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Monetary Policy and Inflation-Output Variability in Sri Lanka: Lessons for Developing Economies

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Abstract

This paper examines the impact of monetary policy on the inflation-output variability trade-off for Sri Lanka, drawing monetary policy lessons for developing economies. We examine how this trade-off has changed across different monetary policy episodes, and investigate the persistence of the variability of inflation and output after supply and demand shocks. Finally we explore the contribution of monetary policy to macroeconomic performance more generally. Learning from the experience of Sri Lanka, our findings suggest that more recently formed central banks should focus on inflation variability, especially where the impact of demand and supply shocks are less persistent.

JEL Classification: E52, E58, O23

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1. Introduction

Whilst the debate over the trade-off between inflation and output has been widely discussed in both the theoretical and empirical strands of the business cycle literature, in the context of developing economies this area is less populated. Which is the more appropriate target for a recently formed central bank presiding over a developing economy? In this study we draw on the experience of Sri Lanka, over the period 1980 to 2017, to suggest that early stage monetary policy should focus on the stability of prices over economic activity. In a structural vector autoregressive model, we make use of sub samples to control for structural changes to the economy, considering the complications presented by supply and demand shocks. The Sri Lankan economy has registered high levels of growth alongside low levels of inflation over the last three decades, that growth and inflation has been highly volatile with a notable and regular cyclical behaviour. The variability of inflation has fallen noticeably while that of output has increased significantly and so provides us with a perfect experiment to measure the connection between monetary policy in a developing economy with macroeconomic outcomes.

Since Taylor (1979), commentators have argued that the trade-off between inflation and output might be described more acurately in terms of their variability[1]; suggesting a Taylor curve more theoretically consistent with mainstream macroeconomics. The variability version of this trade off, used in Taylor (1999), can be thought of as a second-order Phillips curve that captures the trade-off between the variability of inflation and output; any attempt to stabilise inflation will result in larger fluctuations in output. Similarly, an attempt to minimize fluctuations in output risks higher variability in inflation. Policymakers do not face a trade-off between the levels of inflation and output, but between the variability of inflation and output, Taylor (2013).

With the historical implementation of inflation targeting frameworks by central banks, it is also natural that the preferences of policymakers with respect to the stabilization of inflation and output have changed over time. Fackler and McMillin (2011) estimate the inflation-output variability trade-off under inflation forecast targeting using monthly US data between 1962 and 2000. The trade-off between the variability of inflation and output has changed favourably over time; meaning that less policy interventions are required to achieve the targeted level of inflation as time has progressed.

In fact, numerous studies have tried to test for or find evidence of changes in these competing priorities. Olson et al. (2012) examine the efficiency of monetary policy in the United States during the period 1875 to 2000 using the Taylor curve. They claim that the distance between the origin and the Taylor curve was smallest during periods in which monetary policy was more successful in terms of reducing the variabilities of output and inflation. The opportunity cost of reducing the variability of inflation in terms of output variability was significantly lower after the 1950s.

Cecchetti et al. (2002) explore how the policy preferences of central banks has changed

[1]See Chatterjee et al. (2002); Walsh (2009); King (2012) and for examples in agreement more generally

over time. They find that aversion to inflation variability has increased in all 23 countries under investigation during the 1990s compared to the 1980s. However, the study suggests that reduced inflation variability among inflation targeting countries has resulted in increased output variability. By contrast Levin et al. (2004) find that inflation targeting countries do not seem to exhibit higher levels of variability in output, in comparison to non-inflation targeting countries. A later study by Cecchetti et al. (2006) finds that an improved efficiency of monetary policy at cross-country level is often supported by structural changes in the economy and the reduction in the variability of supply shocks [2].

In the context of developing economies, a study by Ndou et al. (2013) investigates how demand and supply shocks have affected the variability trade-off over time, for the case of South Africa. They show that the Taylor curve has shifted inwards during the inflation targeting regimes compared to other regimes. Their results suggest that the performance of the South African economy was improved during the period when the Taylor curve relationship holds. Onyukwu et al. (2011) take a regime approach to investigate how monetary policy has affected the nature of the trade-off between the variability of output and inflation in Nigeria over the period 1995 to 2007. The magnitude of monetary policys impact on output and inflation varies across different policy regimes. Despite no evidence of a strong trade-off between the variability of inflation and output, the study shows that monetary policy has a robust impact on output growth compared to price stability depending on the type of monetary policy regime in place; the volatility of output and inflation becomes more persistent during periods when indirect control of monetary policy was in place.

In a cross country context Amarasekara and Bratsiotis (2015) compare the efficiency of monetary policy in inflation targeting and non-inflation targeting countries. Countries who implement inflation targeting will register lower levels of variability in both inflation and unemployment, though for non-inflation targeting economies the smoothing of inflation comes at the cost of increased unemployment variability. Adopting an explicit inflation

[2] For studies claiming strong evidence of a short run trade off between the variability of inflation and long-run output for the case of the US, see Fuhrer (1997), Logue and Sweeney (1981) and Conrad and Karanasos (2015).

targeting framework provides clarity and transparency towards the inflation stabilization objective of the central bank, thereby helping to improve the trade-off generally. This argument is discussed in Fraga et al. (2003), who compare the performance of monetary policy under inflation targeting in emerging and advanced economies. Their results show that the emerging market economies register a greater level of trade-off between the variability of inflation and output compared to advanced economies. The study highlights the presence of heterogeneity in the development of institutions, low credibility of institutions and adverse supply shocks have resulted in higher volatility in output, inflation and interest rates in both advanced and emerging economies.

Another cross country study by Arestis et al. (2002), examines whether or not the implementation of inflation targeting frameworks by central banks has improved the trade-off between the variability of output and inflation during the 1980s and 1990s. The results suggest that the implementation of inflation targeting frameworks in six central banks out of eight has significantly improved monetary policy trade-offs. To the best of our knowledge, no previous studies have focused on examining the impact of monetary policy on the trade-off between the variability of inflation and output, specifically for Sri Lanka.

Using monthly time series data and a structural vector autoregression model, we examine three different monetary policy regimes. Our choice of samples considers the following background for the case of monetary policy in Sri Lanka: After the economic and financial sector reforms undertaken from 1977, the Central Bank of Sri Lanka (CBSL) has moved from direct to market-based policy instruments, formally adopting a monetary targeting policy framework from the 1980's. Under this framework, the CBSL has conducted monetary policy with the aim of maintaining reserve money as an operating target and broad money as an intermediate target for economic stability. Further, since January 2001 the CBSL has allowed the exchange rate to float freely. This has reduced the role of the exchange rate as a stabilization tool, but increased the role of reserve money as a nominal anchor. Another significant shock for macroeconomic policy is that presented by the Sri Lankan civil war which ran from 1983 to 2009. Consequently, our first subsample runs from 1980 to 2000, marking the floatation of the exchange rate. Our second and third sub samples are separated by the end of the civil war, meaning that our second subsample runs from 2001 to 2009 and the third from 2009 to 2017.

The main results can be summarized as follows. Firstly, we find that the inflation-output variability trade-off for Sri Lanka has shifted favourably over time and that the economy has witnessed the highest level of output growth during the periods in which the Taylor curve relationship is satisfied. Secondly, we find that the impact of demand and supply shocks on the variability of inflation and output are not persistent, suggesting that the deviations from the Taylor curves caused by adverse shocks are transitory if the central bank operates efficiently. Thirdly, we find that the CBSL has increasingly lent weight to the stability of prices over time, suggesting that the bank has adapted monetary policy whilst enjoying substantial improvements in welfare loss during the post-war period compared to other periods.

The rest of this paper is organized as follows. Section 2 outlines the sources of our data and methodological framework adopted, including an in-depth derivation of the Taylor curve. Section 3 offers quantitative insights on the impact of monetary policy on inflation-output variability trade-off for the case of Sri Lanka. The final section summarizes the major findings and provides recommendations for more recently formed central banks in developing economies.

2. Data and Methodology

In this section we outline our empirical strategy, including a presentation of the data and its sources, before a detailed description of the methodology. As this study mainly focuses on inflation-output variability trade-off, we first derive a Taylor curve equation, before outlining the estimation approach we follow to investigate the persistence of the variability of inflation and output in response to supply and demand shocks. Thereafter, we estimate the relevant parameters of the Taylor curve equation using a structural vector autoregressive (SVAR) model in a similar way to Vinayagathasan et al. (2013), also for Sri Lanka. Using the estimated parameters of the Taylor curve equation, we then examine the contribution of monetary policy towards Sri Lanka's macroeconomic performance.

2.1. Data

This study uses time series monthly data, beginning in 1980 to coincide with the adoption of a monetary targeting policy framework in Sri Lanka, up and until 2017. The data on the exchange rate, interest rate, and fiscal variables are mainly drawn from various annual reports of the Central Bank of Sri Lanka (CBSL). Data for other variables have been extracted from three different sources; growth rates of real gross domestic production (GDP) and the inflation rate are sourced from various publications obtained from the Department of Census and Statistics (DCS) of Sri Lanka. Monthly real GDP series are not available for Sri Lanka; the DCS published real GDP data on an annual basis until 1996 and thereafter publishes on both an annual and quarterly basis. We have therefore used a cubic spline interpolation technique proposed by Fox (2000) to convert the annual series (and the quarterly series from 1996) to a monthly frequency. Due to the unavailability of a monthly time series for policy rates of the CBSL, we consider the 3-months Treasury Bill rate as the short-term interest rate. Meanwhile, the output gap is calculated as the percentage deviation of real GDP from its trend value obtained using the HodrickPrescott (HP) filter.

2.2. The Derivation of the Taylor Curve

The Taylor curve can be derived using the minimization of the quadratic loss function of the central bank subject to the dynamics of output and inflation.

$$L = E[\lambda(\pi - \pi^*)^2 + (1-\lambda)(y - y^*)^2] \qquad 0 < \lambda < 1 \tag{1}$$

Equation (1) is the standard quadratic loss function of the central bank widely used in empirical studies to examine monetary policy. Where π is inflation and y is output and π^* and y^* are the targeted levels of inflation and potential output. The parameter λ is the policymakers aversion to inflation variability, Cecchetti et al. (2002). Deviation in actual output from potential or current inflation from targeted inflation generates a loss for the central bank. Meanwhile, the dynamics of output and inflation are assumed as a function of interest rate and given in equations (2) and (3).

$$y_t = \psi(r_t - d_t) + s_t \qquad \psi < 0 \tag{2}$$

$$\pi_t = -(r_t - d_t) - \omega s_t \tag{3}$$

where d_t and s_t denote demand and supply shocks while r_t denotes interest rate. ψ measures the ratio between the responses of output and inflation to a monetary policy shock. This is generally referred to as the inverse slope of the aggregate supply (AS) curve. Similarly, the parameter ω measures the slope of the aggregate demand curve. According to equations (2) and (3), demand and supply shocks are considered as primary sources of exogenous disturbances in the economy and therefore policy responses are crucial. Demand shock moves output and inflation in the same direction while supply shock moves them in opposite directions and creates a policy dilemma, Cecchetti et al. (2002). Supply shocks will force the monetary authorities to face the trade-off between the variability of output and inflation in the long-run. This trade-off can be used to construct an efficiency frontier known as the Taylor Curve that traces minimum points of variability in inflation and output.

Combining equations (2) and (3), we can derive the optimal policy of the central bank as given in equation (4). Accordingly, the interest rate set by the policymakers is a linear function of demand and supply shocks. In the presence of both shocks, the policymakers need to behave optimally to minimize any welfare loss.

$$r_t = ad_t + bs_t \tag{4}$$

Substituting equation (4) into (2) and (3), we can obtain the variances of output (σ_y^2) and inflation (σ_π^2) as given in equations (5) and (6).

$$\sigma_y^2 = (a-1)^2\psi^2 + (1+\psi b)^2\sigma_s^2 \tag{5}$$

$$\sigma_\pi^2 = (1-\psi)^2 + (\omega + b)^2\sigma_s^2 \tag{6}$$

Similarly, substituting equations (5) and (6) into (1) and minimizing the loss function with respect to a and b, we yields the following solution.

$$a = 1 \tag{7}$$

$$b = \frac{a(\psi - \omega) - \psi}{a(1 - \psi^2)} + \psi^2 \tag{8}$$

The solution given in equation (7) sugests that policymakers will completely offset demand shocks one for one on both output and inflation. However, according to solution (8), the reaction of monetary policy to supply shocks is complicated because they themselves generate a trade-off. It further shows the degree of monetary reaction depends on structure of the economy as measured by ω, ψ and the policymakers aversion to inflation variability λ. Substituting solutions (7) and (8) into equations (5) and (6), we can derive the ratio between the variability of inflation and output. This ratio shows the unit cost of output variability in terms of inflation variability, which is generally described as the Taylor curve.

$$\frac{\sigma_y^2}{\sigma_\pi^2} = \left(\frac{\lambda}{(\psi(1 - \lambda))}\right)^2 \tag{9}$$

According to (9), the trade-off between the variability of output and inflation depends on the value of λ and ψ. Allowing λ to vary between zero and one, we can derive output-inflation variability frontier. The shape of this frontier depends on $\frac{1}{\psi}$ but unaffected by ω. This implies that if the value of ψ is higher, then any reduction in inflation variability results in larger increases in output variability. Similarly, when policymakers are concerned solely with output variability $\lambda = 0$, the ratio between variability of output and inflation will be equal to zero. In contrast, if policymakers place their entire attention on minimizing the variability of inflation, then the ratio between variability of output and inflation will be equal to infinity.

In order to derive the Taylor curve relationship given in equation (9), we need to first estimate λ. In this study, we will estimate λ for both full sample and subsample periods using a SVAR approach. Additionally, we need to estimate ψ and the ratio between the variability of output and inflation. For this purpose, our baseline assumption is that policymakers are interested in minimizing the variability of inflation and output.

This study follows the methodology used by Cecchetti et al. (2002) to estimate the variability of output and inflation. Accordingly, we define the variability of output as squared deviations of actual output from potential output, estimated using the Hodrick-Prescott (HP) filter approach. Similarly, the variability of inflation is defined as the squared deviations of actual inflation from the targeted level of inflation π^*. We will consider the average inflation rate registered for each regime as our proxy for targeted inflation. As Sri Lanka registered a monthly inflation rate of more than 20 percent during the 1980s and 1990s, assuming the targeted level of inflation as 5 percent might be viewed as an unrealistic policy goal during these periods. Thus, throughout the analysis, we will consider the average inflation in each regime as that targeted. The procedures that will be applied to estimate the required coefficients of the Taylor curve equation (9) are described in the following section:

2.3. Estimating the Persistence of Variability of Output and Inflation to Demand and Supply Shocks

This section describes our approach to exploring the persistence of the variability of output and inflation in response to demand and supply shocks. In order to identify the trend of the demand and supply shocks, we have to first estimate the aggregate demand and Phillips curve equations. For this purpose, we follow the aggregate demand and supply model developed by Ndou et al. (2013). Equation (10) represents the aggregate demand equation, where the output gap is a function of its own lags, lags of the inflation rate, lags of the nominal interest rate, lags of the exchange rate and lags of the deviation of oil prices from their potential levels. The potential levels of the oil prices are estimated using the HP filter approach.

More precisely, we define our bivariate system as

$$
\begin{aligned}
y_t = c_{1,0} + \sum_{i=1}^{n} \delta_{1,t} y_{t-i} + \sum_{i=1}^{n} \beta_{1,t} \pi_{t-i} + \sum_{i=1}^{n} \kappa_{1,t} i_{t-i} \\
+ \sum_{i=1}^{n} \phi_{1,t} exr_{t-i} + \sum_{i=1}^{n} \psi_{1,t} oil_{t-i} + \varepsilon_{1,t}
\end{aligned}
\tag{10}
$$

$$
\begin{aligned}
\pi_t = c_{2,0} + \sum_{i=1}^{n} \delta_{2,t} y_{t-i} + \sum_{i=1}^{n} \beta_{2,t} \pi_{t-i} \\
+ \sum_{i=1}^{n} \phi_{2,t} exr_{t-i} + \sum_{i=1}^{n} \psi_{2,t} oil_{t-i} + \varepsilon_{1,t}
\end{aligned}
\tag{11}
$$

where $c_{h,0}$ $\delta_{h,l}, \beta_{h,l}, \kappa_{h,l}, \phi_{h,l}$, $\psi_{h,1}$, are the coefficients of the system to be estimated for the variables y_t and π_t respectively. Equation (11) denotes the Phillips curve equation where the inflation is a function of its own lags, lags of the output gap, lags of the exchange rate and lags of the oil prices gap. In both equations, the exchange rate is included to capture the impact of openness on aggregate demand and supply. $\varepsilon_{1,t}$ and $\varepsilon_{2,t}$ are the demand and supply shocks. We will first estimate a VAR model in the form of the above two equations for both full sample and subsample analyses. Thereafter, we will use the impulse response functions (IRFs) to investigate the persistence of the variability of output and inflation to demand and supply shocks.

2.4. Estimating the Impact of Monetary Policy on Output and Inflation

To examine the impact of monetary policy on output and inflation, we can estimate a value for ψ given in equation (9). For this purpose, we use the SVAR model developed by Kim and Roubini (2000) to identify monetary policy shocks from a combination of long-run and short-run restrictions. A detailed description of the SVAR model is presented below. Assume the economy is described by a structural form equation as follows,

$$
G(L)x_t = e_t \tag{12}
$$

where $G(L)$ is a matrix polynomial in the lag operator of L, x_t is an n x 1 vector of variable, and e_t is an n x 1 vector of structural disturbances serially uncorrelated with constant variance, $Var(e_t) = \Lambda$. Λ is a matrix with diagonal elements that represent variances of structural disturbances assumed to be uncorrelated. For simplicity, we have omitted the constant terms in the model. The reduced form equation of VAR can be estimated as given in equation (13).

$$x_t = B(L)x_t + u_t \tag{13}$$

where $B(L)$ is a k x k matrix polynomial (without the constant term) in lag operator L. The lag operator of $B(L)$ can be written as $B(L) = I_k - B_1L - B_2L^2 - B_pL^p$. The variance of u_t implies that $E(u_t, u_t^i) = \Sigma$. There are several ways of recovering the parameters in the structural form equations from the reduced form equations. Econometric methods including the method proposed by Sims (1980) provide restrictions only on contemporaneous structural parameters.

Note that the generalized SVAR suggested by Blanchard and Watson (1986), and Sims et al. (1986) allows nonrecursive structures while providing restrictions only on contemporaneous structural parameters. Let $G0$ be the coefficient matrix (non-singular) on $L0$ in $G(L)$, that is, the contemporaneous coefficient matrix in the structural form. And let $G0(L)$ be the coefficient matrix in $G(L)$ without contemporaneous coefficient $G0$ (see equation (14)). Then, the parameters in the structural form equation and those in the reduced form equation can be related by equation (15).

$$G(L) = G_0 + G^0(L) \tag{14}$$

$$B(L) = -G_0^{-1}G^0(L) \tag{15}$$

The structural disturbances and the reduced form residuals are related by $e_t = G_0U_t$. Accordingly, the relationship between reduced form and structural model can be expressed as follows:

$$\Sigma = G_0^{-1} \Lambda G_0^{-1} \tag{16}$$

As per equation (16), there is $n(n + 1)$ number of free parameters that must be estimated. Since Σ contains $n(n + 1)/2$ parameters, we need at least $n(n + 1)/2$ restrictions. By normalizing diagonal elements of G_0 to 1's, we need at least $n(n + 1)/2$ restrictions on G_0 to achieve identification. In the structural VAR approach, G_0 can be any structure if it has enough restrictions. We use a similar set of six variables as used by Cecchetti et al. (2002) to estimate a SVAR model. The six variables are represented in vector X_t:

$$X_t = (i_t, y_t, \pi_t, E_t, O_t, FF_t) \tag{17}$$

where i_t is the short-term policy interest rate, y_t is output, π_t is the price level expressed by the consumer price index (CPI), E_t is the exchange rate and O_t is the global oil price. FF_t is the federal funds rate. Of the six variables, the global oil price and the federal funds rates represent the foreign variables, while real GDP, CPI, short-term interest rate and the exchange rate represent the domestic variables. Due to the limited availability of the short-term policy interest rate, we use 3-month treasury bill rates. Studies such as Kim and Roubini (2000) and Brischetto et al. (1999) have established that these six variables are adequate to analyze the monetary policy framework of a small open economy. The SVAR model that will be estimated to analyze the impact of monetary policy on inflation and output is thus given as follows:

$$\begin{bmatrix} i_t \\ y_t \\ \pi_t \\ E_t \\ O_t \\ FF_t \end{bmatrix} = \begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \\ \delta_5 \\ \delta_6 \end{bmatrix} + \begin{bmatrix} \psi_{11} & \psi_{12} & \psi_{13} & \psi_{14} & \psi_{15} & x_{16} \\ \psi_{21} & \psi_{22} & \psi_{23} & \psi_{24} & \psi_{25} & x_{26} \\ \psi_{31} & \psi_{32} & \psi_{33} & \psi_{34} & \psi_{35} & x_{36} \\ \psi_{41} & \psi_{42} & \psi_{43} & \psi_{44} & \psi_{45} & x_{46} \\ \psi_{51} & \psi_{52} & \psi_{53} & \psi_{54} & \psi_{55} & x_{56} \\ \psi_{61} & \psi_{62} & \psi_{63} & \psi_{64} & \psi_{65} & x_{66} \end{bmatrix} \begin{bmatrix} i_{t-i} \\ y_{t-i} \\ \pi_{t-i} \\ E_{t-i} \\ O_{t-i} \\ FF_{t-i} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \\ \varepsilon_{6t} \end{bmatrix}$$

The short-run restrictions specified for the monetary policy analysis are given as follows:

$$G_0X_t = \begin{bmatrix} \varepsilon_i \\ \varepsilon_y \\ \varepsilon_\pi \\ \varepsilon_E \\ \varepsilon_O \\ \varepsilon_{FF} \end{bmatrix} = \begin{bmatrix} 1 & \psi_{12} & \psi_{13} & \psi_{14} & 0 & 0 \\ \psi_{21} & 1 & \psi_{23} & 0 & \psi_{25} & 0 \\ 0 & \psi_{32} & 1 & 0 & \psi_{35} & 0 \\ \psi_{41} & \psi_{42} & \psi_{43} & 1 & \psi_{45} & \psi_{46} \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} e_i \\ e_y \\ e_\pi \\ e_E \\ e_O \\ e_{FF} \end{bmatrix}$$

The interest rate equation is interpreted as the policy reaction function of the central bank in which output, inflation and the exchange rate are included. Output is expressed as a function of four variables; namely the oil price, inflation, interest rate and exchange rate. Since price expectations depend on factors such as the oil price, we include a variable on oil prices in our forward-looking monetary policy model. The third equation includes the adverse impact of global oil prices on domestic inflation. The exchange rate is considered as an information market variable that reacts quickly to all relevant economic disturbances. Thus, the structural equation for the exchange rate shows it as contemporaneously affected by all the variables included in the model. Equations five and six represent global oil prices and the federal funds rates respectively, both of which depend on all other variables. The federal funds rate is used as a proxy for global financial conditions.

2.5. Estimating the Contribution of Monetary Policy in Macroeconomic Performance

The second specific objective of this study is to examine the contribution of monetary policy on observed changes in macroeconomic performance. In this section, we will describe the procedures that we follow to measure macroeconomic performance. For this purpose, we adopt the methodology of Taylor (2013) and Cecchetti et al. (2002). Accordingly, we make use of the central bank's welfare loss function as an indicator of how well the central bank stabilizes both inflation and output subject to various shocks. The optimal monetary policy is defined as a policy that minimizes the variability of the central banks ultimate objectives from their target, Fuhrer (1997). This implies that the central bank focuses on the levels of inflation and output relative to potential and therefore adjusts its policy rates to minimize the variability of output and inflation.

$$P_i = \lambda VAR(\pi_i) + (1 - \lambda)VAR(y_i) \tag{18}$$

$$\Delta P_{i,t} = P_{i,t-1} - Pi, t \tag{19}$$

where $0 \leq \lambda \geq 1$ and $i = 1, 2, 3....$ are policy regimes. The macroeconomic performance that will be estimated in this study is given by the variability of output and inflation weighted by λ from equation (18). Since we seek to compare welfare losses across different policy regimes, we will not consider a discount factor in the loss function. Meanwhile, the changes in macroeconomic performance are measured consistent with equation (19). $\Delta P_{i,t} > 0$ shows an improvement in macroeconomic performance. To allow for an appropriate comparison across periods, we need to assume λ is constant over all periods. Allowing different values for λ may lead to the wrong conclusion. For instance, ΔP can suggest a slowdown in macroeconomic performance even when variability of both output and inflation remain at the lowest level.

3. The Case of Sri Lanka: Results and Discussion

Given that our sample involves the period around the introduction of the flexible exchange rate in 2000 and the end of civil war in 2009, we place special focus on the presence of two structural breaks in the conduct of monetary policy in Sri Lanka. Consequently, our entire sample period of this study is divided into three sub-samples. Starting in 1980 to coincide with the introduction of a monetary targeting framework in Sri Lanka, we insert 2000 (exchange rate) and 2009 (civil war) as interventions, with the sample ending in 2017. The analysis is conducted for both full sample and subsample periods for comparison purposes and as a basic robustness check.

We begin by examining the stationary properties of all the series considered in this study, using the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests, before estimating the Taylor curve for Sri Lanka, across the entire sample and subsamples, including a time varying rolling inspection of the correlation between output and inflation variance. Following this we carry out a simple impulse response function exercise to inspect the impact and persistence of economic shocks on the variability of output and inflation, before using the welfare loss function for the central bank to investigate the linkage between monetary policy and macroeconomic performance for Sri Lanka.

3.1. Unit Roots

The stationary properties of all the series are examined using the ADF, PP and KPSS tests, the results of which for the full sample period are presented in Table 1. The tests confirm that four variables are non-stationary since the null hypothesis of the ADF, PP and KPSS tests cannot be rejected at 5 percent level of significance. However, the remaining variables are integrated with order one in their first differences. These results are consistent for all variables across all tests. As this study places focus on the presence of structural breaks in the conduct of monetary policy, the stationary properties of all variables also need to be investigated for subsample periods as well. We have also tested the order of integration across the subsample periods, which are largely consistent, though with a higher likelihood of integration of order one.

Table 1: Unit root tests - levels and first differences (Full sample).

Variable	ADF Test				PP Test				KPSS Test			
	Levels		First Diff.		Levels		First Diff.		Levels		First Diff.	
	Int.	Trend & Int.	Int.	Trend & Int.	Int.	Trend & Int.	Int.	Trend & Int.	Int.	Trend & Int.	Int.	Trend & Int.
CPI	4.902	-0.637	-11.003*	-16.848*	4.214	-0.679	-17.524*	-17.698*	2.401	0.637	1.580	0.091*
FPI	-1.640	-2.758	-9.085*	-9.075*	-1.337	-2.407	-12.615*	-12.601*	1.734	0.297	0.069*	0.057*
RGDP	-4.786*	-4.742*	-9.880*	-9.875*	-4.309*	-4.336*	-13.967*	-13.946*	0.128*	0.099*	0.068*	0.046*
TB	-2.934*	-3.732*	-13.692*	-13.698*	-3.016*	-3.790*	-23.207*	-23.206	0.933	0.184*	0.061*	0.023*
EXR	0.685	-2.730	-8.932*	-9.006*	1.018	-2.298	-14.882*	-14.942*	2.617	0.389	0.219*	0.041*
OIL	-2.048	-2.976	-14.134*	-14.121*	-1.309	-2.405	-13.651*	-13.636*	1.525	0.348	0.079*	0.062*
FB	-2.796	-3.458*	-7.358*	-7.378*	-3.645*	-4.093*	-17.213*	-17.203*	1.530	0.168	0.103*	0.038*
FED	-2.780	-6.643*	-14.532*	-14.467*	-2.142	-3.283	-12.933*	-13.017*	2.181	0.173*	0.094*	0.031*

Notes: * indicates significance at 5%. Tests carried out for interval only (Int.) and trend and interval together (Trend and Int.). RGDP, TB, FB and FED found I(0) and CPI, FPI, EXR and OIL found I(1).

3.2. The Taylor Curve Relationship for Sri Lanka

As a preliminary analysis, we examine the profiles of inflation and economic growth for Sri Lanka in both their level and first differences. As can be seen in Figure 1, neither series exhibit any trend over the period. The Sri Lankan economy registered an episode of 30 percent of inflation rate during the early 1980s, before declining back towards 1985, thereafter escalating during the early part of the 1990s. The profiles, suggest that the central banks loss function may have given a relatively small weight to inflation variability. However, after 2009, the inflation rate fell back to within single-digit levels; during the same period, the economy witnessed an average growth rate of around five percent. Especially, high levels of economic growth can be observed following the end of the civil war in 2009. However, the fluctuations in inflation appear higher than that for economic growth rate.

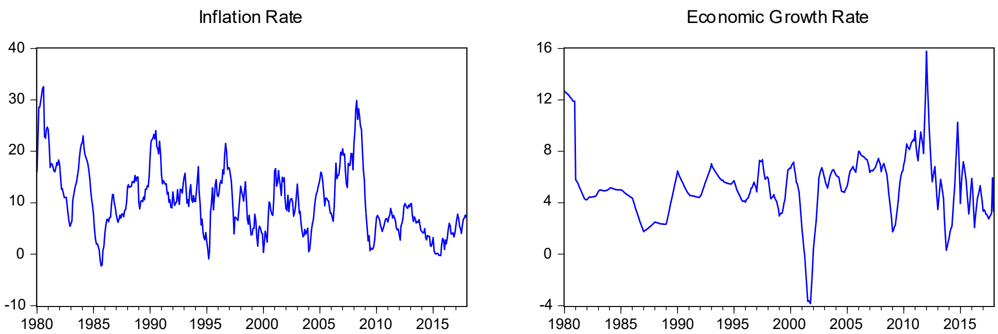


Figure 1: Movements of Inflation and Output Growth in Levels

As this study focuses on the trade-off between the variability of inflation and output, we next show how the variability of inflation and output growth changed over the sample. From Figure 2, several conclusions can be drawn. Firstly, over this period the variability of inflation has decreased while the variability of output has increased, implying an improvement in macroeconomic performance. Inflation variability fell during the early 1990s and 2000s. Forward from 2012, the country witnessed inflation variability of less than five percent. This suggests that the central bank has predominantly placed a higher level of importance on implicit inflation targeting. We can also see that monetary policy was less effective in reducing output variability during the periods 1997-2005 and then from 2010-2015. It is possible that low inflation variability was attained at the expense of increased output variability.

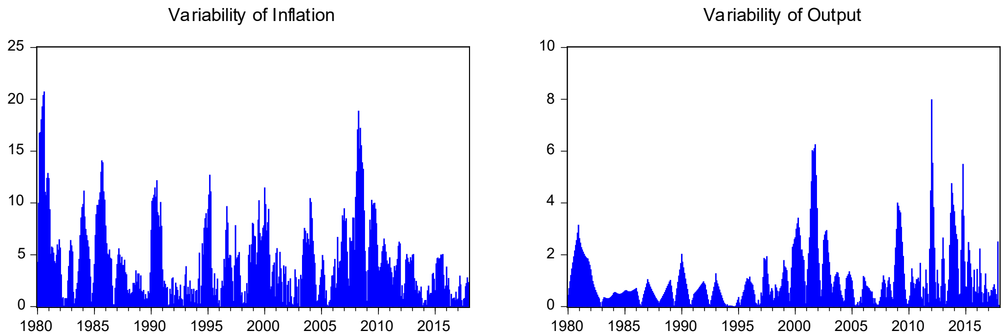


Figure 2: Movements of the Variability of Inflation and Output Growth

For comparison purposes, we examine movements of inflation and output growth in first differences. According to Figure 3, the volatility of inflation is significantly higher than that of output growth. Although the high level of volatility in inflation could be observed prior to 2010, the trend of volatility has diminished since. This implies that the Sri Lankan economy experienced a transition from relatively higher volatile inflation regimes at the beginning of the study period to more stable regimes thereafter. The reduced volatilities in inflation might also be supported by the low level of external and domestic supply shocks, a more stable economic structure and the implementation of better monetary policy, Jegajeevan (2016). However, the examination of these factors is beyond the scope of this study, though it is worth noting that the volatility of growth was almost stable till the end of 1995, thereafter increasing. Volatility increased significantly after 2010, largely inline with the conclusions drawn from Figure 2.

To identify the Taylor curve relationship, we plot the relationship between the variability of inflation and output for both the full sample and subsamples using scatter diagrams. As we can see from Figure 4, the patterns of the Taylor curve relationships have changed across different monetary policy regimes. The negative trade-off appears established in all periods,

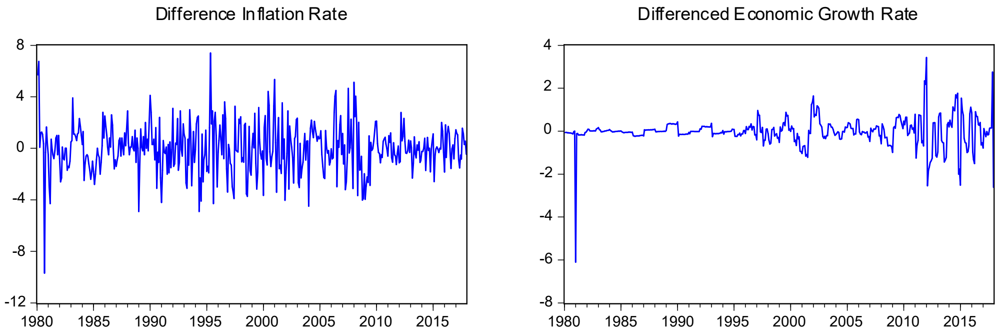


Figure 3: Movements of the Inflation and Output Growth in First Differences

except 1980-2000. To investigate further, we calculate the constant correlation between the variability of inflation and output, for which the results are presented in Table 2. Note that the lowest growth rate was witnessed when the variability of both inflation and output registered their highest level. This is particularly notable during the period 2001-2009 where the economy registered its lowest average growth rate while recording the highest level of variability in both inflation and output growth relative to other periods. This suggests that the central bank should maintain lower fluctuations in inflation in order to attain higher level of output growth. It is also evident that the economy witnessed the highest level of output growth during the periods in which the negative Taylor curve relationship is satisfied.

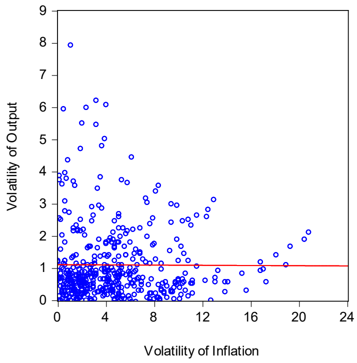
Table 2: The Trade-off Between the Variability of Inflation and Output

Period	Average		Correlation	Average		Policy Stance
	Inflation Var	Output Var		Inflation Rate	Growth Rate	
1980-2017	4.328	1.109	-0.038	10.461	5.202	Optimal
1980-2000	4.914	0.841	0.291	11.809	5.070	Suboptimal
2001-2009*	5.034	1.447	-0.199	12.564	4.908	Optimal
2009-2017	2.195	1.441	-0.107	4.985	5.800	Optimal

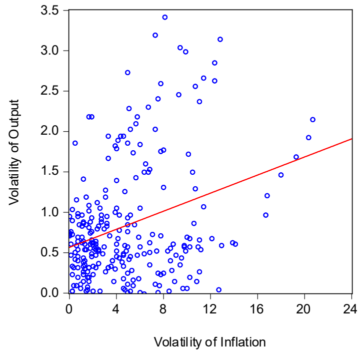
Notes: *Up to May 2009

From Table 2 we can see that monetary policy was optimal in every period, except when

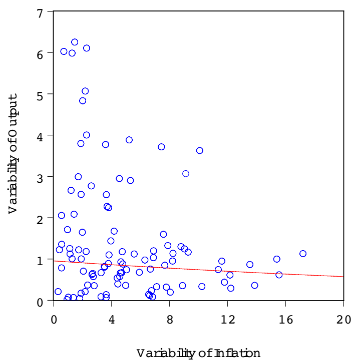
(a) 1980-2017



(c) 1980-2000



(b) 2001-2009



(d) 2009-2017

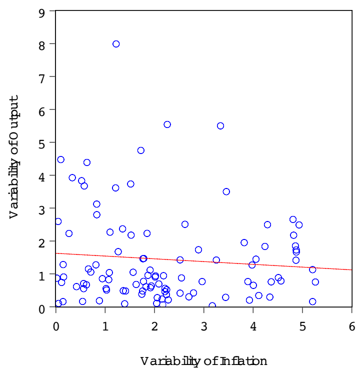


Figure 4: Time-Varying Rolling Correlation between Variability of Output and Inflation

we select the subsample period of 1980-2000. The positive correlation established during the period 1980-2000[3] suggests that the monetary authority in Sri Lanka has placed more weight on stabilizing output. Although constant correlation coefficients provide valuable evidence with respect to the nature of the relationship, estimating correlation coefficients as a time-varying process would provide more insights on how the Taylor curve relationship has evolved over time. For this purpose, we estimated rolling window correlations of between

[3]According to Taylor (1999), monetary policy is optimal when the trade-off between the variability of output and inflation is negative. But, according to Friedman (2006), if the trade-off between the variability of inflation and output is positive, then monetary policy is characterized as suboptimal.

1 to 4 years for both the full sample and subsamples; we present smoothed correlations using a rolling window of 2 years, making the assumption that the CBSL has implemented its monetary policy in a forward-looking manner where the real effects of changes in the interest rates on the economy have taken place after 2 years. [4]

The time-varying correlations analysis shown in Figure 5, provides a more detailed perspective on the episodes of monetary policy for which we might classify as either optimal or suboptimal. The correlation was largely positive between 1980 and 1994 with marked exception in 1992, suggesting that monetary policy was suboptimal during this period. However, the existence of a negative correlation between the variability of inflation and output showed that monetary policy was largely optimal during the period 2001-2005. Although this relationship supports the presence of a negative trade-off between both variabilities, this relationship has changed in the later part of the study period. Most notably, there is a positive correlation during the period 2006-2008, and the latter part of 2010. This positive relationship again observed from the third quarter of 2016, authenticating that monetary policy was suboptimal during these periods.

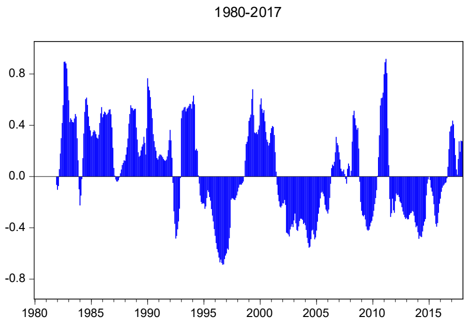
Although the time-varying correlation analysis has provided valuable insights about the nature of the relationship between the variability of output and inflation, and thus the stance of monetary policy, it would be interesting to know how the patterns of the Taylor curves have change over the business cycle. For this purpose, we have plotted the 2-year rolling correlation against the GDP growth rate, see Figure 6. We find that in most of the periods the positive trade-off between the variability of inflation and output is followed by a slowdown in output growth. This suggests that the suboptimal monetary policy could have had an adverse affect on economic growth in Sri Lanka.

3.3. The Persistence of Variability of Output and Inflation to Demand and Supply Shocks

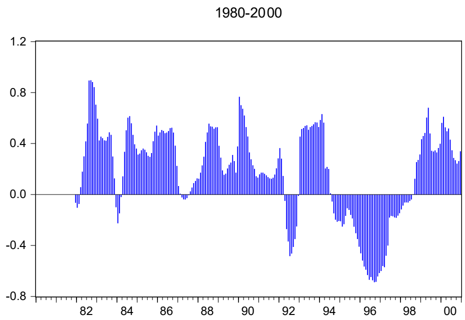
We extend our analysis to study how demand and supply shocks have affected the variability of output and inflation during the period under consideration. After estimating aggregate demand and Philips curve equations, we utilise impulse response fucntions (IRF)s

[4] The time varying correlations for the remaining intervals are available from the authors, upon request.

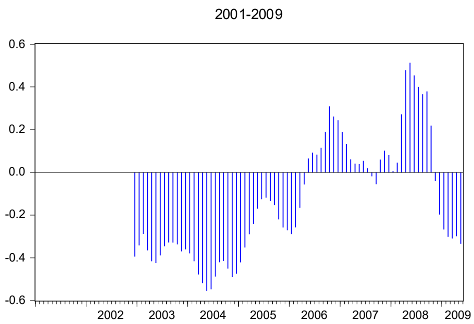
(a) 1980-2017



(c) 1980-2000



(b) 2001-2009



(d) 2009-2017

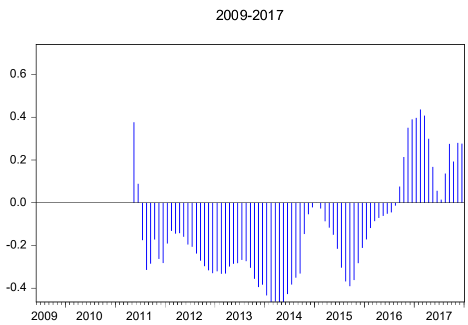


Figure 5: Time-Varying Rolling Correlation between Variability of Output and Inflation

to predict how the variability of output and inflation react in response to demand and supply shocks. We have made use of the generalized IRFs to deal with the orderings of the variables.

The estimated IRFs, presented in Figure 7, show that both demand and supply shocks do not have highly persistent impacts on the variability of inflation and output, but do suggest transitory effects. In the case of output variability, both demand and supply shocks die out after 15 months. However, for inflation variability, the persistence was moderate, where demand and supply shock die out after 20 months and 24 months respectively. We conduct a similar analysis for the subsamples,[5] and in contradiction, the subsample analysis shows that inflation is more persistent in response to both demand and supply shocks. This is particularly evident during the periods 1980-2000 and 2001-2009. This may have been

[5]The results from the subsample analysis are available from the authors, upon request

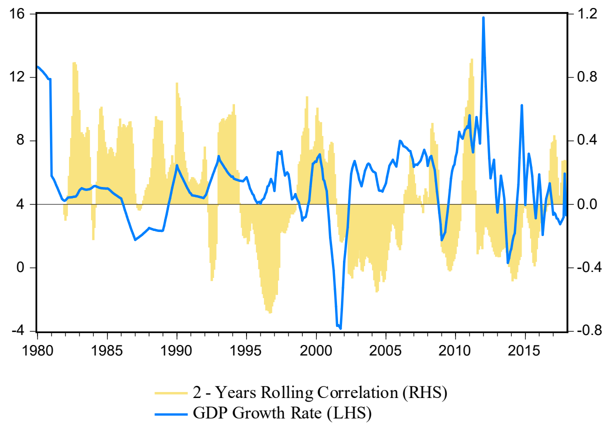


Figure 6: Rolling Correlation of Volatilities and GDP Growth (1987-2017)

caused by the central bank reacting to minimize the adverse impacts caused by these shocks during the post-war period. As the response of variability of inflation and output are not persistent for the case of the full sample, we move forward with the conclusion that deviations from the Taylor curve should be transitory if the central bank conducts its monetary policy efficiently.

3.4. The Contribution of Monetary Policy to Macroeconomic Performance in Sri Lanka

In this section, we examine the contribution of monetary policy to observed changes in macroeconomic performance under different monetary policy regimes. The macroeconomic performance will be measured using the loss function of the central bank, assuming that the central bank chooses an interest rate path to minimize its loss function.

To estimate the welfare loss function, we first need to investigate the policy preferences of the central bank with respect to the stabilization of inflation over time; for this purpose, we need to compute the inverse slope of the aggregate supply curve $\left(\frac{1}{\psi}\right)$. We employ a SVAR approach to establish a valid baseline SVAR model, from which the IRFs are used to analyse the impact of a monetary policy shock on output and inflation. Using the estimated value of $\frac{1}{\psi}$ along with the ratio between the variability of output and inflation, we will estimate the preference parameter of the central bank, λ. After which, we use the estimated preference parameter to study the contribution of monetary policy to observed changes in

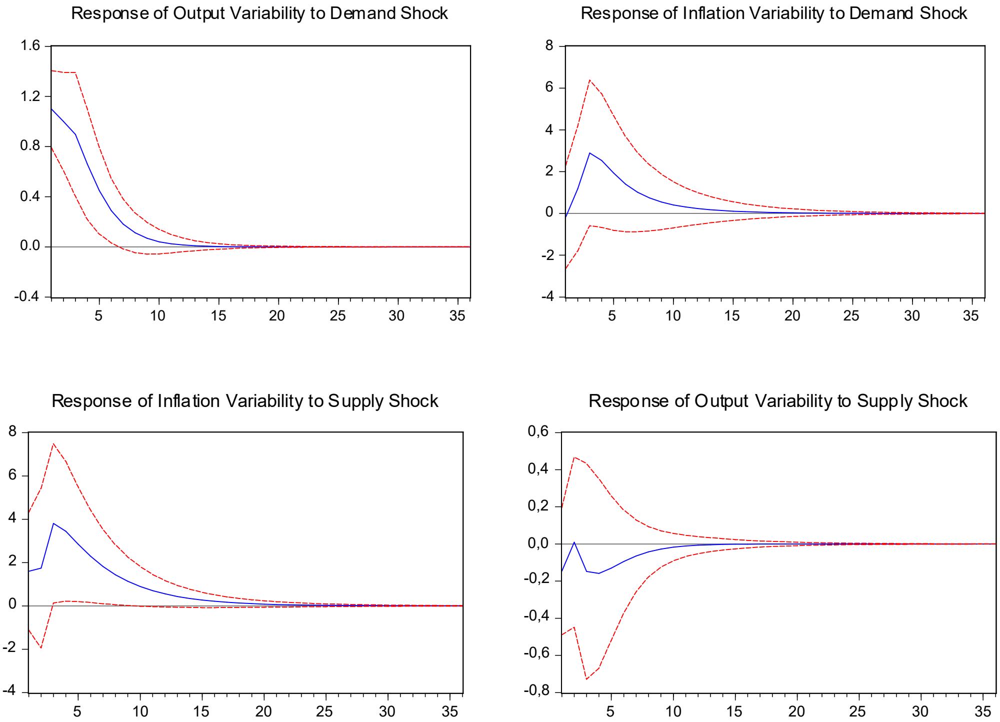


Figure 7: Responses of the Variability of Output and Inflation to Demand and Supply Shocks

macroeconomic performance in terms of welfare loss during the period 1980-2017. Further we use the sub samples to investigate whether monetary policy in Sri Lanka became more efficient over the three periods in terms of reducing welfare loss.

3.5. The Estimation of Inverse Slope of the Aggregate Supply Curve

The IRFs shown in Figure 8 show the responses of output and inflation to a positive monetary policy shock for the full sample period. The patterns of IRFs vary quite dramatically; an unexpected rise in short-term interest rates causes a statistically significant decline in output growth, including the expected hump shaped response from output that bottoms-out after 7-10 months. The immediate reduction in output in response to contraction of monetary policy is compatible with many standard US based studies, and with previous findings such as from Disyatat and Vongsinsirikul (2003) for Aisa, and Perera and Wickramanayake (2013), specifically for Sri Lanka.

The response of inflation to a positive interest rate innovation is positive for at least 8

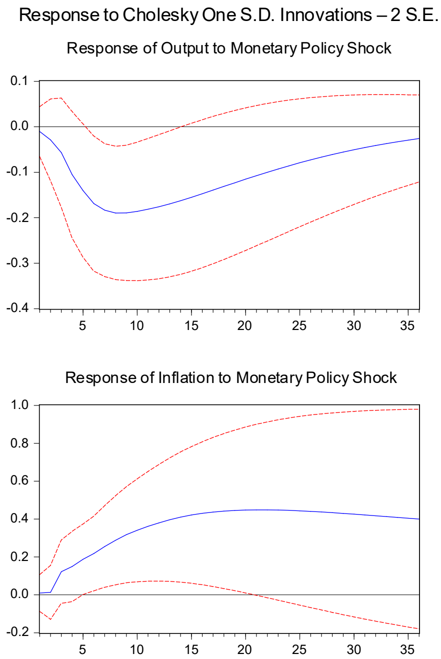


Figure 8: Responses of Output and Inflation to Monetary Policy Shock (1980-2017)

months, but thereafter gradually falling back. This finding challenges the consensus within the theoretical literature and is referred to as the price puzzle. The results are consistent with previous empirical literature such as Morsink and Bayoumi (2001), Arin and Jolly (2005) and Perera and Wickramanayake (2013) for the case of Sri Lanka. Although there is modest evidence here, that a monetary policy shock will produce a much larger response in inflation compared to output, the results are far from conclusive.

Table 3: The Impact of Monetary Policy Shock on Output and Inflation

Period	Maximum Impact		Inverse Slope of AS (ψ)$*$
	On Output	On Inflation	
Full Sample	-0.011	-0.449	0.289
1980-2000	-0.032	-0.005	0.201
2001-2009	-0.189	-0.228	0.283
2009-2017	-0.214	-0.358	0.294

Notes: *Three year averages of the impact of monetary policy innovations on output divided by three year averages of the impact of monetary policy on inflation.

We carry out the same exercise for the subsample periods and, although we find a positive innovation on monetary policy will adversely affect output in the short-term, the empirical price puzzles can be seen in the sub-samples as well. As shown in Figures 9 to 11, a positive monetary policy shock increased inflation in the short-run but fell back after a 7 to 8 months in all the regimes. Using the estimated IRFs, we calculate the maximum impact of a monetary policy shock on inflation and output for both the full sample and the sub-samples, for which the results are presented in Table 3. We also reports the estimated inverse slope of the AS curve ψ, used to calculate the policymaker's preferences. The interesting aspect here is that the magnitude of the estimated ψ appears to be different across different policy regimes.

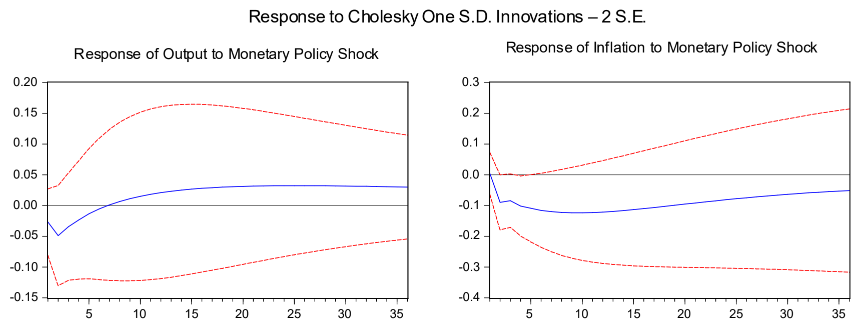


Figure 9: Responses of Output and Inflation to Monetary Policy Shock (1980-2000)

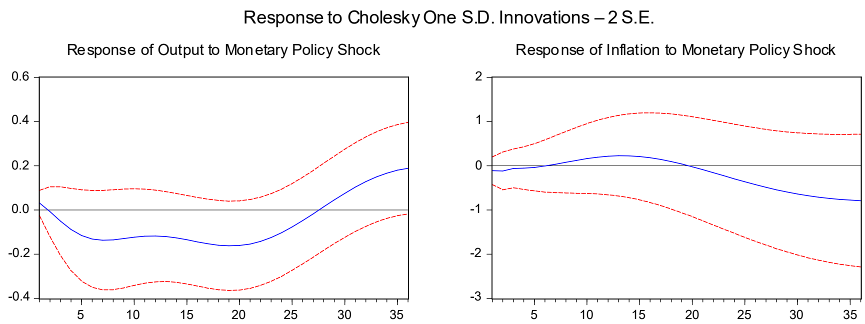


Figure 10: Responses of Output and Inflation to Monetary Policy Shock (2001-2009)

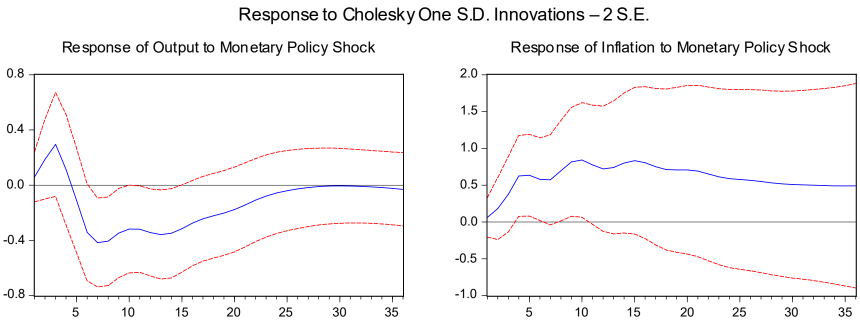


Figure 11: Responses of Output and Inflation to Monetary Policy Shock (2009-2017)

3.6. Estimation of Policymakers' Aversion to Inflation Variability

Using the ratio between the variability of output and inflation along with the estimated value for ψ shown in Section 3.5, we estimate the policymakers aversion to inflation variability (λ). We make a key assumption that policymakers are interested in minimizing the variability of inflation around its target level and output around its potential. As the country has registered a monthly inflation rate, on average, of more than 20 percent during the 1980s and 1990s, a 5 percent rate of inflation as a target could be perceived as an unrealistic policy goal during these periods. We have therefore assumed that the targeted level of inflation is equivalent to the average level of inflation recorded in each policy regime under consideration. For comparison purposes, we estimate the policymakers aversion to inflation variability in both cases and the results are presented in Table 4.

Table 4: Shifts in the Aversion to Inflation Variability

Period	Aversion to Inflation Var. λ	
	$y^* = trend$ $\pi^* = average$	$y^* = trend$ $\pi^* = 5\%$
Full Sample	0.650	0.702
1980-2000	0.527	0.654
2001-2009	0.677	0.609
2009-2017	0.728	0.668

The estimated value of λ for the full sample suggests that the monetary authority in Sri

Lanka has taken the goal of inflation stabilization more seriously since 1980. Notably, with desired inflation at 5 percent, it is evident that the country registered an increased level of aversion to inflation variability (0.702). The estimated value of λ for the full sample period provides interesting insights into the stabilization objective of the CBSL. The value of our estimate suggests that inflation stabilization remains the major concern of the monetary authority. However, taking into account the structural changes that have taken place in the economy, investigating how inflation stabilization objectives of the CBSL have changed under different policy regimes becomes important.

The difference in estimated values for λ under the various regimes is prominent. λ increased substantially at varying degrees over the periods. The exceptions are during the period 1980-2000, where the estimated level of λ was relatively small (0.5272) compared to other periods. This suggests that the CBSL has placed more weight on stabilizing inflation and output together, during the period 1980-2000, a finding consistent with that found in Section 3.2. The policymakers preferences with respect to inflation stabilization was 0.728 during the period 2009-2017, showing that policymakers have attached a higher level of weight to stabilizing inflation more recently.

3.7. The Estimation of Welfare Loss in Sri Lanka

A reduction in both average inflation and its variability for a given variability of output can be identified with an improved welfare loss. Using the value estimated for λ in Section 3.2, we compute the welfare loss measured by the central bank loss function to study the changes in macroeconomic performance over time. To best compare welfare losses across different policy regimes we idenitfy the value estimated for the full sample period of (0.651).

As we can see from Table 5, Sri Lanka exhibited a slight increase in welfare loss during the period 2001-2009 (3.7816) compared to 1980-2000 (3.4904). This could be partly explained by increased inflation variability caused by adverse supply shocks during the same peruod. Welfare loss improved significantly during the post-war period (2009-2017), suggesting that monetary policy during this period was welfare enhancing compared to other periods. The time-varying welfare loss shown in Figure 12 provides further insight of how the welfare

Table 5: The Estimated Welfare Loss and Performance Change

Period	Estimated λ	Estimated Welfare Loss (variable λ)	Estimated Welfare Loss (constant λ)
1980-2000 (1)	0.587	3.233	3.490
2001-2009 (2)	0.677	3.878	3.782
2009-2017 (3)	0.728	1.990	1.932
1980-2017	0.651	3.203	3.203

Notes: We calculate the performance gain across the entire sample as 48.69% and 48.92% for varying λ and constant λ respectively; compared to a performace loss of 19.97% and 8.34% between periods (1) and (2)

loss has changed over time. Graph A shows the time-varying welfare loss for constant λ (λ=0.6505) while B shows for different λ estimated in Section 3.6. It is interesting to note that welfare loss from fourth quarter of 2016 fell significantly though the time-varying correlation analysis in Section 3.2 showing that monetary policy was suboptimal in this period. The reduced welfare loss could be due to lag effects of optimal monetary policy implemented before 2016.

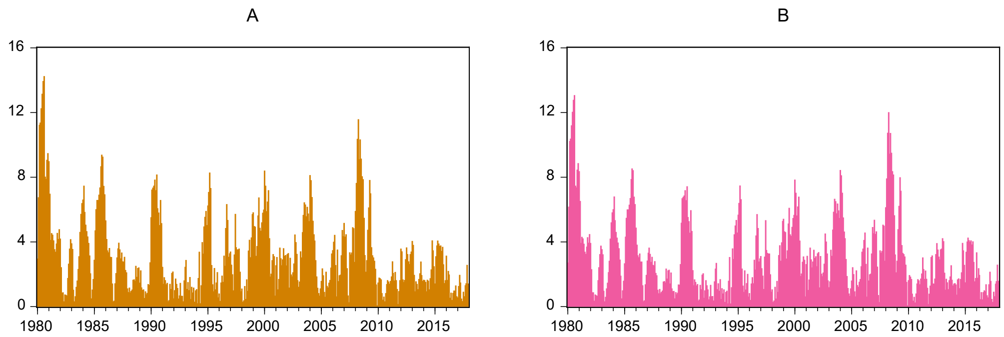


Figure 12: Estimated Time-Varying Welfare Loss

The results further demonstrate that around 45 percent of performance gain is equivalent to a drop of around 58 percent points in the average annual inflation rate between 1980-2000 and 2009-2017. Around 49 percent performance gain is equivalent to a drop of around 60 percent points in the average annual inflation rate between 2001-2009 and 2009-2017. Overall, we conclude that a larger increase in performance gain indicates substantial improvements in terms of welfare loss, bearing in mind that it is not necessarily true that these gains exist solely as a result of monetary policy.

4. Conclusion

This study examines the impact of monetary policy on the inflation output variability trade-off for Sri Lanka, for the period 1980-2017. The objective of this empirical exercise is two-fold; firstly, to explore the trade-off between the variability of inflation and output under different monetary policy regimes; and secondly, to examine the contribution of monetary policy to macroeconomic outcomes by measuring changes to welfare losses from a standard central bank loss function. For this purpose, we have used a structural vector autoregression model.

The key results presented in this study are summarized as follows: we have found that Sri Lanka experienced a transition from relatively higher volatile inflation regimes to more stable regimes, though the variability of output has increased over time. We suggest that reduced inflation variability, largely supported by the increased level of importance placed by the CBSL on inflation, is attained at the expense of increased output variability. It is evident that the country has witnessed the higher levels of economic growth during the periods in which it has satisfied the negative Taylor curve relationship. Based on the rolling window correlations, the study has found that the conduct of monetary policy was optimal during the study period, except for 1980-2000.

The responses of output and inflation to demand and supply shocks are not persistent, concluding that deviations from the Taylor curves caused by adverse shocks will be transitory if the central bank operates efficiently. Furthermore, the responses of output and inflation to a monetary policy shock vary quite dramatically; an unexpected rise in short-term interest rates causes a significant decline in output. The study has also revealed that the reaction of inflation to a positive interest rate innovation is positive. Although this is in contradiction to the theoretical consensus, the results are consistent with previous findings drawn in many empirical studies. Overall, a monetary policy shock produces a much larger response in inflation compared to that from output.

We have also investigated how the policy preferences of the CBSL have changed over time. The estimated policymakers aversion to inflation variability reinforces our earlier finding, that Sri Lanka has taken the goal of inflation stability more seriously since 1980 and increasing substantially during certain episodes. Using the preference estimates for the CBSL, we have used a simple central bank loss function to estimate welfare losses under different policy regimes. The study finds substantial improvements in welfare loss during the post-war period and confirms that monetary policy during this period was welfare enhancing compared to other periods.

Whilst it is normal for central banks of developing economies to make use of a range of targets in the formulation of monetary policy, we suggest that an explicit inflation objective might better serve macroeconomic outcomes. When facing the trade-off between inflation and output variability it is better to follow price stability as a basis for monetary policy and communications. Anchoring inflation can reduce interest rate volatility, promote financial market development, and enhance the transmission of monetary policy. Hence, more recently formed central banks should focus more closely on inflation while following a forward-looking monetary policy framework that promotes their goals and fosters better macroeconomic and financial stability.

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