitable monetary policy rule is not sufficient. There is a strong relationship between rules and Inflation targeting. Inflation targeting aims to reduce the price level to the target level of inflation without any negative impacts on real variables of the economy e.g. real GDP and employment. There exists a trade-off between inflation and unemployment in the short run. So, monetary authorities need to devise a suitable monetary policy rule that can help to achieve inflation targeting goal in the economy (Taylor, 2019).

Inflation targeting is not a new approach to monetary policy. It is a framework to achieve low and stable inflation with the choice of monetary policy rules: Taylor rule or McCallum rule (Brash, 1999). A suitable monetary policy rule provides less volatility regarding the inflation target rate (Taylor, 2019). Monetary policy rules are always attached with a given value of inflation target inside the models on policy rules (Taylor, 2000a). The Taylor rule is a suitable monetary policy rule that has possible monetary policy characteristics (Carlozzi and Taylor, 1983, 1985). Monetary authorities decrease the short-term nominal interest rate by a specific level when the inflation rate in the economy falls below the target rate of inflation or if real GDP falls below the potential level of GDP and the converse is true Taylor, 1993). Monetary authorities aspire to stabilize inflation in the country, follow Taylor rule in its standard form (Kuhn and Muysken, 2012).

This paper is organized into five sections. Section 2 elaborates the literature review. Model specifications of Taylor rules along with data and methodology are given in section 3 while section 4 is about results and discussions. The last section is about the conclusions and policy implications.

2. Literature Review

A wide relevant literature is provided in this section regarding the Taylor rule, inflation targeting, the influence of exchange rate management, interest rate smoothing, and fiscal deficit.

Billi (2020) examined the output gap with the robustness of monetary policy rules in the USA by employing a small new Keynesian model with zero lower bound of interest rate. The study showed that in the absence of zero lower bound, the central bank should focus on inflation stability rather than nominal GDP stabilization and the opposite was true in the presence of zero lower bound. Kurihara and Fukushima (2020) probed that the McCallum rule was best fitted as compare to the Taylor rule in the recent Japanese conditions. On the other hand, Beckworth and Hendrickson (2019) pointed out that nominal GDP targeting was best comparing to Taylor rule for producing lower variability in inflation and output gap. Mayandy (2019) applied a forward-looking version of the Taylor rule with reaction functions. The findings revealed that the central bank of Sri Lanka (CBSL) followed Taylor rule and had a great focus on price stability. The author indicated that a tight monetary policy was adopted to overcome deprecation in the nominal exchange rate. It was also observed that CBSL did not react over the fiscal deficit, indicating that inclusion of fiscal deficit was not a good specification provision in the Taylor rule. Neuenkirch and Tillmann

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(2014) investigated the non-linearity of Taylor Rule and its credibility with the inflation targeting framework and found the positive and negative asymmetric reactions in credibility. Wang and Chao (2019) found that the Peoples Bank of China gave more weightage to interest rate tool for price stability. Yagcibasi and Yildirim (2019) estimated the Taylor rule with the Markov switching approach in Turkey and found that the central bank gave more importance to output gap stabilization than inflation stability. Sherazi and Mahmood (2018) found an inverse and insignificant relationship between nominal ER and inflation in Pakistan. The study concluded that SBP should not adopt exchange rate targeting for the stability of prices in Pakistan. Saghir and Malik (2017) found that Pakistan economy did not follow the Taylor type rule and found robust results of different specifications of the Taylor rule with the inclusion of exchange rate and interest rate smoothing. Instability was found in the case of inflation, output gap and differenced exchange rate. Yasmin and Afzal (2012) obtained the desired signs of inflation and output gap based on Taylor type rule for Pakistan. Ahmad and Malik (2011) also found that with the objective of interest rate smoothing and exchange rate management, SBP reactions were consistent with Taylor (1993). Kemal (2011) uncovered that there was no significant short-run association between real exchange rate and real interest rate and discovered no exchange rate pass-through in Pakistan. The interest rate was suggested as an instrument to control inflation in Pakistan. Mishra and Mishra (2012) evaluated inflation targeting as a monetary policy objective for India, through the small open economy model and found a trade-off between output-gap and exchange rate stabilization under domestic inflation targeting and consumer price index inflation targeting. The study concluded that discretionary optimization worked better for the traditional Taylor rule to stabilize the Indian economy. Ahmad and Malik (2010) indicated that with the implementation of the Taylor rule, output and inflation stability could be achieved and suggested that more gains could be achieved by slightly modifying the values of parameters. Malik and Ahmad (2007) revealed that SBP was not following Taylor rule as the values of parameters were according to the atmosphere of the economy rather than according to the Taylor rule in the case of Pakistan. Cavoli and Rajan (2008) elaborated an inflation-targeting framework in an open economy with monetary policy rules in India and found no evidence that interest rate reacted towards inflation forecasting rather found that interest rate tended to react to current inflation. The study also inferred that the interest rate did not react towards the exchange rate. Leitemo (2008) evaluated a more accurate rule for inflation targeting by examining the history dependence of inflation targeting or forward-looking behaviour of inflation targeting. The findings showed that the strategy of inflation targeting was inversely related to the private sector behaviour towards pricing as a policy was backward-looking when private sector price behaviour was forward-looking. Fair (2007) found that the interest rate rule was good for low inflation variability when FED had done its best. Razzak (2001) compared the Taylor rule and McCallum rule in a New Keynesian model by taking three different specifications; forward-looking behaviour, backward-looking behaviour and mixed behaviour and found stability in modified McCallum Rule. McCallum Rule achieved its goals through gradual responding to the deviations of nominal GDP growth from its target, and the process continued until deviations removed. Svensson (2000) examined a small open economy under inflation targeting. The study analyzed the forward-looking aggregate supply and demand model as well. It compared CPI inflation

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targeting and domestic inflation, flexible inflation targeting and strict inflation targeting, and reaction functions to inflation targeting and Taylor rule. The findings exhibited that flexible CPI inflation targeting was successful for CPI inflation, output gap and real exchange rate variability.

After reviewing the available literature, it can be pointed out that existing literature consists of the comparison of the Taylor rule with nominal GDP targeting rule, exchange rate targeting rule, and McCallum rule. The literature also elaborates non-linearity of the Taylor rule. Most of the studies are in favour of the adoption of the Taylor rule. Only one study is found on different specifications of the Taylor rule.

This study estimates the numerous specifications of the Taylor rule for Pakistan by using one policy instrument with three time periods: Three months treasury Bill rate, six months Treasury Bill rate and Twelve months Treasury Bill rate. Moreover, various specifications of the Taylor rule have been examined by considering close economy, static and dynamic version in an open economy. The study has also estimated modified Taylor rules with a backward-looking and forward-looking behaviour, and Modified Taylor Rule with RGDP. Modified Taylor rules with the inclusion of fiscal deficit are also estimated. This type of work has not been found in the existing literature on Pakistan except one study by Saghir and Malik (2017).

3. Model Specifications, Data and Methodology

We estimate two types of Taylor Rules i.e., Non-Modified Taylor Rules and Modified Taylor Rules.

A) Non-Modified Taylor Rules

Non-modified Taylor rules consist of two specifications: i) Taylor rules in the closed economy and ii) static and dynamic versions of Taylor rule in an open economy.

Taylor Rule Specification in Close Economy

Taylor rule provides the optimal reaction of monetary policy to make changes in the economy via real interest rate. It is used as a practical guide to conducting monetary policy in the country. Standard Taylor rule specification in econometric form is:

$$TB(i)_t = \alpha_0 + \alpha_1 OG_t + \alpha_2 INF_t + \varepsilon_t \quad \textbf{(1)}$$

Where *TB* means treasury bill and *i* takes values 3, 6 and 12 for*TB3, TB6,* and *TB12* as three months treasury bill rate, six months treasury bill rate, and twelve months treasury bill rate, respectively in all equations. *OG*, *INF* and e_t are output gap, inflation rate and error term respectively. All coefficients are assumed to be positive. Benchmark values for the coefficients a_2 and a_1 are 1.5 and 0.5 respectively. The results of equation (1) are shown in Table 1. To measure equation (1), we have applied the OLS method (Rule 1).

Taylor Rule Specification with Static Version in Open Economy

Taylor rule in a closed economy is augmented with ER management for an open economy. Econometric form for Taylor rule static analysis in an open economy, with an inclusion of exchange rate can be written as:

$$TB(i)_t = \alpha_0 + \alpha_1 OG_t + \alpha_2 INF_t + \alpha_3 \Delta ER_t + \varepsilon_t \quad \textbf{(2)}$$

ER is the exchange rate in equation (2). Exchange rate in Taylor rule has also taken in many studies e.g. (Ball, 1999b & Taylor, 2001). The signs for all coefficients are assumed to be positive. The literature does not provide any benchmark value for the coefficient of the exchange rate. The results of equation (2) are shown in Table 1. Equation (2) is estimated through the OLS method (Rule 2).

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Taylor Rule Specification with Dynamic Version in Open Economy

The financial system of the economy may destabilize due to abrupt variations in short term interest rates. Central banks may make it possible to allow gradual adjustment in the short run interest rate to achieve the optimum level of interest rate (Woglom, 2003). It is assumed that central banks set the interest rate as a weighted average of the suggested interest rate in the rule and actual observed previous period interest rate. It will allow lagged value inclusion of interest rate into an open economy. The inclusion of interest rate smoothing is consistent with Belke and Polleit (2010). The econometric equation is given as follows:

$$TB(i)_t = \alpha_0 + \alpha_1 OG_t + \alpha_2 INF_t + \alpha_3 \Delta ER_t + \alpha_4 TB(i)_{t-1} + \varepsilon_t \quad \textbf{(3)}$$

$TB(i)_{t-1}$ is lagged value of dependent variable showing short term interest rate smoothing in the Taylor rule. Again, positive values for the parameters are assumed. Values for the coefficients of smoothing parameters lie between zero and 1 for exhibiting the counter cycle of monetary policy. The results of equation (3) are shown in Table 1 and are estimated by the OLS method as Rule 3.

B) Modified Taylor Rules

Modified Taylor rules explain the backward-looking behaviour and forward-looking behaviour of Taylor rules. Moreover, modified Taylor rules with the inclusion of real GDP growth rate instead of traditional output gap and modified version of Taylor rules with the inclusion of fiscal deficit are also a part of the present section.

Taylor Rules with Backward-Looking and Forward-Looking Behavior

Econometric specification of backward-looking and forward-looking versions of Taylor rule with *TB3, TB6* and *TB12* is as follows:

$$TB(i)_t = \alpha_0 + \alpha_1 lagOG_t + \alpha_2 lagINF_t + \alpha_3 \Delta ER_{t-1} + \alpha_4 TB(i)_{t-1} + \varepsilon_t \quad \textbf{(4)}$$

We have used fourth lagged to estimate the equation (4). Monetary authorities take decisions today but it will affect the overall economy in future (outside lag effect). So, today's monetary decisions are taken by keeping into consideration future expected values of relevant economic variables. For this, the study estimates a forward-looking version of the Taylor rule through GMM method.

Taylor Rule with Fiscal Deficit

Fiscal dominance is the main issue in Pakistan as government borrows a significant amount from SBP without any limit to support the budget deficit. Budget deficit in Pakistan is financed by both the internal and external sources. It is assumed that the actual interest rate is settled by the decision of SBP and by the decision of financing budget deficit from SBP. Hence, interest rate is linearly related to fiscal deficit and target interest rate. The econometric forms of Taylor rule with inclusion of fiscal deficit (for Rule 1, 2,3 and 4) are as follows:

$$TB(i)_t = \alpha_0 + \alpha_1 OG_t + \alpha_2 INF_t + \alpha_3 FD_t + \varepsilon_t \quad \textbf{(5)}$$

$$TB(i)_t = \alpha_0 + \alpha_1 OG_t + \alpha_2 INF_t + \alpha_3 TB(i)_{t-1} + \alpha_4 FD_t + \varepsilon_t \quad \textbf{(6)}$$

$$TB(i)_t = \alpha_0 + \alpha_1 OG_t + \alpha_2 INF_t + \alpha_3 \Delta ER_t + \alpha_4 TB(i)_{t-1} + \alpha_5 FD_t + \varepsilon_t \quad \textbf{(7)}$$

$$TB(i)_t = \alpha_0 + \alpha_1 OG_t + \alpha_2 INF_t + \alpha_3 \Delta ER_t + \alpha_4 TB(i)_{t-1} + \alpha_5 TB(i)_{t-2} + \alpha_6 FD_t + \varepsilon_t \quad \textbf{(8)}$$

FD is a fiscal deficit, and the coefficient of fiscal deficit is assumed to be positively related with short term interest rate when borrowing from commercial banks is dominant over-

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borrowing from SBP and the converse is true. OLS estimates of linear Taylor rule equations 5, 6, 7 and 8 are presented in Table 3.

Taylor Rule with RGDP

This study also examines all specifications of the Taylor rule with real GDP growth rate rather than output gap. The results are presented in Table 4. Econometric specifications of relevant equations of Rule 1, Rule 2, and Rule 3 are as follows:

$$TB(i)_t = \alpha_0 + \alpha_1 RGDPG_t + \alpha_2 INF_t + \varepsilon_t \quad \textbf{(9)}$$

$$TB(i)_t = \alpha_0 + \alpha_1 RGDPG_t + \alpha_2 INF_t + \alpha_3 \Delta ER_t + \varepsilon_t \quad \textbf{(10)}$$

$$TB(i)_t = \alpha_0 + \alpha_1 RGDPG_t + \alpha_2 INF_t + \alpha_3 \Delta ER_t + \alpha_4 TB(i)_{t-1} + \varepsilon_t \quad \textbf{(11)}$$

C) Data

Quarterly data have been taken from 2005q1 to 2019q3 for the economy of Pakistan. Variables used in the study are three months treasury bill rate (TB3), six months treasury bill rate (TB6), twelve months treasury bill rate (TB12), consumer price index based inflation rate (INF), the nominal exchange rate (ER), real GDP (RGDP), fiscal deficit (FD) and output gap (OG). Statistical bulletin of SBP (various issues) and Pakistan Economic Survey (various issues) have been used to collect the data. We have converted monthly data (high frequency) into quarterly data (low frequency) by applying average observation conversion method. The output gap is estimated through the HP-filter method. OLS and GMM techniques are applied to estimate the models.

4. Results and Discussions

4.1 Results of Non-Modified Taylor Rule: Linear, Static and Dynamic

Now we discuss the results of non-modified Taylor rules. Equations 1, 2 and 3 are estimated as Rule 1, Rule 2, and Rule 3 with the help of one policy instrument with three time periods. Table 1 shows that SBP is not following Taylor rule in the Pakistan as the coefficients of output gaps in all equations of rule 1 are negative. The output gap in the first equation of rule 1 (with TB3 as policy variable) is statistically significant but insignificant in the remaining two equations of Rule 1. The negative and insignificant results of the output gap are consistent with Saghir and Malik (2017). The parameters of inflation are positive and significant in all three equations of Rule 1, but values of the coefficients of INF are much below the benchmark value, given by Taylor (1993) that is 1.5[1]. INF coefficients do not satisfy Taylor principle that is coefficient of inflation is greater than 1. Low values of adjusted R-square exhibit the existence of objectives to the monetary authorities are other than the objectives of output stabilization and stability of price in Pakistan. The risk of spurious results is present when variables are non-stationary but OLS estimates are super consistent if cointegration exists among variables (Ender, 2009). ADF statistics exhibit the cointegration of variables so, results are not unreliable because of the non-stationarity of variables. The low value of Durbin Watson (DW) is an indication of autocorrelation but autocorrelation is not the only reason for the low value of DW, its lowest value maybe also due to the existence of misspecification of dynamics in the

[1] According to Adema (2003), benchmark value of Taylor rule is 0.5 for the coefficient of inflation gap i.e., $(\pi - \pi^T)$, π^T is inflation target. Benchmark value is 1.5 (Taylor, 1993).

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relevant models so if the models are properly and correctly specified then the low value of DW shows autocorrelation (Thursby, 1981). LM statistic with significant value shows the rejection of the null hypothesis of no autocorrelation. The study has also applied likelihood ratio (LR) test to observe that whether DW low value is because of autocorrelation or because of model misspecification error. The null hypothesis of LR test is that errors in the equations under Rule 1 of Taylor rule are autocorrelated. The results of LR show the rejection of null hypothesis so models are not correctly specified i.e., some important variables are missing and the missing variable is the exchange rate.

The differenced lagged exchange rate is included in the equations of Rule 2. The results show that exchange rate is positive but it is insignificant in all three equations of Rule 2, which means exchange rate stabilization is not the preferable objective of the SBP. INF coefficients are positive and significant but these are much lower than the benchmark value and even do not satisfy the Taylor principle, exhibiting that SBP is not following Taylor rule. The output gap is negative in all equations of Rule 2 but significant with TB3 and insignificant with TB6 and TB12.

Table 1: OLS Estimates of Static and Dynamic Linear Taylor Rules

Explanatory Variables	Rule 1 (Static Analysis) Closed Economy Macroeconomic Model			Rule 2 (Static Analysis) Open-Economy Macroeconomic Model			Rule 3 (Dynamic Analysis) Open-Economy Macroeconomic Model		
	TB3	**TB6**	**TB12**	**TB3**	**TB6**	**TB12**	**TB3**	**TB6**	**TB12**
C	7.339 (0.000)	7.536 (0.000)	7.509 (0.000)	7.335 (0.000)	7.526 (0.000)	7.487 (0.000)	1.130 (0.001)	1.442 (0.001)	1.635 (0.002)
OG	-0.160 (0.092)	-0.132 (0.144)	-0.091 (0.349)	-1.160 (0.09)	-0.131 (0.149)	-0.090 (0.358)	0.023 (0.455)	0.035 (0.350)	0.054 (0.268)
INF	0.219 (0.000)	0.206 (0.000)	0.213 (0.000)	0.220 (0.000)	0.207 (0.000)	0.216 (0.000)	0.074 (0.000)	0.074 (0.000)	0.081 (0.003)
D(ER(-1)	----	----	----	0.010 (0.829)	0.023 (0.622)	0.051 (0.326)	-0.009 (0.575)	-0.0004 (0.981)	0.008 (0.733)
TB(-1)	----	----	----	----	----	----	0.821 (0.000)	0.789 (0.000)	0.761 (0.000)
Adj-R^2	0.25	0.24	0.21	0.23	0.23	0.21	0.80	0.88	0.81
DW	0.12	0.17	0.24	0.13	0.18	0.26	0.76	1.23	1.41
LM Stat	178.92 (0.000)	117.40 (0.000)	85.14 (0.000)	176.08 (0.000)	114.39 (0.000)	79.822 (0.000)	12.52 (0.13)	3.17 (0.25)	2.82 (0.15)
LR Stat	137.50 (0.000)	124.43 (0.00)	84.73 (0.00)	137.45 (0.000)	111.05 (0.000)	87.603 (0.000)	----	----	----
ADF-Residuals	-2.299 (0.021)	-1.980 (0.046)	-1.947 (0.049)	-2.27 (0.023)	-1.957 (0.048)	-2.025 (0.041)	-4.836 (0.000)	-6.059 (0.000)	-6.196 (0.000)
F-stat (Prob)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Adjusted R-square is still quite low as in the case of Rule 1. DW values are also the same with negligible rise but still quite low, maybe due to model misspecification. The inclusion of the exchange rate does not change DW at all. Significant values of the LM test shows autocorrelation. LR criteria are applying to examine misspecification error. LR statistic shows the existence of model misspecification. So, there is a need to include some other important variable, it might be interest rate smoothing together with lagged differenced ER. It is rule 3 in Table 1. Changing signs of output gap show that the output gap is influenced by the lagged value of the short-term interest rate, as any monetary policy action influences

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the economic variable after time lags. The coefficients of INF are positive and significant but lower from benchmark value 1.5 and the Taylor principle does not satisfy by the equations. The parameters of differenced lagged exchange rate are insignificant but negative in the first two equations and positive for the last equation. This result is consistent with Erdem *and* Kayhan (2011), Molodtsova et al. (2008), Hacker et al. (2012) and Wu et al. (2015) etc. Lagged values of dependent variables are significant and positive. Inclusion of smoothing variable causes to raise the value of adjusted R-square considerably in large amount, indicating that smoothing variable is important for the model and has a larger share in the variations of dependent variables as compared to any other variable. This result is compatible with Saghir and Malik (2017). Short term interest rate is influenced by its lag value. Output gap, inflation and exchange rate also show different behaviour after the inclusion of the lagged value of interest rate. DW values show much better results now with considerable rise, showing that previous models are mis-specified and inclusion of smoothing variable is more important for the model. LM statistics show no autocorrelation. ADF results in all specifications show that all variables are cointegrated. Findings show that any specification of Taylor rule is not followed by SBP and our results are consistent with Saghir and Malik (2017), Malik and Ahmad (2010), Tariq and Kakakhel (2018).

4.2 Results of Modified Taylor Rules

In this section, we present the OLS and GMM based results of different specifications of modified Taylor rule.

Modified Taylor Rule with Backward-Looking and Forward-Looking Behavior

This section explains the Taylor rule with modification version of backward looking and forward-looking Taylor rules with TB3, TB6, and TB12. To understand the importance of time lags in the transmission of monetary policy, this study has included four lags of inflation and output gap in the Taylor rule. The results of equation (4) are exhibited in Table 2.

Table 2: Estimates of Modified Linear Taylor Rules (with Backward- and Forward-Looking Behavior)

Explanatory Variables	(OLS Estimates) Backward Looking Behaviour			(GMM Estimates) Forward-Looking Behaviour		
	TB3	TB6	TB12	TB3	TB6	TB12
C	0.798 (0.028)	0.959 (0.032)	1.196 (0.037)	-0.163 (0.88)	0.346 (0.503)	0.677 (0.28)
Lag of OG	0.034 (0.025)	0.032 (0.036)	0.023 (0.062)	0.081 (0.051)	0.079 (0.080)	0.078 (0.005)
Lag of INF	0.049 (0.007)	0.051 (0.014)	0.055 (0.053)	0.055 (0.040)	0.006 (0.0835)	0.034 (0.0281)
D(ER(-1)	0.103 (0.049)	0.002 (0.088)	0.004 (0.085)	0.489 (0.073)	0.158 (0.025)	0.086 (0.040)
TB(-1)	0.880 (0.000)	0.860 (0.000)	0.830 (0.000)	1.084 (0.000)	0.967 (0.000)	0.900 (0.000)
Adj-R^2	0.92	0.88	0.81	-0.44	0.74	0.78
DW	0.78	1.48	1.64	1.97	2.10	2.07
LM Stat	14.13 (0.000)	1.494 (0.233)	1.907 (0.158)	----	----	----
ADF-Residuals	-4.278 (0.000)	-6.36 (0.000)	-6.645 (0.000)	-7.397 (0.000)	-7.944 (0.000)	-7.819 (0.000)
F-stat (Prob)	0.000	0.000	0.000	----	----	----

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The OLS estimates indicate the backward-looking behaviour and GMM estimates exhibit the forward-looking version of Taylor rule. One policy instrument with three time periods i.e., TB3, TB6, and TB12 are taking as proxies of short-term nominal interest rate in both types of specifications.

Table 2 exhibits that all the parameters are according to the theory in both the specifications. The lagged values of the dependent variable are closer to 1 in the forward-looking version as compared to the backward-looking version. Adjusted R-square is quite high in backward looking version. The low value of DW and LM statistic for the first equation of backward-looking version, indicate autocorrelation but the remaining two equations of the backward-looking version have large values of DW while LM statistics show no autocorrelation. Adjusted R-square is quite low in the first equation of the forward-looking version but for the remaining equations, it is somehow larger in value. DW statistics are about 2 showing no autocorrelation so there is no need further for applying LM test. In both versions, the coefficients of inflation are lower than the benchmark value and even do not fulfil the Taylor principle. The significance of ADF statistics shows that all variables are cointegrated and there is no chance of spurious results. So, it is concluded that in both versions of the modified backward-looking Taylor rule and modified forward-looking Taylor rule, SBP does not follow Taylor rule at all. The significant positive results of the output gap and inflation rate indicate that SBP follows both backward looking and forward-looking in its decisions.

Modified Taylor Rules with Fiscal Deficit

Table 3 provides the OLS estimates of equation 5, 6, 7, and 8. The results exhibit that the sign of output gap is negative all three equations and it is significant only in the last equation of rule 1. However, coefficients for INF are positive and significant but their magnitudes are much lower than benchmark value and the Taylor principle suggesting that when the output gap rises, it increases the short-term interest rates and allows easy monetary policy by the SBP.

The parameters of fiscal deficit are positive and significant. It implies that when budget deficit increases, it would increase the short-term interest rates which influences borrowing from commercial banks and central bank. Our results are consistent with Saghir and Malik (2017). Adjusted R-square and DW are quite low in value indicating the need to add more important and relevant variables into the model. Value of LM statistics shows autocorrelation.

In rule 2, lagged value of the dependent variable is added. It causes to change the sign of output gap in the model; now the output gap is positive but is still insignificant. The same results are drawn for inflation as in rule 1. The coefficients of lagged dependent variables are positive, high in magnitude and significant. It indicates that its inclusion is important and sign reversal of output gap is consistent with its inclusion in the model so SBP is giving more importance to the lagged value of the dependent variable. The parameters of fiscal deficit become negatively significant in the second equation of rule 2, suggesting that central bank borrowing offsets the borrowing from commercial banks but results are the same for the remaining equations as in rule 1. These results are also consistent with Saghir and Malik (2017). Adjusted R-square and DW are showing high values, indicating that the previous model was mis-specified and that inclusion of the first lagged dependent variable

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as interest rate smoothing is important for the model. LM statistics for the last two equations are insignificant showing no autocorrelation but for the first equation, it shows autocorrelation.

In rule 3, we have added the differenced lagged exchange rate. The same results have been found for the output gap and INF but fiscal deficit becomes negative and still significant in all three equations, indicating that in short term interest rate determination, fiscal deficit plays an important and dominant role. Effects of borrowing from the central bank by the government to finance budget deficit offset by the effects of borrowing from commercial banks. Exchange rate coefficients are insignificant, indicating that SBP does not prefer exchange rate stabilization over inflation and output stabilization. It also indicates that the exchange rate is not playing any role in the fluctuations of short-term interest rates in Pakistan. The exchange rate pass-through is not present in Pakistan. There is a slight improvement in the values of adjusted R-square and DW but still, need for an additional variable is required.

Table 3: OLS Estimates of Taylor Rules with Fiscal Deficit

Explanatory Variables	Rule 1 (Static Analysis) Closed Economy Macroeconomic Model			Rule 2 (Static Analysis) Open-Economy Macroeconomic Model		
	TB3	**TB6**	**TB12**	**TB3**	**TB6**	**TB12**
C	5.09 (0.00)	5.697 (0.00)	6.061 (0.00)	0.275 (0.39)	0.265 (0.51)	0.091 (0.87)
OG	-0.064 (0.46)	-0.056 (0.53)	-0.031 (0.00)	0.010 (0.71)	0.027 (0.43)	0.060 (0.21)
INF	0.233 (0.00)	0.217 (0.00)	0.222 (0.00)	0.078 (0.00)	0.076 0.00	0.083 (0.00)
TB(-1)	----	----	----	0.843 (0.00)	0.828 (0.00)	0.810 (0.00)
FD	0.570 (0.00)	0.467 (0.00)	0.368 (0.00)	0.157 (0.00)	-0.203 (0.00)	0.279 (0.00)
Adj-R^2	0.38	0.31	0.24	0.94	0.91	0.85
DW	0.12	0.17	0.22	1.00	1.85	1.96
LM Stat	127.21 (0.00)	75.54 (0.00)	83.43 (0.00)	9.76 (0.00)	0.14 (0.86)	1.44 (0.24)
F-stat (Prob)	0.000	0.000	0.000	0.000	0.000	0.000
Explanatory Variables	**Rule 3 (Dynamic Analysis) Open-Economy Macroeconomic Model**			**Rule 4 (Dynamic Analysis) Open-Economy Macroeconomic Model**		
	TB3	**TB6**	**TB12**	**TB3**	**TB6**	**TB12**
C	0.511 (0.14)	0.277 (0.39)	0.073 (0.89)	0.483 (0.08)	0.156 (0.72)	-0.103 (0.87)
OG	0.052 (0.07)	0.010 (0.73)	0.065 (0.18)	-0.054 (0.04)	0.006 (0.88)	0.054 (0.34)
INF	0.087 (0.00)	0.077 (0.00)	0.085 (0.00)	0.026 (0.09)	0.071 (0.00)	0.085 (0.00)

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D(ER(-1)	0.003 (0.80)	-0.019 (0.88)	0.021 (0.33)	-0.002 (0.05)	0.007 (0.07)	0.018 (0.04)
TB(-1)	0.785 (0.00)	0.844 (0.00)	0.801 (0.00)	1.464 (0.00)	0.856 (0.00)	0.757 (0.00)
TB(-2)	----	----	----	-0.539 (0.00)	-0.008 (0.94)	0.059 (0.67)
FD	-0.224 (0.00)	-0.155 (0.01)	-0.30 (0.00)	0.050 (0.08)	-0.190 (0.01)	-0.306 (0.00)
Adj-R^2	0.93	0.94	0.85	0.95	0.91	0.85
DW	0.93	1.00	1.91	2.00	1.89	1.88
LM Stat	0.26 (0.19)	9.52 (0.00)	1.35 (0.26)	0.108 (0.89)	0.73 (0.48)	0.26 (0.19)
F-stat (Prob)	0.000	0.000	0.000	0.000	0.000	0.000

In rule 4, we have added second lag of interest rate smoothing. Short-term interest rates are negatively related in the first two equations and it is significant only in the first equation. It is the indication that the first lagged variable is important inclusion into the model as compared to the second lagged value of the dependent variable as interest rate smoothing. The same results have been found for fiscal deficit, inflation and output gap as we have noticed in the previous rules. Adjusted R-square is quite high now, DW is about 2 and LM statistics shows no autocorrelation in rule 4.

Modified Taylor Rule with RGDP

The results of modified Taylor rule with the inclusion of RGDP (instead of the output gap), based on equations are 9, 10 and 11 are displayed in Table 4. OLS estimates of Rule 1 show negative and significant coefficients for RGDPG i.e., the higher RGDPG is attached with easy monetary policy and shows pro-cyclical monetary policy actions of SBP. The parameters of inflation are positive and significant but still do not satisfy the Taylor principle as well as benchmark criteria. A lower value of DW and adjusted R-square indicates that there are some objectives by the SBP other than the objectives of output and price stability. LM statistic indicates autocorrelation.

Table 4: OLS Estimates of Taylor Rule with RGDP Growth Rate

Explanatory Variables	**Rule 1**			**Rule 2**			**Rule 3**		
	TB3	**TB6**	**TB12**	**TB3**	**TB6**	**TB12**	**TB3**	**TB6**	**TB12**
C	10.925 (0.000)	10.433 (0.000)	9.906 (0.000)	10.921 (0.000)	10.418 (0.000)	9.807 (0.000)	3.166 (0.000)	3.035 (0.000)	3.158 (0.000)
RGDP Growth Rate	-3.108 (0.000)	-2.150 (0.000)	-2.085 (0.000)	-3.106 (0.000)	-2.504 (0.000)	-2.071 (0.000)	-1.021 (0.000)	-0.814 (0.000)	-0.908 (0.002)
INF	0.152 (0.000)	0.152 (0.000)	0.170 (0.000)	0.153 (0.000)	0.153 (0.000)	0.172 (0.000)	0.076 (0.000)	0.075 (0.000)	0.079 (0.018)
D(ER(-1)	----	----	----	0.006 (0.870)	0.0198 (0.617)	0.047 (0.307)	-0.008 (0.525)	-0.004 (0.978)	0.010 (0.665)
TB(-1)	----	----	----	----	----	----	0.704 (0.000)	0.700 (0.000)	0.694 (0.000)
Adj-R^2	0.58	0.48	0.36	0.58	0.47	0.36	0.94	0.89	0.83
DW	0.44	0.47	0.37	0.45	0.48	0.40	1.13	1.55	1.57
LM Stat	35.89 (0.000)	34.94 (0.000)	47.64 (0.000)	35.46 (0.000)	34.06 (0.000)	44.125 (0.000)	4.29 (0.18)	0.741 (0.48)	1.755 (0.182)
ADF-Residuals	-3.682 (0.000)	-3.485 (0.000)	-2.861 (0.004)	-3.700 (0.000)	-3.537 (0.000)	-2.999 (0.003)	-5.503 (0.000)	-6.982 (0.000)	-6.825 (0.000)

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F-stat (Prob)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

In rule 2, the study adds differenced lagged exchange rate. The parameters of RGDPG are still negative and significant indicating easy monetary policy behaviour of the SBP. For coefficients of inflation are the same as shown in rule 1. However, coefficients of differenced exchange rate are positive and insignificant indicating that SBP does not follow exchange rate stabilization over output and price stabilization. The results of adjusted R-square and DW are also the same as appeared in Rule 1, suggesting to add another important variable. The significant values LM statistics indicate autocorrelation.

The lagged dependent variable as an explanatory variable is inserted in Rule 3. RGDPG and INF have the same results. Sign reversion has been observed in case of the differenced lagged exchange rate in the first two equations of Rule 3, but in the third equation, it becomes positive. The parameters of lagged differenced ER are insignificant in all three equations, indicating that SBP is completely ignoring exchange rate stabilization. The coefficients of interest smoothing variables show the significant and positive influences on short term interest rates, indicating that short term interest rates TB3, TB6, and TB12 affect more from their own lagged variables as compared to any other variables. SBP gives more importance to the interest smoothing parameter. This inclusion enhances the values of adjusted R-square and DW statistics. Insignificant LM statistics also show no autocorrelation in each of the equation of Rule 3. Our results are consistent with Saghir and Malik (2017).

5. Conclusions and Policy Implications

The study has tested the various specifications of non-modified and modified linear Taylor rules to examine the inflation targeting in Pakistan with the help of short-term interest rate of three time periods. The study has used quarterly time series data from 2005q1 to 2019q3. The findings concludes that the Taylor rule is not followed by SBP, as coefficients of output gap and inflation are against the application of the Taylor rule of inflation targeting in Pakistan. It indicates SBP does not adopt inflation targeting and inflation is not controlling through interest rate adjustment, as suggested in the Taylor rule. The parameter of output gap is negative and insignificant with TB6 and with TB12 under rule 1 and rule 2. Negative and significant coefficients of output gap with TB3 under rule 1 and rule 2, are uncovered but under rule 3 (with exchange rate management and interest rate smoothing), all coefficients regarding output gap are found positive but insignificant. On the other hand, coefficients of inflation are discovered positive and significant as demanding in Taylor rule but the magnitude is far below the benchmark value of 1.5, suggested by Taylor (1993). Inflation parameters are much lower in value as the Taylor principle has not fulfilled. The study finds that SBP is not preferring exchange rate management over the goals of output gap and inflation stabilization. This result is robust in different specifications of the Taylor rule. Interest rate smoothing is positive and significant, showing strong interest rate inertia in Pakistan. It has appeared as an important determinant of the short-term interest rate in Pakistan. This result is also found robust with TB3, TB6 and with TB12.

From OLS estimates of backwards-looking behaviour of Taylor rule and GMM estimates of forward-looking behaviour of Taylor rule, it is revealed that all the coefficients are statistically significant and have correct signs. This result is robust with all three short-term interest rates of TB3, TB6 and TB12. But still, the Taylor principle is not satisfied as the

benchmark value of 1.5 is still much greater than the estimated values of the coefficients of inflation rate. The coefficients of exchange rate are also found positive and significant, showing that SBP also prefers exchange rate stabilization together with output gap and price stabilization. This result is the same in both the forward-looking and backwards-looking behaviour of the Taylor rules. This result is also robust in TB3, TB6 and TB12. It is pointed out that replacement of RGDPG in the Taylor rule has not altered the results of the study. It is concluded that the inclusion of fiscal deficit plays important role in determining the short-term interest rates in Pakistan. The government of Pakistan is borrowing internally from commercial banks and SBP.

The study suggests that SBP should adopt flexible inflation targeting to control inflation in Pakistan in which other objectives like exchange rate management and interest rate smoothing are also considered. SBP should be independent in its decisions to adopt flexible inflation targeting and modify the Taylor rule. Moreover, government of Pakistan should rely on taxes to finance fiscal deficit.

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