Effects of Optimal Monetary Policy Rules on Welfare in a Small Open Economy: A Simulation Analysis

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Abstract

This study explores the optimal monetary policy reaction function and its consequences on social welfare, considering an emerging open economy. Our analysis finds that due to discretionary policy the central bank faces price and exchange rate puzzles and does not care about macroeconomic condition. This analysis shows that with discretion the benefit of policy do not accrue to the society, as predicted, rather the central bank's stance followed during the period of study has not helped in declining inflation. Under discretion the exchange rate channel is not significant. A Monte Carlo simulation experiment indicates that rules perform better in an open economy using Pakistan's data. If central banks of an emerging economy follow a rule based monetary policy, it will help the economic agents to form expectations regarding investment, consumption and other decision. Thus, it is plausible that central bank should adopt any rule, particularly when it is working in an open economy. We also find that following an open economy rule a liberal target of inflation would work better than the strict target, perhaps due to higher average rate of inflation and openness to national and international shocks. The relationship of variance of interest rate with output variance is almost linear, while with other two variables is non-linear. This result emphasizes that the choice of rule rests in the hands of monetary authorities.

Key Words: monetary policy rule, social welfare, exchange rate, reaction function, simulation, discretionary policy

JEL Code: E47, E52, E58

1. Introduction and Background

A considerable research volume over the last few years has attempted to evaluate policy rules in empirical-based macroeconomic models with simple loss functions that cut-down output, inflation and interest rate variability. In open economy case the exchange rate variability is also related to this notion.

It is explained by the New Keynesian literature on credibility of monetary policy that the non-committed equilibrium is suboptimal with forward-looking determination of prices, even without any aggressive output target. As a result of supply shock, commitments regarding upcoming policy can affect equilibrium in an affirmative manner by affecting expectations through a credible way. A good chunk of literature shows that commitment, based on specific rules, improves welfare relative to the discretionary option. Policy rules that boost welfare under the New Keynesian considerations also do improve within a conventional backward-looking model if there are forward-looking asset prices.[1]

[1] Clarida et al., 2000

The studies on the welfare issues and the classification of optimal monetary policy rules for different economic models have shown that welfare-maximizing monetary policy in a closed economy should aim to stabilize both inflation and the output gap.[2] In most open economies, the ranking of alternative monetary regimes and policy rules has been extensively performed on the basis of objective functions or, otherwise, welfare representations derived for closed economy models. A surprising conclusion drawn by some studies is that exchange rate fluctuations have no direct impact on welfare and under perfect exchange rate pass-through; the qualitative results for the closed economy carry over to the open economy (Gali and Monacelli (2002)). Contrary to this result we find that the inclusion of exchange rate in the reaction function has significant outcome for a developing country's monetary policy.

In the early literature on the issue of welfare implications of monetary policy, the link between monetary variability and welfare is channelized through wage indexation; an increase in monetary fluctuations can raise the degree of wage indexation (Devereux (1987)). Consequently, higher wage indexation reduces the authorities' commitment to generate shocks which reduce the average inflation rate. Devereux (1987) comments that the possibility of improvement in welfare due to monetary variability, is a property of discretion. Whereas, in the rational expectations macro-models[3] it is viewed that a rise in monetary variances clearly reduces the welfare thus leaving the impression that monetary variability is awful. An increase in monetary fluctuations leads to an increase in the contracts concerning wage indexation and reduces the responsiveness of output to these surprises (Gray 1976). The welfare judgment is based on an inspection of the variability of output and inflation to different rules (Woodford 2003).

In the analysis concerning open economies, the ranking of alternative monetary regimes and policy rules has been extensively performed on the basis of objective functions. Some literature has assigned weights to variance of inflation and output in different policy options (for example Williams (1999), Dennis (2001).[4]

Contrastingly, a good number of studies solve a model based on Taylor-type rule in a small open economy with Calvo-type price settings, using second order linear approximation technique, assumed shocks to the uncovered interest parity, to domestic production, to the world interest rate and to world inflation, (Kollmann (2002); Sutherland (2006). The inference drawn in such cases are that any optimal rule implies significant nominal and real exchange rate volatility with an anti-inflation stance. Open economy policy rules on have real effects on mean and variance of output (business cycle) and consumption (the welfare of individuals). Sutherland (2006) analyzed the implication of expenditure switching effects of welfare maximizing monetary policy, additionally assumes non-unitary elasticity of substitution between goods produces at home and foreign. Such analysis also finds the scope of writing welfare as weighted sum of the variances of prices and terms of trade in open economy version of models. Corsetti and Pesenti (2001) find that for short run, when the terms-of-trade between domestic and foreign goods favors the foreign economy, demand of home goods increases, home agents' nominal income increases, but their purchasing power falls proportionally.

If the elasticity of substitution are greater than one (as in Obstfeld and Rogoff (1995)), the effect on the real income of home agent will be positive, increasing relative to foreigners and if the final goods are produced from imported and domestic inputs, the degree of competitiveness of the market affects the benefit stream of foreign country after a monetary shock (Berger (2006)). If the competitiveness is too low then the foreign country benefits from domestic monetary expansion. Home-product bias also leads to overshooting and increased precariousness of exchange rates (Warnock (2003). So, the welfare effect of a domestic monetary shock depends on preferences of the consumers. Obstfeld and Roggoff (1995) also concern that monetary policy has prospers-thyself and beggar-thy-neighbor effects but still the policy makers should be careful about the response of neighboring countries to monetary changes at home. Provided this, the welfare would be equally affected by an international monetary policy adjustments in such a way that the cross-country differentials of welfare changes is zero. In short an expansion in monetary stance is likely to have beneficial effects for domestic economy until the cross-country links are weaker.

[2] Woodford (2003) derives the related loss function from the utility function of the representative household.
[3] Barro, Robert J. (1978)
[4] For Pakistan, Malik and Ahmed (2007) are first to estimate the loss function for a closed economy Taylor rule.

For Pakistan, there is little literature available on the discussion of open economy monetary, particularly on the issue of welfare. The pioneering study by Malik and Ahmed (2007) shows that the SBP has never followed any rule like Taylor's, which would have performed in more responsive manner, because SBP would not like to lean against the wind in the economic situation of Pakistan where economic performance and decision making is less elastic to policy changes. Fiscal accommodation could be another reason. Akbari and Rankadua (2006) argue that monetary policy in Pakistan since 1999 shows an inflation targeting trend.

This study aims at to explore the welfare consequences of monetary innovations for a small open economy. We aim to study actual policy response and then do a counterfactual exercise using Monte-Carlo experiments to gauge the welfare consequences of the policy.

The rest of this paper is sequenced as follows; after this background, section 2 discusses the model and methodology used by this study, section 3 interprets the estimation results of the model and the simulations of the study with calibration for welfare analysis, section 4 presents optimal monetary policy results for welfare and section 5 concludes.

2. Model and Methodology

In this section the central bank's objective function is discussed which is used to analyze monetary policy rules in open economy framework. The analysis is based on an inspection of the variability of inflation and output, to different rules which we will estimate with different parametric restrictions in the monetary policy rule. Earlier literature has used different options for welfare analysis. For example Kollmann (2002) calibrated utility of consumer and percent variation in the consumption is considered to be the effect on welfare.

We use the following model with little modification from Ball (1998), and Svensson (1997)

$$y_t = -\alpha_1 r_{r-1} - \alpha_2 e_{t-1} + \alpha_3 y_{t-1} + \varepsilon_t^{y} \quad (1)$$

$$\pi_t = \beta_o + \beta_1 y_{t-1} - \beta_2 (e_{t-1} - e_{t-2}) + \beta_3 \pi_{t-1} + \varepsilon_t^{\pi} \quad (2)$$

$$e_t = \vartheta_1 r_t + \vartheta_2 e_{t-1} + \varepsilon_t^{e} \quad (3)$$

$$i_t = \psi_0 + \psi_1 \pi_t + \psi_2 y_t - \psi_3 e_t + \varepsilon_t^{i} \quad (4)$$

Equation 1 discusses the goods market equilibrium of a small open economy is and is representative of aggregate demand for domestically produced final good. The good is consumed by domestic economic agents; individuals, firms, or government; and by foreigners. y_t is the gap of real output from its steady-state level, r real interest rate, e is the real exchange rate deviation from its trend, ε_t is white noise errors. α_1, α_2 and α_3 characterize instantaneous effects of real interest rate, real exchange rate, and output where $\alpha_1$and α_2 are negative, since a real appreciation has negative direct impact on output and interest rate also impedes output growth. In a situation where output is below its long-run trend, lowering the real interest rate will be expansionary move. It will have a straight forward IS effect i.e., through investment. A positive sign of α_3 confirms that there is inertia in output. Equation 2 is Phillips curve and presents the summary of supply-side. Equation 3 is international parity condition where, theoretically, positive value of θ_1 poses the idea that a rise in the interest rate makes domestic assets more attractive, leading to an appreciation. But sign of θ_1 is still ambiguous because of the definition of real exchange rate and its impacts on the economy. Equation 4 is the open economy monetary policy response function, where i is nominal interest rate and all other variables are as defined earlier. Interest rate depends on weighted sum of an equilibrium level of interest rate, inflation, output gap, and exchange rate gap. In this function we expect $\psi_1 > 0$, $\psi_2 > 0$ and $\psi_3 < 0$.

For welfare analysis, following Taylor, Svensson, Ball and Kollmann, we use the objective function of the central bank, i.e.,

$$\textit{min}\ \mathbf{L_t} = \tfrac{1}{2}\,[\lambda_1\ \mathbf{Var}(y_t) + \lambda_2\ \mathbf{Var}\ (\pi_t)] \quad (5)$$

s.t. equations 1 and 2

Here λ_1 and λ_2 are the weights assigned to output and inflation volatility, respectively. In this exercise we want to relate the objective function of monetary authority to the core model and the welfare of the society.

We investigate the hypothesis that the central bank aims at minimizing the fluctuation in the output and inflation. We then compare the results of this analysis with more conventional analysis, which has been based on constructing Taylor efficiency frontiers, by plotting variance of inflation and output obtained under different open and closed economy rules. We also differ from earlier literature in the choice of variables, frequency of the data and openness of the system i.e., by allowing exchange rate entering the rule.

2.1. Data and Variables

Monthly data of Industrial Productivity Index, Interest rates (both domestic and foreign), Exchange Rate in terms of US Dollars, Inflation, Foreign prices (USA) to convert nominal exchange rate into real exchange rate are used for analysis. The dataset comprises 1981:01 through 2008:06. We have utilized consumer price inflation for two reasons: (i) the impact of monetary policy on the exchange rate may be passed into consumer prices faster than monetary policy affects domestic prices through other channels of the transmission mechanism; (ii) practically, all central banks implementing inflation targeting we have chosen a CPI based measure of inflation. We convert and organize some series into usable shape because a time series with monthly frequencies has many issues; seasonality and trend. So the data series that required to be adjusted is attuned properly. We have used both historical and stochastic simulation techniques to back-cast the data for detailed implication of rules based possibilities on social welfare. The welfare analysis is calibrated in the following subsection.

3. Estimation

After applying unit-root test for the stationarity, we apply ordinary least squares method for the estimation of baseline model. The OLS results confirm the theoretical foundation of section 2 (Table A-1 in appendix). The real interest rate and the real exchange rate gap affect the output gap negatively through the upward shift in LM curve, thereby reducing the output. We also find that when home currency depreciates, via its impact through exports on growth, the output increases. At the same time imports also become costly and prices of raw materials and imported machinery may also increase. So the terms-of-trade loss and higher cost of industrial machinery dampen the output. The reason for the low parametric value of lagged exchange rate for output gap (yet statistically significant) could be off-setting behavior of terms of trade loss. The inertia in output is also confirmed most of the output volatility is self driven. These results are consistent with economic theory and earlier empirical evidence. Ball (1998) found the similar signs of the parameters but the magnitude is different.

For supply side, an increase in positive output gap increases inflation, confirming SR aggregate supply considerations that when output is above its potential level; an increase in output gap will increase the prices. While the impact of lagged-difference of real exchange rate is negative, explaining that a 10 percent increase in the real depreciation a period before, would have lowered the prices by about half percentage point. This means that exchange rate plays very little role in determining inflation, vindicating Taylor (2000) and Ahga et. al. (2005): no exchange rate channel in pass through. For case of Pakistan many factors affected the values of coefficients. The direct control on interest rate; aggregate and individual bank credit ceilings; preferential central bank financing facilities to priority sectors; and high reserve and liquid asset requirement bring a small value of $\alpha 1$ and $\beta 1$ in this *actual* analysis of Pakistan economy. Credit ceiling and other direct controls halt efficient resource allocation. This situation gave birth to unregulated financial intermediation system that compete the regulated system in Pakistan (particularly in 1990s). The impact of real interest rate on exchange rate is positive and theoretically it depicts that an increase in real rate domestically, yields capital inflow under the condition of perfect capital mobility. The lag of dependent variable indicates the exchange rate inertia. Due to inertia factor the results of exchange rate equation also indicate that despite the announcement of flexible exchange rate on January 8th 1982, there has been a control (managed float) by central bank in Pakistan.

The open economy response function has shown the standard sign of parameters and statistically significant at 5% level of significance. But the estimated parameters indicate that the State Bank has not been following a Taylor type rule even for open economy. DW-stat indicates the presence of autocorrelation which shows interest rate smoothing has been the objective of State Bank of Pakistan. The magnitude of our results for interest rate function is little lower than those estimated by Malik and Ahmed (2007). The coefficient of exchange rate confirms Ball (1998) suggesting a 10 percent increase in real exchange rate causes one percent decline in interest rate. The analysis based on OLS estimators raises many issues. It confirms that the SBP has followed a discretionary policy, guided by political influence and implicitly trying to control the inflation.

This actual analysis also shows the inertia in output gap, exchange rate gap and inflation. So in a situation, where no rule is being followed by a central bank, the variation in macroeconomic variables is self-driven.

3.1. Simulations

In the light of basic estimation of the previous section, we have used the interest rate based reaction function for the simulation of the data. The calibrated rules are given in table 1 in the appendix A. Here TR stands for actual Taylor Rule, ATR1 is the augmentation of Taylor rule by providing all weight to inflation in the response of monetary policy with strict target rate of 2%. ATR2 is the case where equal weight is assigned to output gap and inflaton in the response function of the central bank. OTR is open economy taylor rule where we have added exchange rate in the original Taylor rule with full weight to inflation, and OTR2 is open economy Taylor rule with equal weight to output and inflation. The results of these rules after one time simulations are given in Table 2

We first discuss the interest rate response function where we have not directly incorporated the impact of exchange rate. On the basis of the assumptions discussed in previous section and presented in table, we have calculated variances of variables of model.

TR is a Taylor rule under all its standard assumptions. If we compare the simulated series with actual data then we find that the variability of interest rate increases with two percent inflation target. The σ_i^2 almost doubled but this helped a lot to control the variation of inflation, output and exchange rate. Average values of inflation and output decreased while exchange rate and interest rate increased with Taylor rule. It means that following a rule, the economy would have less distortion. This is clear cut indicator of the fact that frequent changes in interest rate (if prescribed by the rule) will result in less deviation of output from its mean.

While in the special cases where we assume that monetary authorities put all effort to a strict inflation targeting (ATR1), the variance of both output and inflation decreased compared to the actual data. In this case output gap has been given zero weight in formulating monetary policy reaction function and policy responded to inflationary changes only. This has increased the variation in exchange rate.

A policy rule when central bank adjust inflationary expectations equal to the nominal interest rate (holding real interest rate equal to zero), assigning equal weights to output and inflation, is the first best rule in closed economy model; it has produced the minimum variance in output and inflation. This case represents the 8% target level of inflation and assigning equal weight to inflation and output gap. At the same time variance of exchange rate decreased to its minimum level, too. This is analogous to the first best case proposed by Malik and Ahmed (2007). Thus we can infer that in an open-economy model with flexible exchange rates the inflation target of 8% has improved the macroeconomic performance by reducing the distortions in the output gap, inflation and exchange rate. The performance of the economy has improved in open economy framework compared to the closed one. If flexible exchange rate is adopted then the variation in output gap and inflation is less than that found in Malik and Ahmed. But the main result is same that a liberal target of 8% inflation is the best rather than any strict mark. Interestingly the variance of interest rate has over-shot. Thus the interest rate smoothing cannot take place simultaneously, if authorities want to achieve the dual objective of output gap and inflation targeting.

So for, we have discussed the results of closed economy version of the rules. Now we draw our attention towards rule OTR, OTR1 and OTR2 which are defined as above. One interesting feature, we see is that the variance of inflation has decreased by handsomely.

The average variance of inflation for all open economy rules is 6.3, while for the closed version this average is 6.69, thus reducing the inflationary variation by 0.39 points. On the other hand these new rules have not any significant influence on σ_y^2; it lowered just by 0.01 point. But we have achieved a minimal point in output and inflation variance, described by OTR2 which could be the first best rule among all the cases.

Similarly, the variance of exchange rate has also decreased in almost every case of open economy version. The average variance of real exchange rate gap in closed form model is 31.73 while it has reduced to 23.7, resulting in an average reduction of 8.03 point. On the other hand the variance of interest rate has increased on average. This analysis of variances suggests again that there is a trade-off between the variance of interest rate and those of output gap, real exchange rate gap and inflation.

For the selection of first best parametric values of the rule we used the minimum loss[5] criteria. The first best rule according to minimum variance of inflation and output criteria is the OTR2 and second best is ATR2. But we will discuss four rules from both types of the economic scenarios for stochastic simulation. So we will discuss first best pair of rules and second best pair of rules.

We applied bootstrap simulation for all the cases. This stochastic simulation is being presented for the best cases only. The selection of the best cases was made on the criteria of economic performance of the selected variables. The nature of the results is same as discussed above. Now we discuss these four cases one by one.

The First Best Rule

After estimation we found the best rule in terms of reducing the variability in inflation and output: it is an open economy case where we have incorporated following set of assumptions: central bank should set real interest rate equal to zero along with equal weight to both output and inflation. The rule takes the form;

$$i= -4+1.5\pi + 0.5\, y - 0.5e$$

If authorities use exchange rate as a policy tool then the variation in inflation is controlled more than the case where only domestic distortions are in focus. In this first best rule the stochastic treatment indicates that there is probability of 0.026 for this rule to produce greater variance of inflation from that of actual data and zero probability of variance of output with rule being greater than that in the actual data.

In first best set of parameters, the inflation variance on average is slightly higher than that in one time simulation, and probability of this average variance to be greater than that in actual variance is about 44%. Thus it could be inferred that variability in inflation and output could be decreased if State Bank of Pakistan would have followed a rule analogous to this.

The Second Best Rule

Table shows the results of second best, open-economy rule. In this rule full weight is given to inflation targeting, and output gap did not have any attention of the central banker. The rule has the following shape;

$$i = 0+2\pi - 0.5e$$

Here we can confirm that the state bank could have followed strict inflation targeting setting inflation rate at 2 percent with no weight to output gap. The strict inflation targeting can be defined as the policy that minimizes the variance of inflation without any focus on real stabilization. When inflation departs from the assigned target, then the strict targeting diminishes the departure as quickly as possible. Choosing such policy implies a huge sacrifice in output stability (variance of output gap increased by 1 point) for a small gain in inflation stability (the variance of inflation lowered just by 0.18 points). Strict inflation targeting is found to be suboptimal if policy-makers put a medium and negligible weight on output gap. The bootstrap results also indicate that inflationary variation has been at its minimum in these rules with the probability 0.06 % of rule based variance being greater than that in actual data.

The variance of exchange rate has not changed significantly between the two rules. The average value of interest rate has gone up by 204 basis points. The increase in interest rate may shorten the boom period. Average level of output gap became negative, indicating that this regime would have produced output below the long run trend level.

ATR2

A rule assigning equal weight to both output and inflation with zero real rate is found to be best for closed version rules. Stochastic simulation indicates that out of 1000 times the probability of variance with rule being greater than variance of the actual data is 2.4% for inflation and for output it is 2.5%. Bootstrapping has increased the average variance of both output and inflation.

This rule minimized the variance of output even more than the overall first best rule. But the variance of interest rate is at highest indicating that with a higher inflation target (8% in this case) produces more variations in the interest rate.

[5] This minimum loss has been the concern for welfare which is scope of this paper, we discuss in next section.

The tri-cycle will follow this path: a lower variation in output will close the gap between output level and its trend, which will create an up-word pressure on prices, so targeting the inflation at 8% will generate reduction in purchasing power of the people, reducing the demand, people will hold money with them. This will shift the demand for money up, resultantly shifting the LM to the left causing an increase in interest rate. In this case the rule is based on following considerations:

$$i = -4+1.5\pi + 0.5\ y$$

3.2 Calibration for Welfare Analysis

The literature discussed above provides us enough rationale to use a loss function of the form we used in equation 5, which has another look in equation 6 and 7. Here we discuss some rules which performed better in bringing down the variations in output and inflation to calibrate loss function**.** Objective is to minimize loss subject to aggregate demand and supply curves. We use following calibration for the computation of welfare measure; (here *L* represents loss to the society)

$L_t = \lambda\ \text{Var}\ (y_t) + (1-\lambda)\ \text{Var}\ (\pi_t)$ (6)

$L_t = \lambda_1\ \text{Var}\ (y_t) + \lambda_2\ \text{Var}\ (\pi_t) + \lambda_3\ \text{Var}\ (e_t) + \lambda_4\ \text{Var}\ (i_t)$ (7)

Case 1: If $\lambda_3 = \lambda_4 = 0$ then

$L_t = \lambda_1\ \text{Var}\ (y_t) + \lambda_2\ \text{Var}\ (\pi_t)$

and $\lambda_1 + \lambda_2 = 1$, so $\lambda_1 = 1-\lambda_2$

Three more assumptions are given as;

$\lambda_1 = 1$, $\lambda_1 = 0$, $\lambda_1 = 0.5$

$L_t = \lambda\ \text{Var}\ (y_t) + (1-\lambda)\ \text{Var}\ (\pi_t)$

If $\lambda_1 = 1$; all the weight in loss function is given to variance of output.

If $\lambda_1 = 0$; all the weight in loss function is given to variance of inflation.

If $\lambda_1 = 0.5$; equal weight is given to variances of both output and inflation.

If $\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = 0.25$ means equal weight is given to the variance of all the variables.

And similarly we can incorporate different options of λ_3 and λ_4 as well. We have formed seven different options of loss functions named $L_1\ L_2\ L_3\ L_4\ L_5\ L_6\ L_7$ to choose the best performing rules selected on the basis of minimum loss to society. We have summarized these in table 1.

4. Optimal Monetary Policy and Welfare Analysis

Table 6 shows that in $\mathbf{L_1}$ all weight is given to inflation variability, in $\mathbf{L_2}$ equal weight is assigned to inflation and output variances with no weight to interest rate and exchange rate distortions. In $\mathbf{L_3}$ equal weight is assigned to the variance of all the objective variables except for the response variable i.e., interest rate. $\mathbf{L_4}$ bears the equal weights of all the variables' variances in the model. $\mathbf{L_5}$, $\mathbf{L_6}$ and $\mathbf{L_7}$ are cases where we have assigned all the weight to the variances of output, exchange rate and interest rate respectively.

Table 7 shows the loss incurred to the society by different monetary settings. The loss function of an open economy policy rule in which all weight assigned to inflation target, presents less distortion to the welfare of the economic agents. In this loss function we have given all weight to inflationary swings with zero values of $\boldsymbol{\lambda_2, \lambda_3, \lambda_4}$**.** But in case, where equal weight is shared by both output and inflation variances the loss to the society is minimum, i.e., a rule with modest inflation target of 8% with nominal interest rate equal to expected inflation. When the inflationary expectations of economic agents exactly match the pre-announced rules, their decisions regarding consumption, investment and savings become more efficient. In $\mathbf{L_3}$ where we have assigned equal weights to the variances of all the endogenous variables, the rule with strict inflation target, without any weight to output stability in the rule is better. In this case exchange rate variance has been given equal weight. So if central banks want to bring fewer distortions in the open economy framework, then they must follow a policy rule analogous to what is found better in this study.

A situation where monetary authorities assume that output distortions are much important for the welfare of the society then they must put all the weight to the variance of output gap without considering other variables is $\mathbf{L_5}$. In this situation rule ATR2 which is a closed version of the rule, performs better than all other rules. But with a very small difference, OTR2 is also among the better performers.

In both, rule ATR2 and OTR2, the common assumption is regarding the expected inflation equal to nominal interest rate and a modest target of inflation, with equal weight given to inflation and output.

If central banks want to minimize the distortion in the economy through disciplining the exchange rate variability then they can use a canon similar to rule OTR1. Whereas if the central bank wants to smooth the interest rate then she should not follow any rule rather their discretionary policy is better than anything else. This is quite clear from the results of estimation of our macroeconomic model.

Figures 1 to 3 present the relationship between the standard deviations of interest rate and other variables. Interest rate variations have negative relationship with the variances of output gap, real exchange rate gap and inflation. The relationship of variance of interest rate with output variance is almost linear, while with other two variables is non-linear. This result emphasizes that the choice of rule rests in the hands of monetary authorities, i.e., if they want to lower the welfare loss then they have to withdraw the discretionary policy. Central banks will have to sacrifice the discretionary status if the maximization of welfare is the objective.

5. Concluding remarks and Policy Implications

The objective of this study is to find out the welfare implication of monetary policy. We analyzed both discretion and rules that are found optimal for policy. We found that with discretion central bank of an emerging economy serves only to control the variation in interest rate whereas the volatility in macroeconomic variables was higher. We also find that for emerging economies liberal inflation target would be better than he strict one, because of the sacrifice that low inflation brings in the shape of low production as a result of low investment. We also find that the twin objective of obtaining stability in macroeconomic variables, particularly output and the interest rate smoothing cannot be achieved simultaneously. This result emphasizes that the choice of rule rests in the hands of monetary authorities, i.e., if they want to lower the welfare loss then they have to withdraw the discretionary policy. Central banks will have to sacrifice the discretionary status if the maximization of welfare is the objective. However, there could be many limitations in this analysis, which in future research can be addressed in detail, e.g., the non-linearity in the behavior of central bank and in the Phillips curve require smooth transition analysis.

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Appendix A

Table A-1: Estimated Coefficients of Macro Model

Coefficient	Estimated Coefficients	t-Stats	R^2 & DW
α_1	-0.0952	-4.015	R^2 = 0.523 DW = 2.213
α_2	-0.0242	-1.91	
α_3	0.581	11.41	
β_o	0.429	2.88	R^2= 0.94 DW =1.8
β_1	0.082	2.44	
β_2	-0.0421	-1.30	
β_3	0.9445	52.00	
ϑ_1	0.059	2.061	R^2 = 0.950 DW = 2.03
ϑ_2	0.9657	63.81	
ψ_0	5.609	8.01	R^2 = 0.0.16 DW = 0.84
ψ_1	0.299	3.44	
ψ_2	-0.3256	-2.67	
ψ_3	-0.0923	-2.37	

Table 1

Rules	Parametric Restrictions and Rule Equations
Rule 0	**Actual estimated response function**
TR	$\bar{r} = 2$, $\pi^* = 2$ and $b = c = 0.5$ $\quad i = 1+1.5\pi + 0.5\, y$
ATR1	$\bar{r} = 2$, $\pi^* = 2$, $b = 0$ and $c = 1$ $\quad i = 0+2\pi$
ATR2	$\bar{r} = 0$, $\pi^* = 8$ and $b = c = 0.5$ $\quad i = -4+1.5\pi + 0.5\, y$
OTR	$\bar{r} = 2$, $\pi^* = 2$, $b = c = 0.5$, $d = -0.5$ $\quad i = 1+1.5\pi + 0.5\, y - 0.5e$
OTR1	$\bar{r} = 2$, $\pi^* = 2$, $b=0$, $c=1$, $d = -0.5$ $\quad i = 0+2\pi - 0.5e$
OTR2	$\bar{r} = 0$, $\pi^* = 8$, $b = c = 0.5$, $d = -0.5$ $\quad i = -4+1.5\pi + 0.5\, y - 0.5e$

Table 2: Variances of Variables in Closed version of the Rule (One time simulation)

Rules	σ_i^2	σ_π^2	σ_e^2	σ_y^2
Actual	12.44	12.07	56.43	3.74
TR	22.46	7.15	32.79	2.46
ATR1	29.87	6.59	33.65	2.73
ATR2	57.39	6.35	28.75	1.76
OTR	27.62	6.60	23.59	2.43
OTR1	35.08	6.06	23.04	2.76
OTR2	59.53	6.24	24.36	1.79

Table 3: Simulation with First Best Rule

			First Best Rule for Open Economy		
		Actual Data	Historical	Bootstrap*	p-value**
Interest Rate	Average	7.85	8.13		
	Variance	12.44	59.53		
Inflation	Average	7.72	7.75		
	Variance	12.07	6.24	6.38 (0.438) (2.271)	0.026
Exchange Rate	Average	0.25	0.18		
	Variance	56.43	24.36		
Output gap	Average	0.13	0.105		
	Variance	3.74	1.79	1.91(0.44) (0.291)	00.00

* Average of 1000 values of variance in bootstrap simulation. In first parenthesis probability of average is given, while standard errors are in the second parentheses.

** Probability of rule based variance being greater than that in actual data.

Table 4: Simulation with Second Best Rule

			Second Best Rule for Open Economy		
		Actual Data	Historical	Bootstrap*	p-values**
Interest Rate	Average	7.85	9.89		
	Variance	12.44	35.07		
Inflation	Average	7.72	6.28		
	Variance	12.07	6.06	5.810 (0.44) (1.99)	0.006
Exchange Rate	Average	0.25	5.35		
	Variance	56.43	23.04		
Output gap	Average	0.13	-0.93		
	Variance	3.74	2.76	2.98 (0.44) (0.522)	0.085

* Average of 1000 values of variance in bootstrap simulation. In first parenthesis probability of average is given, while standard errors are in the second parentheses.

** Probability of rule based variance being greater than that on actual data.

Table 5: Simulation with First Best Rule for Closed Version

			First Best Rule for Closed Version		
		Actual Data	Historical	Bootstrap*	p-values**
Interest Rate	Average	7.85	8.12		
	Variance	12.44	57.39		
Inflation	Average	7.72	7.72		
	Variance	12.07	6.35	6.66 (0.44) (2.31)	0.024
Exchange Rate	Average	0.25	0.29		
	Variance	56.43	28.75		
Output gap	Average	0.13	0.093		
	Variance	3.74	1.76	2.81 (0.47) (0.46)	0.025

* Average of 1000 values of variance in bootstrap simulation. In first parenthesis probability of average is given, while standard errors are in the second parentheses.

** Probability of rule based variance being greater than that in actual data.

Table 6: Weights of λs in Loss Functions

Λs	**L_1**	**L_2**	**L_3**	**L_4**	**L_5**	**L_6**	**L_7**
λ_1	1	0.5	0.33	0.25	0	0	0
λ_2	0	0.5	0.33	0.25	1	0	0
λ_3	0	0	0.33	0.25	0	1	0
λ_4	0	0	0	0.25	0	0	1

Table 7: Loss to the Society by Different Monetary Settings

Rules	**L_1**	**L_2**	**L_3**	**L_4**	**L_5**	**L_6**	**L_7**
Actual	12.07	7.905	23.839	21.17	3.74	56.43	**12.44**
TR	7.15	4.805	13.99	16.215	2.46	32.79	22.46
ATR1	6.59	4.66	14.180	18.21	2.73	33.65	29.87
ATR2	6.35	4.055	12.164	23.56	**1.76**	28.75	57.39
OTR	6.6	4.515	10.765	**15.06**	2.43	23.59	27.62
OTR1	**6.06**	4.41	**10.514**	16.73	2.76	**23.04**	35.08
OTR2	6.24	**4.015**	10.689	22.98	1.79	24.36	59.53

Figure 1

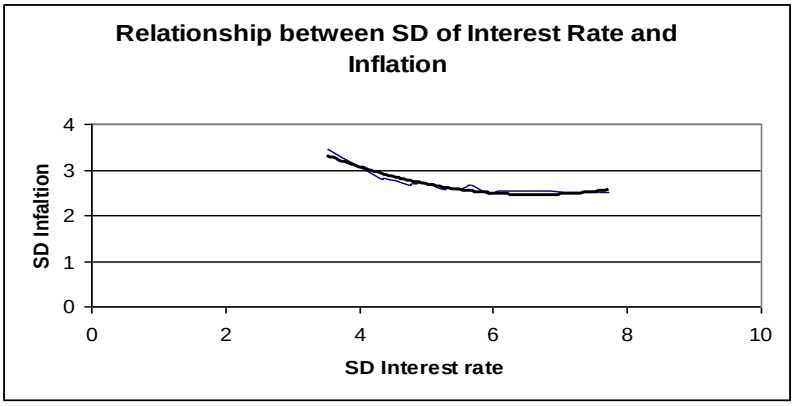

Figure 2

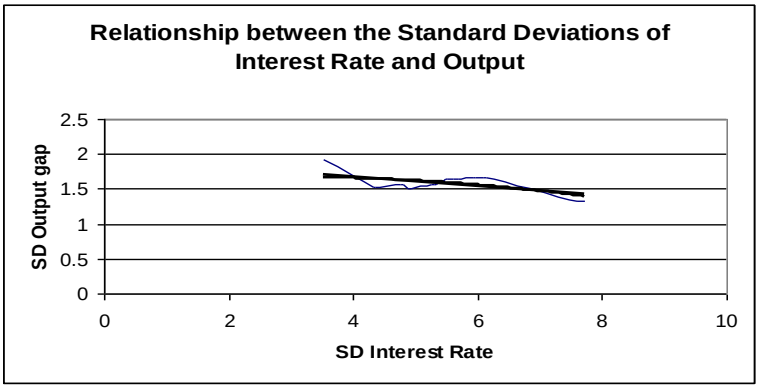

Figure 3