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Threshold Effects in the FED`s Monetary Policy Before and After Inflation Targeting

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Abstract: The present study uses the threshold SVAR models to analyse the periods before and after inflation targeting, covering monthly data between 1992 and 2024. It examines whether the Fed reaction function based on the expanded Taylor equation with the US economic and policy uncertainty index is asymmetric with respect to the inflation and output gap. The results indicate that when inflation is below the 2% threshold, the Fed reacts to economic instability rather than inflation and the output gap. The empirical findings show that once inflation exceeds this level during the inflation targeting period, the Fed reacts to inflation in the long term, output gap in the short term, and economic instability in both the short and long term. Also, when inflation is greater than 2%, the Fed reacts more to expected inflation than to current inflation. Moreover, in post-inflation-targeting period, when inflation rises above this level, the Fed reacts to positive shocks in current inflation with a three-month lag, whereas its reaction to expected inflation is instantaneous. According to the output gap threshold value, it was determined that the Fed's reactions were symmetrical before inflation targeting and asymmetrical afterwards. Empirical findings show that the Fed reacts to economic instability before inflation targeting, to both output gap and economic instability in the short term after inflation targeting, and to inflation in the long run. The results show that the asymmetric effects of the Taylor rule are due to the asymmetric preferences of the Fed.

Keywords: Taylor rule, Monetary policy, Asymmetries, Threshold SVAR

JEL Classification: C32, E42, E43, E52, E58.

1. Introduction

Taylor (1993) described the rule-based linear reaction function in determining the Fed`s monetary policy. He showed that the Fed's monetary policy can be linearly defined by an interest rate rule based on deviations of output and inflation from the target. The baseline Taylor rule might also be inappropriate for open economies subject to external shocks. In some studies following Taylor (1993), the original linear Taylor rule was extended using some indicators such as exchange rates, asset prices, credit/leverage, spreads, and discussed nonlinear reaction functions (Svensson, 2000, 2003; Cecchetti et al., 2000, Castro, 2011).

Taylor's (1993) monetary policy reaction function has developed in a linear framework, ignoring possible asymmetries of central bank preferences. The symmetrical Taylor rule means that central banks pay equal attention to both inflation and deflation, or positive and negative output gaps. The linear Taylor rule proposes a symmetrical policy response to negative and positive deviations of inflation and/or output from the target. If two variables give signals of nonlinearity between them, using a linear model leads to biased and misleading results (Ncube and Tshuma, 2010). The nonlinear Taylor rule can arise from nonlinear macroeconomic relationships or from the asymmetric preferences or goals of policymakers. Therefore, it would be more appropriate to use a nonlinear Taylor rule. In simpler terms, nonlinear models are needed to explain nonlinear policy behaviour. The actions of central banks can be affected by economic developments and their response during economic expansions tends to be inflation management, while during economic contractions, the focus may shift to stabilizing output (Cukierman and Gerlach, 2003; Ahmad, 2016). However, during economic booms, as a result of the convex nature of the economy, central banks' response to inflation appears to be stronger than during periods of recession.

In literature, there are controversies about the backward-looking or forward-looking Taylor rule. Originally introduced by Taylor (1993), it is a backward-looking monetary rule. However, economists use expected inflation when determining the interest rate. It is assumed that central banks exhibit forward-looking behaviour and have perfect control over the interest rate. In the study by Clarida et al. (2000), it is argued that a forward-looking Taylor rule allows central banks to consider additional factors that may affect the market, such as inflation in commodity prices or the difference between short-term and long-term market interest rates. This allows the monetary rule to more accurately describe the behaviour of central banks. Some empirical research, including Fourçans and Vranceanu (2004), and Sauer and Sturm (2007), highlights the importance of including a forward-looking Taylor rule in the evaluation of the European Central Bank's monetary policy.

This study examines the Fed's asymmetric reaction function with respect to inflation and output gaps using a threshold SVAR model based on the extended Taylor rule with the US economic policy uncertainty index, employing monthly data from 1992 to 2004 for the periods before and after inflation targeting. Unlike previous studies, the US economic policy uncertainty index was used as an indicator of economic instability in the extended Taylor equation. In addition, separate analyses were performed for the periods before and after the inflation targeting regime for the US, and the effects of the Fed's transition to the inflation targeting regime on the Fed reaction function were also discussed. In addition, by using both current and expected inflation data, an answer was sought to the question of which of the backward-looking or forward-looking Taylor rule is more dominant. In addition, asymmetric preferences in the Fed`s monetary policy were examined from the findings obtained from the threshold SVAR model, which is defined based on the asymmetric Taylor rule according to inflation and output gaps.

The layout of the paper is as follows. Section 2 reviews the relevant literature. Section 3 outlines the assumptions and discusses the data and section 4 presents empirical results. Finally, section 5 offers concluding remarks.

2. Literature review

2.1. Previous research

Following the pioneering work of Taylor (1993), many researchers have made efforts to study and expand on the Taylor rule. In particular, the asymmetric reactions of central banks to inflation and output gaps are those that have attracted the attention of researchers. Therefore, one of the issues discussed in the literature on the Taylor rule is whether the effects of inflation and growth variables on monetary policy are linear or nonlinear. Blinder (1998) argues that the intensity of political and social pressure resulting from the policies implemented by central banks will not be equal. The fact that the reaction of tight policies applied against inflation and expansionary policies in the face of economic recession is not equal points to a nonlinear rather than linear structure of the Taylor rule.

On the other hand, central banks' perspectives on the economy may change according to economic conditions and preferences may change over time. Therefore, this asymmetry that may occur in the preferences of central banks may vary according to time and the state of the economy (Rabanal, 2004). As a matter of fact, Cukierman and Muscatelli (2008) divided the preferences of central banks into "recession avoidance" and "inflation prevention". The findings of their study, which included a sample of the UK and the USA, point to the nonlinear model. In the UK sample, the preference to avoid recession in the period before the inflation targeting strategy; After the adoption of the inflation targeting strategy, it indicates that the anti-inflation monetary policy preference predominates. In the U.S. sample, periodic differences in policy preferences are noteworthy. During the Volcker's tenure as the Fed chair (1979-1987), the Taylor rule followed a linear pattern. While anti-inflation preferences emerged during the Vietnam war, it has been stated that the preference to avoid recession was evident in the periods of Burns (1970-1978), Miller (1978-1979) and Greenspan (1987-2006).

Dolado et al. (2004) indicated that the US monetary policy can be characterized by a non-linear policy rule after 1983, but not before 1979. This finding is consistent with the view that the Fed's inflation preferences during the Volcker-Greenspan regime differ considerably from the ones during the Burns-Miller regime. Rabanal (2004) points out that the Fed focused on price stability during the expansion period and preferred a growth-oriented policy during the recession. Surico (2007) showed that the Fed's preferences were asymmetrical only before 1979, and that the interest rate response to output contractions was greater than the response to output expansions of the same magnitude. The claim is further substantiated by research conducted by Martin and Milas (2013), which provides empirical evidence in favour of a nonlinear Taylor rule in the United Kingdom. Villavicencio (2013 shows that the Fed's policy preferences are shaped by raising interest rates more aggressively in the face of excess demand, output gap, or unemployment falling below a certain level, but the Fed is more reluctant to cut interest rates during recession periods.

Dolado et al. (2005), on the other hand, based on the effects of the nonlinear Phillips curve on monetary policy, suggested that the decisions of the central banks of the US, France, Germany and Spain contradict the linear Taylor rule. It was emphasized that the policy applied by central banks when raising interest rates is different from the policy applied when reducing violence. Therefore, it draws attention to the fact that if inflation and the output gap are above the desired level, interest rates increase faster. Petersen (2007) uses a logistic smooth transition regression model for the U.S. over the period 1985-2005 and finds evidence to support the nonlinearities, indicating that the Fed reacts harshly when inflation reaches a certain threshold. However, Petersen does not use the forward-looking Taylor rule.

Bunzel and Enders (2010) use threshold models to characterize the Fed's policy rule, using the inflation rate, the output gap, and the weighted average of the two as threshold variables. They found that the Fed acts very aggressively when inflation exceeds its interim target, while during normal periods it acts relatively passively, and the federal funds rate tends to maintain its current value. Ma et al. (2018) pointed out that the Fed responded more aggressively to increases in the capacity utilization rate as the inflation rate rose above 2%, and the Fed reacted to macroeconomic uncertainties by lowering the policy rate. Castro (2011), on the other hand, pointed out that the monetary policy preferences of the Fed can be explained by the linear Taylor rule, and the policy preferences of the European Central Bank and the Bank of England can be explained by the nonlinear Taylor rule. He applies a smooth transition regression model for the U.S. over the period 1982-2007 and considers a prospective Taylor rule but finds no evidence of nonlinearity in the behaviour of the Fed. He showed that the European Central Bank (ECB) adheres to the nonlinear Taylor rule, whereby it responds to inflation only when it exceeds 2.5% and reacts to the business cycle only after inflation stabilizes, i.e., after it falls significantly below that level. Martin and Milas (2004) pointed out that after the inflation targeting strategy implemented in the United Kingdom in 1992, the central bank's policy response increased as inflation moved away from the target range. Similarly, Taylor and Davradakis (2006) suggested that although there is a symmetrical inflation target specified by the central bank in the UK, the policy implemented contains asymmetrical measures. They estimate a threshold model for the Bank of England's monetary policy and find that both inflation and the output gap occur significantly when inflation is above a single threshold, while only a weak, but still statistically significant, effect of the output gap is detected when inflation is below this threshold. The claim is further substantiated by research conducted by Martin and Milas (2013), which provides empirical evidence in favour of a nonlinear Taylor rule in the United Kingdom.

2.2. Current Work

This study examines the asymmetrical relationships in the Fed`s monetary policy separately for the periods before and after the inflation targeting regime through the threshold SVAR models defined based on the expanded Taylor rule using the US economic policy uncertainty index. The first contribution of the study to the literature is to examine the effects of economic instability on the Fed's monetary policy preferences using the US economic policy uncertainty data. In addition, by using actual inflation and expected inflation data separately in econometric analyses, an answer is sought to the question of which of the 'backward-looking' and `forward-looking' Taylor rule is more considered in the Fed monetary policy.

This study is divided into pre-2012 and post-2012 periods, thus examining whether the inflation targeting regime is effective in the asymmetrical relationships in the Fed's monetary policy. In this context, it is aimed to reveal the asymmetric effect of the inflation targeting strategy on the Fed's monetary policy preferences.

3. Assumptions and data collection

It is known that central banks have two main motivations in setting short-term interest rates. First, in the face of rising inflation, central banks increase short-term interest rates, causing the money supply to shrink and investment to decrease. Thus, in the face of decreasing inflation, unemployment increases or economic situation becomes a more stagnant. Second, in the face of a recession in the real economy, central banks reduce short-term interest rates, expanding the money supply and increasing investment. As a natural consequence of this monetary policy, output increases.

Taylor (1993) argued that the interest rate rule in monetary policy can be defined by the output gap and inflation deviations from the target. On the other hand, monetary policies are determined in a more complex structure under the assumption that central banks have a duty to support economic stability. For this reason, it is argued that economic instability (or uncertainty) should be considered in determining central bank interest rates, as well as inflation and output gaps. Therefore, Taylor's formulation has been criticized for failing to consider the effects of economic instability (uncertainty) on monetary policy. Economic uncertainties can disrupt money transmission mechanisms – especially the expectation channel – and thus economic stability. Economic stability is not seen as a simple goal of monetary policy, but as a prerequisite for central banks to carry out their policies and achieve their inflation and output stability goals.

Economic instability is a phenomenon that cannot be observed. On the other hand, some proxy variables for economic instability are proposed in the literature. Svensson (2000, 2003) suggests that it may be appropriate to extend the Taylor rule to include the exchange rate. In contrast, Taylor (2000, 2001), Edwards (2007), Mishkin (2007), and Garcia et al. (2011) argue that it may be appropriate to include exchange rates in monetary policy rules only for developing countries. In addition, some studies investigate whether financial asset prices can be influential in explaining the behaviour of the central bank. Cecchetti et al. (2000), Lowe and Borio (2002), Goodhart and Hofmann (2000), Rigobon and Sack (2003), and Chadha et al. (2004) argue that central banks should consider the effects of changes in asset prices on macroeconomy when determining central bank policies. Driffill et al. (2006) find evidence that it improves the econometric fit of the Taylor rule, which is extended by the inclusion of financial stability. Montagnoli and Napolitano (2005) developed a financial indicator consisting of the exchange rate, equity markets, and housing prices and found that the inclusion of these variables improved the econometric definition of monetary policy. Shrestha and Semmler (2015) found that the inclusion of the indicator of financial instability in their study of five Asian countries improved Taylor rule.

Using the US economic uncertainty, the extended Taylor equation is defined as follows:

$$i_t = r^* + \pi^* + \beta(\pi_t - \pi^*) + \gamma(y_t - y_t^*) + \delta EPU_t$$

where the variable i regards the nominal short-term interest rate as the monetary policy instrument, while r^* represents the equilibrium real rate. The difference between the inflation rate π_t and the inflation target π^*, also known as the inflation gap, is denoted by $(\pi_t - \pi^*)$. Similarly, the difference between the actual output (y_t) and the potential output (y_t^*) is referred to as the output gap. EPU_t corresponds to the indicator of economic instability. In this study, both the equilibrium real rate and the inflation target are assumed to be constant. In order for monetary policy to stabilize in the Taylor equation, the inflation gap coefficient must be greater than 1. This means that the central bank increases the real rate in response to higher inflation, thus exerting a stabilizing effect on inflation. The output gap coefficient, on the other hand, must be positive. If the output gap coefficient is positive, it means that when output is below its potential, a decrease in the interest rate will have a stabilizing effect on the economy. In times of economic crisis that starts with the increase in economic instability, there are contractions in the economy. As a reaction to the economic contraction, central banks cut interest rates. Therefore, the coefficient of the economic instability variable in the extended Taylor equation is negative.

Taylor's (1993) original rule considers the deviation of realized inflation from the inflation targeted by the central bank. This is why the original Taylor rule is called a backward-looking monetary rule. In practice, however, central banks tend to target expected inflation, not current inflation. Therefore, Clarida et al. (1998) recommend the use of a forward-looking version of the Taylor rule. Forward-looking Taylor rule is defined by the following equation:

$$i_t = r^* + \pi^* + \beta\left[E_t\left(\pi_{t+p}|\Omega_t\right) - \pi^*\right] + \gamma E_t\left[\left((y_{t+p} - y_{t+p}^*)|\Omega_t\right)\right] + \delta E_t\left(EPU_{t+p}|\Omega_t\right)$$

where E is the expectations operator and Ω_t is a vector including all the available information for the central bank at the time it sets the interest rate.

In this study, the news-based U.S. economic policy uncertainty index (EPU) proposed by Baker et al. (2016) was used as the proxy variable representing economic instability. This index reflects both uncertainty and perceived uncertainty about the Fed's policy actions and/or their consequences, which is calculated based on the frequency of newspaper articles that mention economic policy. The economic policy uncertainty index proposed by Baker et al. reflects important fiscal policy agendas such as the debt ceiling dispute, as well as critical events such as presidential elections, wars, and terrorist attacks that may affect economic indicators. At the same time, it emphasizes the importance of communication and expectations in the context of macroeconomic uncertainties, as the variables used in calculating the index include market information, fiscal policies and expectations surveys.

Economic policy uncertainty (EPU) index for the US was used as an indicator of economic instability[1]. Inflation is measured by the annual percentage change in the consumer price index (CPI). Expected inflation is taken as the expected inflation for 1 year ahead. Output is measured by the seasonally adjusted industrial production index (IPI). The potential output level is the Hodrick-Prescott (HP) trend of the IPI. The output gap is then computed as the difference between the IPI and its HP trend. The federal funds effective rate was taken as the policy rate. Data is obtained from the Federal Reserve Bank of St. Louis.

The sample period is 1992:01 to 2024:08, but we focus on the subsamples 1992:01 to 2011:12 and 2012:01 to 2024:08. The first subsample corresponds pre-inflation-targeting regime, and the second subsample corresponds to post-inflation-targeting regime. The variables in the study were defined as follows

EPU_t: News-based the US economic policy uncertainty index

π_t: Inflation based on the annual percentage change in the CPI

$E(\pi_t)$: 1-year expected inflation

y_t^{gap}: Output gap

i_t: Federal funds effective rate

[1] Data were obtained from the https://www.policyuncertainty.com.

4. Empirical results

4.1. Unit root tests

Augmented Dickey-Fuller (ADF, 1981) or Phillips-Perron (PP, 1988) unit root tests are the most commonly used methods for investigating unit roots in the time series. However, Perron (1989) argues that the ADF test is biased in that it does not reject the unit root zero hypothesis in the presence of a breakpoint. Under structural break, Zivot and Andrews (1992), Perron (1997), and Vogelsang and Perron (1998) propose unit root tests that allow endogenously determining structural break from the data. Three alternative unit root tests, ADF, PP and Vogelsang-Perron (WP), were used to robustly investigate the unit root properties of the variables within the scope of the study. The results of the unit root tests are given in Table 1.

According to the results of the unit root tests, except for the PP unit root test of the policy interest rate, the three alternative unit root tests give the same results at traditional significance levels. When the results of unit root tests are evaluated, not all of the variables within the scope of the study contain unit roots. These results show that the variables are stationary at the level, in other words, their order of integration is zero.

Table 1: Unit Root Test Results

	Augmented Dickey-Fuller (ADF)		Phillips-Perron (PP)		Breakpoint Unit Root Test (Vogelsang and Perron, WP)	
Variable	t-Statistic	p-value	Adj. t-Stat	p-value	t-Statistic	p-value
EPU_t	-3.7722	0.0035	-6.8855	0.0000	-6.9542	< 0.01
π_t	-3.0198	0.0340	-10.8551	0.0000	-9.0736	< 0.01
$E(\pi_t)$	-2.8152	0.0570	-4.5435	0.0002	-5.2291	< 0.01
y_t^{gap}	-4.3063	0.0006	-4.5866	0.0002	-5.7125	< 0.01
i_t	-2.7329	0.0694	-1.8429	0.3595	-4.4859	0.0450

Only the constant term is taken as the deterministic component. Appropriate lag length for ADF and WP tests has been selected using Akaike information criterion (AIC) for a maximum lag of 12 periods. Appropriate Newey-West bandwidth for PP unit root tests is selected using Bartlett kernel. Break date is selected by using Dickey-Fuller min-t.

4.2. Slope-based testing for symmetry

Central banks may react more to a negative rather than a positive output gap. Central bankers with this type of asymmetry tend to avoid an economic recession. In the presence of uncertainty regarding future shocks, such asymmetry leads the central bank to take more hedges against negative rather than positive output gaps. On the other hand, during periods of inflation stability when monetary policymakers are trying to build credibility, they may be more reluctant to face positive rather than equally large negative inflation gaps. This type of asymmetry is defined as a preference to avoid inflation. In the presence of uncertainty about future shocks, policymakers with such preferences tend to react more strongly to positive rather than negative inflation gaps. The basic theoretical inference is that when recession-avoidance preferences predominate, the reaction function is concave in both output and inflation gaps, and when inflation-avoidance preferences predominate, the reaction function is convex in both gaps. This result suggests that we can expect to find different nonlinear patterns between normal periods and credibility-building periods.

In this study, it is examined whether the effect of both the output gap and inflation on the policy interest rate is asymmetrical. The threshold value is taken as 2% for inflation and zero for the output gap. The asymmetric specification for the inflation rate levels is defined as follows:

$$D_t^{high} = \begin{cases} 1 & if\ \pi_t > 2 \\ 0 & otherwise \end{cases} \text{ and } D_t^{low} = \begin{cases} 1 & if\ \pi_t < 2 \\ 0 & otherwise \end{cases} \quad (1)$$

The null hypothesis, which claims that the effect of economic uncertainty index, output gap, and inflation on the policy rate is symmetrical in periods when inflation rates are above and below the inflation target level, can be tested using the symmetrical approach of Kilian and Vigfusson (2011) with the following equations:

$$i_t = b_{10} + \sum_{i=1}^{p} b_{11,i} Y_{t-i} + \sum_{i=1}^{p} b_{12,i} i_{t-i} + \varepsilon_{1t} \quad (2)$$

$$i_t = b_{20} + \sum_{i=0}^{p} b_{21,i} Y_{t-i} + \sum_{i=1}^{p} b_{22,i} i_{t-i} + \sum_{i=0}^{p} \beta_i (D_t^{high} \times Y_{t-i}) + \varepsilon_{2t} \quad (3)$$

where the variable Y corresponds to the economic uncertainty index, output gap, and inflation. The equation-2 is a standard linear VAR in Y_t and i_t, but the equation-3 now includes both Y_t and $D_t^{high} \times Y_{t-i}$. Thus, the effects of economic instability, output gap, and inflation (or expected inflation) on the policy rate in the US differ during periods of high and low inflation. The OLS residuals of the above model are uncorrelated. This means that the model can be estimated by standard regression methods (Kilian and Vigfusson, 2011).

The test of all symmetrical restrictions on the slopes involves the null hypothesis

$$H_0: \beta_0 = \beta_1 = \cdots = \beta_p = 0 \tag{4}$$

The equation-3 of the above model can be estimated by least squares and uses a Wald test to determine whether including $\left(D_t^{\text{high}} \times Y_{t-i}\right)_{i=0}^{p}$ improves the fit of the model. This modified slope-based test has an asymptotic Chi-square distribution with degrees of freedom $p + 1$.

The asymmetric specification for the output gap is defined as below:

$$D_t^p = \begin{cases} 1 & if\ y_t^{gap} > 0 \\ 0 & otherwise \end{cases} \text{ and } D_t^n = \begin{cases} 1 & if\ y_t^{gap} < 0 \\ 0 & otherwise \end{cases}$$

The null hypothesis, which claims that the effect of uncertainty index, output gap, and inflation on the policy interest rate is symmetrical during periods when the output gap is negative and positive, can be tested using the symmetrical approach of Kilian and Vigfusson (2011) given above.

Table 2: Slope-based symmetry test when current inflation is above and below the target level

Null hypothesis: The effect of Y on the policy rate is symmetrical.		
Before inflation targeting period (1992-2011)		
Y	Chi-square	p-value
EPU	1.6981	0.1925
Inflation	2.1954	0.1384
Output gap	3.2721	0.0705
Y	Chi-square	p-value
EPU	12.1877	0.0023
Expected inflation	4.8163	0.0282
Output gap	3.7495	0.0528
After inflation targeting period (2012-2024)		
Y	Chi-square	p-value
EPU	0.0544	0.8155
Inflation	0.3757	0.5399
Output gap	0.1028	0.7485
Y	Chi-square	p-value
EPU	0.0414	0.8388
Expected inflation	0.0010	0.9748
Output gap	0.4155	0.5192

In the post-inflation-targeting period, the selected model is ARDL(4,1,0,2, 0,1,0) when inflation is used and it is ARDL(6,1,0,1, 0,1,0) when expected inflation is used; they are ARDL(3,1,0,0,0,2,0) and ARDL(3,0,1,0,0,0,0) in the pre-inflation-targeting period, respectively

In the study, autoregressive distributed lag model (ARDL) for slope-based symmetry testing is defined as follows, considering the extended Taylor rule.

$$i_t = b_0 + \sum_{i=1}^{p} b_{1i} i_{t-i} + \sum_{i=0}^{p} b_{2i} EPU_{t-i} + \sum_{i=0}^{p} \beta_{1i} (D_t^{high} \times EPU_{t-i}) + \sum_{i=0}^{p} b_{3i} \pi_{t-i} + \sum_{i=0}^{p} \beta_{2i} (D_t^{high} \times \pi_{t-i}) + \sum_{i=0}^{p} b_{4i} y_{t-i}^{gap} + \sum_{i=0}^{p} \beta_{3i} (D_t^{high} \times y_{t-i}^{gap}) + \varepsilon_t \quad (5)$$

In alternative ARDL models, it is sufficient to write expected inflation instead of current inflation (equation 5). In addition, according to the level of output gap, it will be sufficient to write D_t^p instead of D_t^{high} in the ARDL models.

Appropriate lags for the ARDL model were estimated to be using AIC, with the maximum lag length of 12. The results of the slope-based symmetry tests for the periods above and below the target inflation are given in Table 2 for the pre-inflation-targeting and post-inflation-targeting periods. Using current inflation for the pre-inflation-targeting period, the effect of the economic uncertainty on the policy rate was asymmetrical at the level of 10%, while the effects of other variables were determined symmetrical. On the other hand, when expected inflation is used, it is determined that the effects of both the output gap and the economic uncertainty as well as the expected inflation on the policy interest rate are asymmetrical at the 5% significance level. However, when both current and expected inflation are used after inflation targeting, the effects of all variables on the policy rate are determined symmetrically.

Table 3: Slope-based symmetry test when output gap is negative or positive

Null hypothesis: The effect of Y on the policy rate is symmetrical.		
	Before inflation targeting period (1992-2011)	
Y	Chi-square	p-value
EPU	0.0019	0.9655
Inflation	0.9953	0.3184
Output gap	25.5003	0.0000
Y	Chi-square	p-value
EPU	0.0978	0.7545
Expected inflation	0.2817	0.5966
Output gap	24.2785	0.0000
	After inflation targeting period (2012-2024)	
Y	Chi-square	p-value
EPU	18.1141	0.0001
Inflation	7.2907	0.0261
Output gap	7.7862	0.0053
Y	Chi-square	p-value
EPU	18.1141	0.0001
Expected inflation	20.5120	0.0000
Output gap	7.7862	0.0053

In the after inflation targeting period, the selected model is ARDL(4,1,1,2, 1,1,0) when inflation is used and it is ARDL(6,1,1,0, 1,1,0) when expected inflation is used; they are ARDL(3,1,0,0,0,1,1) and ARDL(3,1,0,0,0,1,2) in the pre-inflation-targeting period, respectively.

According to the negative and positive output gap, the results of the claim that the effects of the variables within the scope of the research on policy interest rates are symmetrical are given in Table 3. For pre-inflation-targeting period, the effect of output gap on the policy interest rate were asymmetrical when the output gap was negative or positive, while the effects of other variables were found to be symmetrical at conventional significance levels. On the other hand, in asymmetric relationships defined according to negative and positive output gaps, in the periods after the implementation of inflation targeting, the effects of current inflation, expected inflation and economic uncertainty, in addition to output gap on the policy rate, were determined as asymmetric at the 5% significance level.

4.3. The threshold SVAR model

A SVAR model can generate additional descriptive assumptions to describe instantaneous relationships between endogenous variables. These assumptions can be shaped by economic theory, institutional knowledge, and other constraints (Köse and Ünal, 2021). A SVAR model structures economic assumptions to analyse instantaneous connections between determinants through structural factorization (Bernanke, 1986; Blanchard and Watson, 1986; Sims, 1986). The innovation terms of a VAR model, or orthogonalization of reduced form residuals, can be applied recursively (Cholesky decomposition) or non-recursively (structural factorization). Orthogonalization by Cholesky decomposition shows a causal chain that is imposed rather than learning causal relationships from variables. This solution may make sense with a reasonable interpretation for recursive ordering (Kilian, 2013). In this study, we used the SVAR model. One of the most important reasons for this is that the instantaneous relationship between variables such as policy rate-expected inflation and output gap-interest rate is defined as bidirectional. These contemporaneous constraints from economic theory allow for structural factorization, while Cholesky decomposition does not.

The short-run SVAR(p) specification for the A-B model can be written as the following:

$$\boldsymbol{A}(\mathbf{I}_{\boldsymbol{k}} - \boldsymbol{A}_{\mathbf{1}}\boldsymbol{L} - \boldsymbol{A}_{\mathbf{2}}\boldsymbol{L}^{\mathbf{2}} - \ldots\ldots\ldots. \boldsymbol{A}_{\boldsymbol{p}}\boldsymbol{L}^{\boldsymbol{p}})\boldsymbol{y}_{\boldsymbol{t}} = \boldsymbol{A}\boldsymbol{e}_{\boldsymbol{t}} = \boldsymbol{B}\boldsymbol{u}_{\boldsymbol{t}}$$

where, $\boldsymbol{L}$ is lag operator, the vector $\boldsymbol{e}_{\boldsymbol{t}}$ is error terms of the standard VAR model with covariance matrix $\boldsymbol{\Sigma}_{\boldsymbol{e}}$, the vector $\boldsymbol{u}_{\boldsymbol{t}}$ is error terms of the structural VAR model with covariance matrix $\mathbf{I}_{\boldsymbol{k}}$, k is the number of variables in the model, and $\boldsymbol{A}$ and $\boldsymbol{B}$ are restriction matrices. The order condition requires $k^2 + \frac{k(k-1)}{2}$ restrictions for identification in the short-run A-B model.

The economic policy uncertainty (EPU) index is used as an indicator of economic instability. The EPU index was assumed as an exogenous variable. Thus, while its shocks instantaneously affect the shocks of other variables in the study, their own shocks are not instantaneously affected by the shocks of any variable. Both the output gap and inflation gap shocks have an instantaneous effect on policy interest rate shocks. The shocks of these variables are only affected by EPU index's shocks. While the shocks of the policy interest rate are instantaneously affected by the shocks of other variables in the study, its shocks have no instantaneous effect on the shocks of any variable. Under these assumptions, the policy interest rate is the most exogenous variable.

In this study, both current and expected inflation data were used for inflation. Thus, an answer was sought to the question of whether there is a change in SVAR results according to current and expected inflation and therefore which of the backward-looking and forward-looking Taylor rule is more effective.

In the SVAR model, stationary levels of variables were used. While the maximum lag length was 12, the optimal lag lengths for VAR models were determined using AIC. Under the above restrictions, a SVAR model with A and B matrices can be specified as below:

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 & 0 & 0 \\ a_{41} & a_{42} & 0 & 1 & 0 & 0 & 0 \\ a_{51} & a_{52} & 0 & 0 & 1 & 0 & 0 \\ a_{61} & a_{62} & 0 & 0 & 0 & 1 & 0 \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & 1 \end{bmatrix} \begin{bmatrix} e_t^{D_t^{\text{high}} \times EPU_t} \\ e_t^{D_t^{\text{low}} \times EPU_t} \\ e_t^{D_t^{\text{high}} \times y_t^{gap}} \\ e_t^{D_t^{low} \times y_t^{gap}} \\ e_t^{D_t^{\text{high}} \times \pi_t} \\ e_t^{D_t^{low} \times \pi_t} \\ e_t^{\text{i}} \end{bmatrix} = \begin{bmatrix} b_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & b_{55} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & b_{66} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & b_{77} \end{bmatrix} \begin{bmatrix} u_t^{D_t^{\text{high}} \times EPU_t} \\ u_t^{D_t^{\text{low}} \times EPU_t} \\ u_t^{D_t^{\text{high}} \times y_t^{gap}} \\ u_t^{D_t^{low} \times y_t^{gap}} \\ u_t^{D_t^{\text{high}} \times \pi_t} \\ u_t^{D_t^{low} \times \pi_t} \\ e_t^{\text{i}} \end{bmatrix}$$

In the threshold SVAR model, which is defined according to whether inflation is lower or higher than the target level, the EPU index is used for economic instability and current inflation is used for inflation. In alternative threshold SVAR models, it is sufficient to write expected inflation instead of current inflation. In addition, according to the level of output gap, it will be sufficient to write D_t^p instead of D_t^{high} and D_t^n instead of D_t^{low} in the SVAR models.

4.4. Threshold SVAR model results with inflation

The results of variance decomposition indicate the proportion of the changes in a variable due to its own shocks versus shocks to the other variables. The results of the forecast error variance decomposition for the policy interest rate, which is based on the threshold SVAR model for periods when inflation levels are less than or more than the inflation target of 2%, and in which the US economic policy uncertainty index for economic instability and current inflation are used for inflation, are given separately in Table 4 according to both the before and after inflation-targeting periods.

The variable that has the highest shares in the variance decomposition of the policy interest rate for both pre- and post-inflation-targeting periods is the uncertainty index. In addition, for both before and after inflation targeting, the share of the uncertainty index in the variance decomposition of the policy rate is higher in periods when inflation is higher than the targeted level compared to the periods when inflation is lower than the targeted level. Before inflation targeting periods, when inflation rates were lower than 2%, the share of the certainty index in the variance decomposition of the policy interest rate was 7.16% in the first forecast period, while this share increased to 16.37% in the second forecast period and to 27.26% in the twelfth forecast period. In periods when inflation is greater than 2%, these shares increase from 5.00% in the first forecast period to 19.77% in the second forecast period, and continue increasing in the following periods, reaching a very high level of 41.17% in the twelfth forecast period. In the periods after the implementation of the inflation targeting regime, while inflation rates were below 2%, the share of the uncertainty index in the variance decomposition of the policy interest rate was 10.34% in the first forecast period, 11.61% in the second forecast period, and 18.14% in the twelfth forecast period. In periods when inflation rates were greater than 2%, these shares were 21.43% in the first forecast period and 24.98% in the second forecast period, while they remained high in the following forecast periods and were 24.33% in the twelfth forecast period.

Table 4: Results of variance decomposition of the policy rate according to inflation levels using current inflation

	Inflation is lower than 2%			Inflation is higher than 2%			
Before inflation targeting							
Period	EPU	Current inflation	Output gap	EPU	Current inflation	Output gap	Policy rate
1	7.16	0.04	1.44	5.00	1.02	0.54	84.80
2	16.37	0.31	0.40	19.77	0.27	0.38	62.49
3	19.52	0.31	0.28	29.16	0.14	0.24	50.34
4	22.70	0.27	0.43	34.00	0.08	0.20	42.32
5	24.68	0.26	0.55	36.38	0.05	0.13	37.94
6	25.80	0.26	0.65	38.11	0.04	0.10	35.04
7	26.54	0.26	0.70	39.36	0.04	0.15	32.94
8	27.02	0.27	0.73	40.19	0.05	0.30	31.44
9	27.29	0.28	0.73	40.73	0.05	0.55	30.37
10	27.39	0.29	0.72	41.04	0.06	0.91	29.59
11	27.37	0.30	0.70	41.18	0.06	1.39	29.00
12	27.26	0.31	0.68	41.17	0.07	1.96	28.55
After inflation targeting							
Period	EPU	Current inflation	Output gap	EPU	Current inflation	Output gap	Policy rate
1	10.34	0.13	0.01	21.43	0.01	7.11	60.98
2	11.61	0.05	0.06	24.98	0.03	5.39	57.89
3	12.24	0.03	0.15	25.40	0.02	3.71	58.44
4	12.36	0.04	0.20	24.81	0.16	2.68	59.75
5	12.54	0.06	0.22	24.64	0.47	1.96	60.11
6	12.84	0.12	0.26	24.22	1.09	1.50	59.98
7	13.29	0.26	0.33	23.91	2.25	1.20	58.77
8	14.12	0.41	0.39	23.99	3.79	1.02	56.27
9	15.14	0.54	0.44	24.11	5.56	0.93	53.28
10	16.17	0.71	0.48	24.21	7.63	0.88	49.93
11	17.17	0.89	0.50	24.27	9.93	0.83	46.40
12	18.14	1.05	0.51	24.33	12.32	0.79	42.86

In periods when inflation targeting was implemented and current inflation was lower than the target inflation, the share of output gap and inflation in the variance decomposition of the policy interest rate was found to be at very low levels. These results show that neither the output gap nor current inflation is effective in the Fed interest rate decision for periods when inflation is below 2 percent in the inflation targeting regime, but uncertainty is effective, albeit limited. On the other hand, if inflation is higher than the target inflation, the share of the output gap decreases from 7.11% in the first forecast period to 5.39% in the second forecast period and decreases rapidly in the subsequent forecast periods, falling to 0.79% in the twelfth forecast period. On the other hand, while inflation was higher than 2% after inflation targeting, the share of current inflation was quite low in the first six-month forecast periods, but it increased rapidly after the seventh forecast period and reached 12.32% in the twelfth forecast period. These results indicate that if inflation is above the target inflation after inflation targeting, the short-term output gap, long-term inflation, and uncertainty in both the short and long term are effective in the Fed's policy rate decision.

Analyses based on threshold SVAR models were repeated using expected inflation instead of current inflation. When the US economic policy uncertainty index is used as an indicator of economic instability, the results of the variance decomposition of the policy interest rate are given in Table 5.

Table 5: Results of variance decomposition of the policy rate according to inflation levels using expected inflation

	Inflation is lower than 2%			Inflation is higher than 2%			
	Before inflation targeting						
Period	EPU	Expected Inflation	Output gap	EPU	Expected Inflation	Output gap	Policy rate
1	8.23	0.22	1.27	4.23	1.41	0.90	83.73
2	17.74	0.12	0.31	18.88	1.12	0.27	61.55
3	22.05	0.08	0.35	28.71	1.02	0.17	47.62
4	24.67	0.06	0.49	35.02	0.87	0.10	38.79
5	26.24	0.05	0.55	38.96	0.78	0.07	33.34
6	27.22	0.05	0.56	41.50	0.74	0.14	29.78
7	27.84	0.05	0.53	43.17	0.75	0.31	27.35
8	28.22	0.05	0.47	44.24	0.80	0.58	25.63
9	28.42	0.06	0.42	44.89	0.89	0.95	24.37
10	28.49	0.08	0.37	45.23	1.00	1.42	23.42
11	28.45	0.10	0.32	45.34	1.15	1.98	22.68
12	28.33	0.12	0.28	45.26	1.32	2.61	22.08

	After inflation targeting						
Period	EPU	Expected Inflation	Output gap	EPU	Expected Inflation	Output gap	Policy rate
1	12.35	0.96	1.06	18.82	2.42	3.51	60.88
2	14.47	1.27	0.58	19.86	4.81	1.18	57.84
3	15.57	2.40	0.33	18.31	9.97	0.64	52.78
4	16.44	3.50	0.19	16.85	15.59	0.65	46.77
5	17.16	4.23	0.13	15.47	20.77	0.79	41.46
6	17.65	4.66	0.09	14.23	25.18	1.03	37.16
7	17.91	4.93	0.07	13.12	28.90	1.34	33.73
8	17.97	5.11	0.06	12.12	32.06	1.70	30.98
9	17.89	5.24	0.06	11.21	34.78	2.08	28.75
10	17.72	5.33	0.07	10.39	37.13	2.46	26.90
11	17.48	5.40	0.08	9.65	39.18	2.85	25.36
12	17.21	5.47	0.09	8.98	40.98	3.21	24.07

It has been determined that expected inflation has a larger share in the variance decomposition of the policy rate than current inflation. It is noteworthy that for periods when inflation is above 2 percent in the inflation targeting regime, these shares increase to quite large levels as the forecast period increases. For example, while the share of expected inflation in the variance decomposition of the policy rate was 2.42% in the first forecast period, this share increased to 25.18% in the sixth forecast period and to 40.98% in the twelfth forecast period. On the other hand, the share of expected inflation in the variance decomposition of the policy rate in the pre-inflation-targeting periods is negligible in periods when inflation is both less than 2 percent and higher than 2 percent. These results show that since 2012, when inflation targeting was implemented, expected inflation has been effective in the Fed's interest rate decision if inflation is greater than the target inflation rate of 2%.

The shares of the uncertainty index in the variance decomposition of the policy interest rate were found to be at high levels both before and after inflation targeting. It is noteworthy that these shares are at higher levels in periods when inflation is above 2%. For example, while the share of the uncertainty index in the variance decomposition of the policy interest rate for the period when inflation is greater than 2% before inflation targeting was 4.23% in the first forecast period, this share increases to 18.88% in the second forecast period. In the subsequent forecast periods, these shares increase significantly, reaching 45.26% for the twelfth forecast period. In the periods after the implementation of inflation targeting, the share of uncertainty in the variance decomposition of the policy interest rate was 18.82 percent in the first forecast period and 19.86 percent in the second forecast period. Although these shares decreased in the following forecast periods, they remained important with 8.98% in the twelfth forecast period. In addition, in periods when inflation is below 2 percent, the shares of policy uncertainty are larger than other variables. In addition, although the share of the output gap for these periods is negligible, the shares of expected inflation before inflation targeting are quite low and vary between 0.96% and 5.47% after inflation targeting. These results show that if inflation is lower than the target inflation of 2%, the Fed reacts depending on the uncertainty. While uncertainty is important in the Fed's interest rate decision if inflation exceeds the target inflation before inflation targeting, uncertainty and partially output gap are effective in the short term after inflation targeting, while these variables are replaced by expected inflation in the long run.

Figures 1 to 4 show how the policy rate responds to positive shocks of 1 standard deviation given to the determinants of the policy rate. The uncertainty index, the current inflation, the expected inflation, and the output gap are the impulses. The response is the policy interest rate.

When current inflation is used, Figure 1 shows the response of policy interest rates to positive shocks in other variables before inflation targeting and Figure 2 after inflation targeting. Before inflation targeting, the policy rate's responses to positive shocks in the uncertainty index are negative. These responses are statistically significant for the first ten periods when inflation is less than 2%, while they remain statistically significant for all the first twelve months when inflation is greater than 2%. On the other hand, before inflation targeting, when inflation was both smaller than or larger than 2%, the responses of the policy rate to positive shocks in both current inflation and the output gap were found to be statistically insignificant. These results indicate that the Fed reacts by considering the uncertainty before inflation targeting. After inflation targeting, when inflation is less than 2%, the policy rate response to positive shocks in the uncertainty index is negative and these responses are found to be statistically significant for the first 4 periods. On the other hand, the policy rate responses to positive shocks to either inflation or the output gap are not statistically significant. After inflation targeting, if inflation is higher than 2%, the policy rate responses to positive shocks in the uncertainty index are negative and these responses are statistically significant for the first six months. In addition, the policy rate responses to positive shocks in current inflation are positive, and while these responses are statistically insignificant for the first three forecast periods, they are found to be statistically significant after the fourth forecast period. The response of the policy rate to positive shocks to the output gap is statistically insignificant. These results indicate that the Fed reacts to economic instability if inflation is less than 2%, and to both economic instability and current inflation when inflation is greater than 2%.

Figure 1: Response of the policy interest rate to structural one standard deviation positive innovations using current inflation before inflation targeting

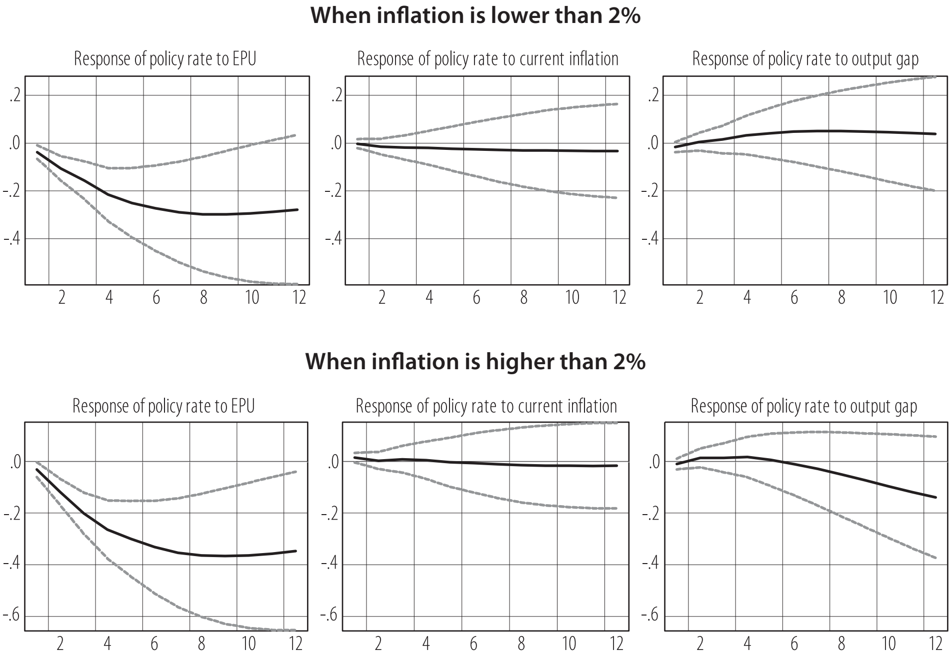
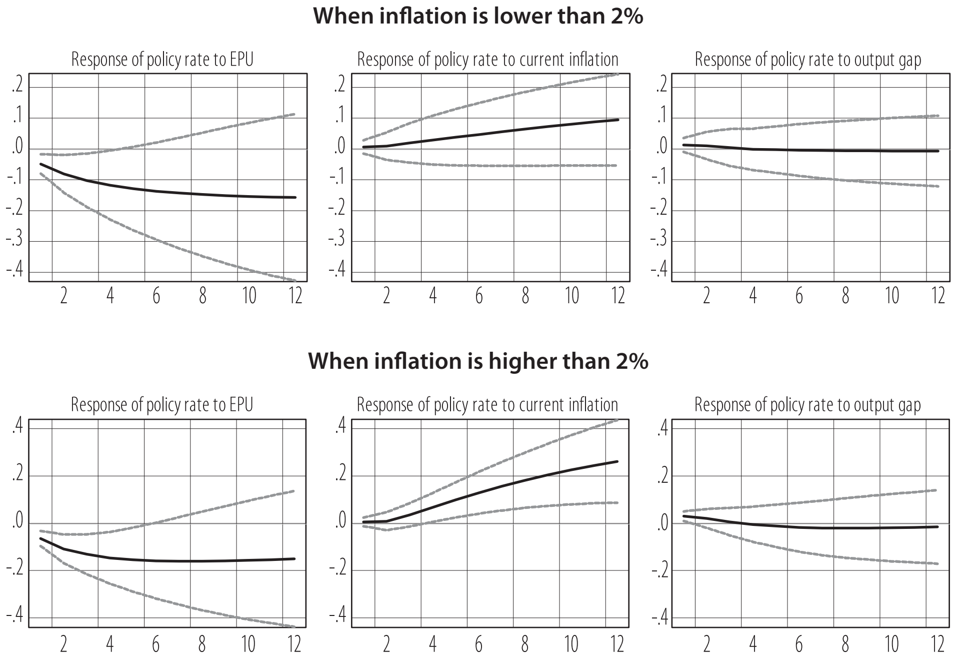


Figure 2: Response of the policy interest rate to structural one standard deviation positive innovations using current inflation after inflation targeting



When expected inflation is used, Figure 3 shows the response of policy interest rates to positive shocks in other variables before inflation targeting and Figure 4 after inflation targeting. The impulse-response functions obtained when using expected inflation are similar to those found when current inflation is used. Before inflation targeting, the responses of the policy rate to positive shocks in the uncertainty index were negative and statistically significant, while the responses to positive shocks in the expected inflation and output gap were found to be statistically insignificant. After inflation targeting, when inflation is less than 2%, the responses of the policy rate to positive shocks in the uncertainty index are negative and statistically significant in the first four forecast periods, while the responses to positive shocks in both expected inflation and output gaps are found to be statistically insignificant. In addition, when inflation is higher than 2%, the policy rate responses to positive shocks in the uncertainty index are negative and statistically significant for the first three forecast periods. On the other hand, when inflation is higher than 2%, the responses of the policy rate to positive shocks in expected inflation are positive, and these responses are found to be statistically significant for the first twelve forecast periods. On the other hand, the response of the policy rate to positive shocks to the output gap is statistically insignificant. These results indicate that after inflation targeting, when inflation is higher than 2%, the Fed's reaction to positive shocks in current inflation lagged for three months, and its reaction to expected inflation is instantaneous.

Figure 3: Response of the policy interest rate to structural one standard deviation positive innovations using expected inflation before inflation targeting

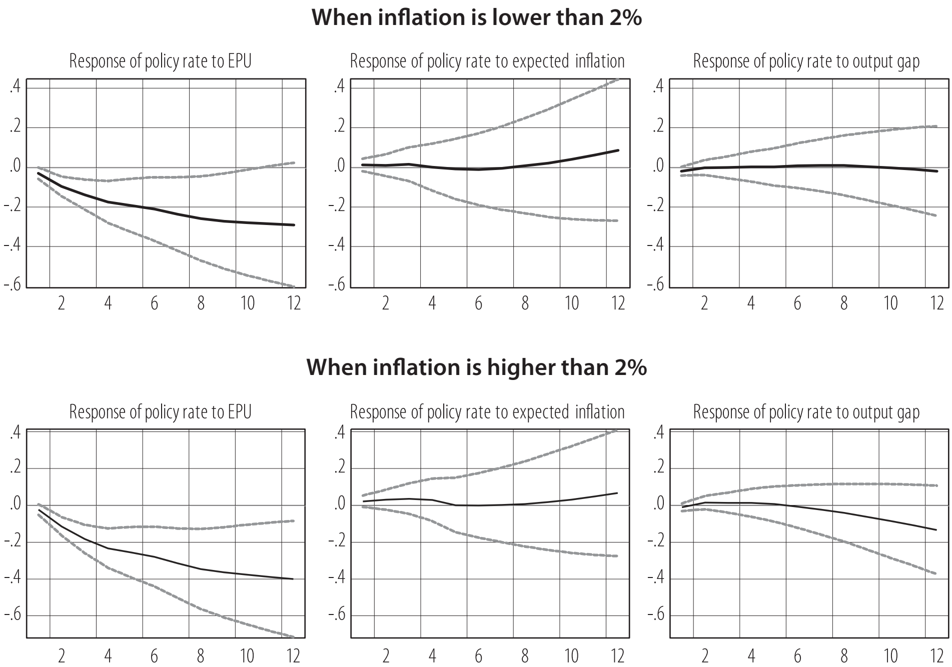
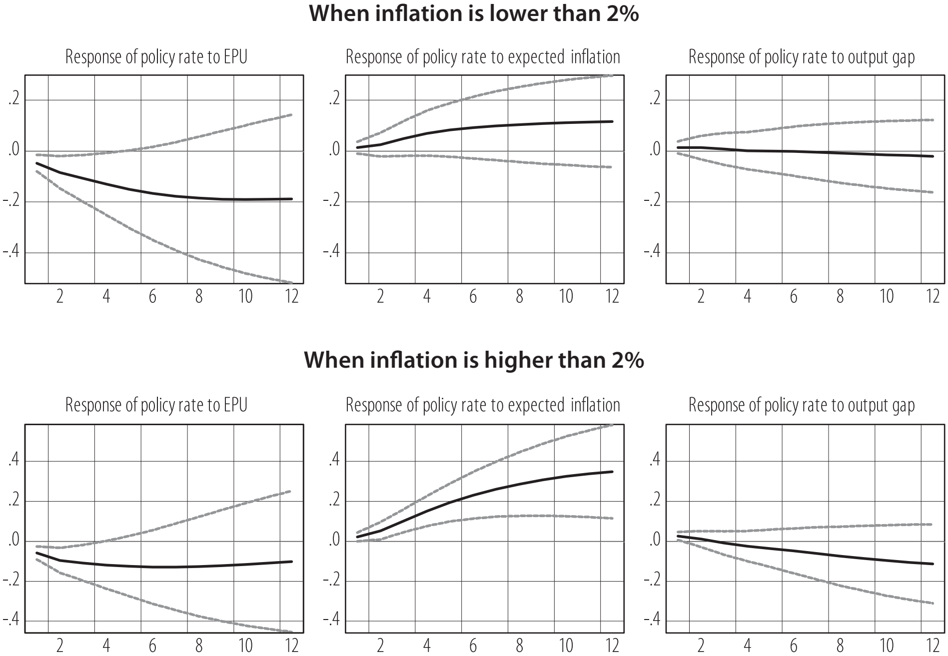


Figure 4: Response of the policy interest rate to structural one standard deviation positive innovations using expected inflation after inflation targeting



4.5. Threshold SVAR model results with output gap

For before and after inflation targeting periods according to the periods of negative and positive output gaps, the results of the variance decomposition of the policy rate are given in Table 6 when current inflation is used, and the results are given in Table 7 when expected inflation is used.

Table 6: Results of variance decomposition of the policy rate according to output gap using current inflation

	Negative output gap			Positive output gap			
	Before inflation targeting						
Period	EPU	Current inflation	Output gap	EPU	Current inflation	Output gap	Policy rate
1	5.24	1.05	0.25	5.92	3.08	0.31	84.13
2	19.98	0.29	0.29	15.45	1.24	0.44	62.31
3	29.18	0.13	0.18	21.82	0.71	0.55	47.45
4	34.05	0.11	0.10	25.48	0.44	0.44	39.39
5	36.76	0.11	0.07	28.08	0.30	0.29	34.39
6	38.28	0.12	0.05	29.98	0.22	0.21	31.13
7	39.07	0.13	0.05	31.42	0.18	0.22	28.94
8	39.40	0.13	0.05	32.53	0.16	0.32	27.41
9	39.44	0.12	0.06	33.41	0.14	0.52	26.31
10	39.28	0.11	0.06	34.09	0.14	0.80	25.51
11	38.98	0.10	0.07	34.63	0.14	1.17	24.92
12	38.58	0.09	0.07	35.03	0.15	1.62	24.46
	After inflation targeting						
Period	EPU	Current inflation	Output gap	EPU	Current inflation	Output gap	Policy rate
1	28.44	0.44	0.01	3.13	0.13	3.32	64.53
2	28.55	0.19	0.33	4.63	0.28	4.31	61.71
3	26.75	0.35	0.48	6.53	2.53	4.11	59.25
4	24.69	0.89	0.50	7.87	5.71	3.79	56.55
5	22.59	1.92	0.47	8.47	9.31	3.49	53.75
6	20.70	3.28	0.42	8.57	12.87	3.20	50.97
7	18.97	4.80	0.38	8.35	16.26	2.94	48.31
8	17.41	6.36	0.34	7.96	19.42	2.69	45.82
9	16.00	7.90	0.31	7.49	22.33	2.47	43.50
10	14.73	9.40	0.28	6.97	25.00	2.27	41.34
11	13.60	10.82	0.26	6.46	27.43	2.09	39.34
12	12.58	12.17	0.24	5.96	29.62	1.94	37.50

While the shares of the uncertainty index in the variance decomposition of the policy interest rate are quite large before inflation targeting, the shares of both current inflation and the output gap are found to be quite low. These results remain valid in cases where the output gap is negative or positive, as well as when current and expected inflation is used. For example, when current inflation is used, before inflation targeting and while the output gap is negative, the share of the uncertainty index in the variance decomposition of the policy interest rate increases from 5.24% in the first forecast period to 19.98% in the second forecast period and to 38.58% in the twelfth period by increasing in the following forecast periods. A similar trend exists when the output gap is positive. It was determined that the results were similar when expected inflation was used instead of current inflation. These results indicate that the Fed reacts depending on uncertainty before inflation targeting.

Table 7: Results of variance decomposition of the policy rate according to output gap using expected inflation

	Negative output gap			Positive output gap			
			Before inflation targeting				
Period	EPU	Expected inflation	Output gap	EPU	Expected inflation	Output gap	Policy rate
1	5.13	1.17	0.70	5.88	1.24	0.22	85.66
2	20.24	0.46	0.50	15.45	1.21	0.54	61.60
3	29.38	0.23	0.27	21.47	0.93	0.64	47.08
4	34.49	0.13	0.15	25.51	0.71	0.49	38.53
5	37.39	0.08	0.10	28.37	0.56	0.33	33.17
6	39.00	0.06	0.07	30.48	0.49	0.23	29.68
7	39.85	0.04	0.06	32.08	0.47	0.22	27.29
8	40.22	0.05	0.05	33.32	0.49	0.28	25.59
9	40.28	0.08	0.04	34.30	0.56	0.42	24.32
10	40.12	0.15	0.04	35.07	0.67	0.62	23.34
11	39.79	0.27	0.03	35.65	0.84	0.88	22.54
12	39.34	0.44	0.03	36.08	1.05	1.18	21.87
			After inflation targeting				
Period	EPU	Expected inflation	Output gap	EPU	Expected inflation	Output gap	Policy rate
1	26.08	3.91	0.04	2.78	0.39	0.92	65.87
2	28.41	4.05	0.74	4.09	2.26	1.06	59.38
3	26.54	5.22	1.13	5.14	9.03	0.81	52.13
4	24.03	6.71	1.23	5.39	17.00	0.65	44.99
5	21.70	8.22	1.22	5.08	24.08	0.53	39.17
6	19.67	9.64	1.20	4.56	29.92	0.43	34.59
7	17.88	10.91	1.18	3.99	34.69	0.34	31.01
8	16.28	12.03	1.18	3.46	38.60	0.27	28.18
9	14.86	13.02	1.18	2.98	41.84	0.22	25.91
10	13.58	13.89	1.19	2.57	44.53	0.18	24.06
11	12.44	14.65	1.20	2.22	46.78	0.16	22.54
12	11.43	15.33	1.21	1.93	48.67	0.15	21.28

After inflation targeting, there are noticeable differences in the shares of variables in the variance decomposition of the policy rate according to the negative and positive output gap periods. For example, when current inflation is used, the shares of the uncertainty index in the variance decomposition of the policy interest rate in the negative output gap periods were 28.44% in the first forecast period and 28.55% in the second forecast period, while these shares decreased in the following forecast periods and became 12.58% in the twelfth forecast period. These shares were determined as 3.13%, 4.63%, and 5.96%, respectively, for the periods when the output gap was positive. Similar results are obtained when expected inflation is used instead of current inflation. These results indicate that the effect of the uncertainty index on the policy rate after inflation targeting is asymmetrical due to the negative and positive output gap. In addition, these results show that the uncertainty index has a greater effect on the policy rate in periods when the output gap is negative during post-inflation-targeting.

After inflation targeting, the share of current inflation in the variance decomposition of the policy rate in the periods when the output gap is negative was 0.44% in the first forecast period and 0.19% in the second forecast period, while these shares increased in the subsequent forecast periods and reached 12.17% in the twelfth forecast period. In periods when the output gap was positive, these shares were 0.13%, 0.28%, and 29.62%, respectively. When expected inflation is used instead of current inflation, it is determined that the expected inflation shares are larger than the shares of current inflation in the variance decomposition of the policy rate. After inflation targeting, the share of expected inflation in the variance decomposition of the policy rate in periods when the output gap is negative was 3.91% in the first forecast period and 4.05% in the second forecast period, while it increased in the subsequent forecast periods and reached 15.33% in the twelfth forecast period. In the positive output gap periods, these shares were as low as 0.39% in the first forecast period and 2.26% in the second forecast period, moving up to 9.03% in the third forecast period, 17.00% in the fourth forecast period, and increasing in the subsequent forecast periods, reaching a very high level of 48.67% in the twelfth forecast period. These results indicate that the Fed's responses to both current and expected inflation are asymmetrical compared to periods when the output gap is positive and negative. In addition, the findings indicate that the Fed's responses to both current and expected inflation in the long run are quite high during periods of positive output gap.

The shares of the output gap in the variance decomposition of the policy rate are negligible, except in periods when the output gap is positive after inflation targeting, when current inflation is used. For this period, the share of the output gap in the variance decomposition of the policy rate is 3.32%, which is higher than both the current inflation and the uncertainty index in the first forecast period. These shares rise to 4.31% in the second forecast period. These results indicate that the output gap has an effect on the policy rate in the short run if the output gap is positive during inflation targeting periods.

When current inflation is used, the responses of the policy rate to positive shocks in other variables are given in Figure 5 for the pre-inflation-targeting periods and in Figure 6 for the post-inflation-targeting periods. Before inflation targeting, the policy rate responses to positive shocks in the uncertainty index for periods when the output gap was negative and positive were negative and statistically significant. On the other hand, the policy rate responses to positive shocks to both current inflation and the output gap are not statistically significant. These results show that the Fed only reacts to the uncertainty index before inflation targeting, and that these reactions are symmetrical according to the output gap.

After inflation targeting, the policy rate responses to positive shocks in both the uncertainty index and current inflation were statistically significant in periods when the output gap was negative, while positive shocks in the output gap were statistically insignificant. The policy rate responses to positive shocks in the uncertainty index are negative and these responses are statistically significant for the first five forecast periods. On the other hand, the response of the policy rate to positive shocks in current inflation is positive. While these responses were statistically insignificant in the first seven forecast periods, they were statistically significant after the eighth forecast period. After inflation targeting, when the output gap is positive, although the policy rate responses to positive shocks in the uncertainty index are negative, these responses are statistically insignificant. On the other hand, in this period, the response of the policy rate to positive shocks to the output gap is positive and is found to be statistically significant for the first three forecast periods. In addition, the policy rate responses to positive shocks in current inflation were positive, and while these responses were statistically insignificant in the first two forecast periods, they were statistically significant in all forecast periods after the third forecast period. The policy rate responds to the output gap in the short run and to current inflation in the long run when the output gap is negative, and when the output gap is positive, it responds to the output gap in the short run and current inflation in the long run.

Figure 5: Response of the policy interest rate to structural one standard deviation positive innovations using current inflation before inflation targeting

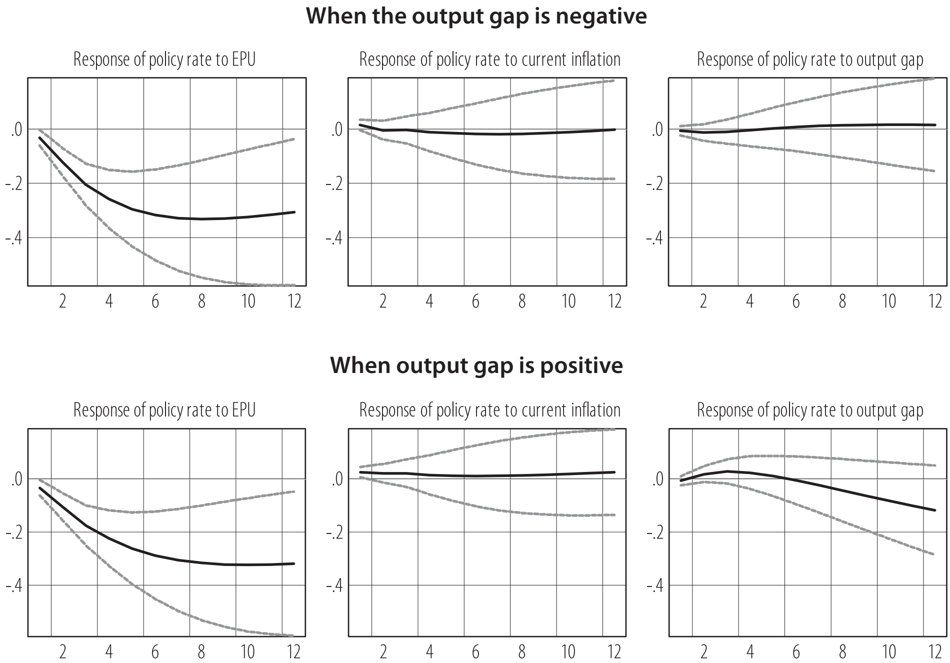
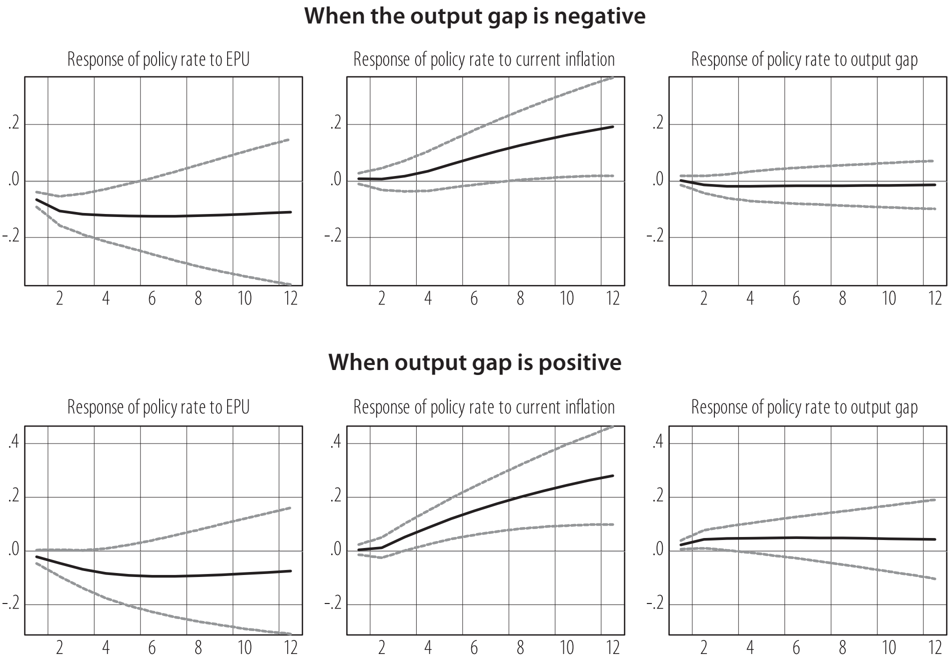
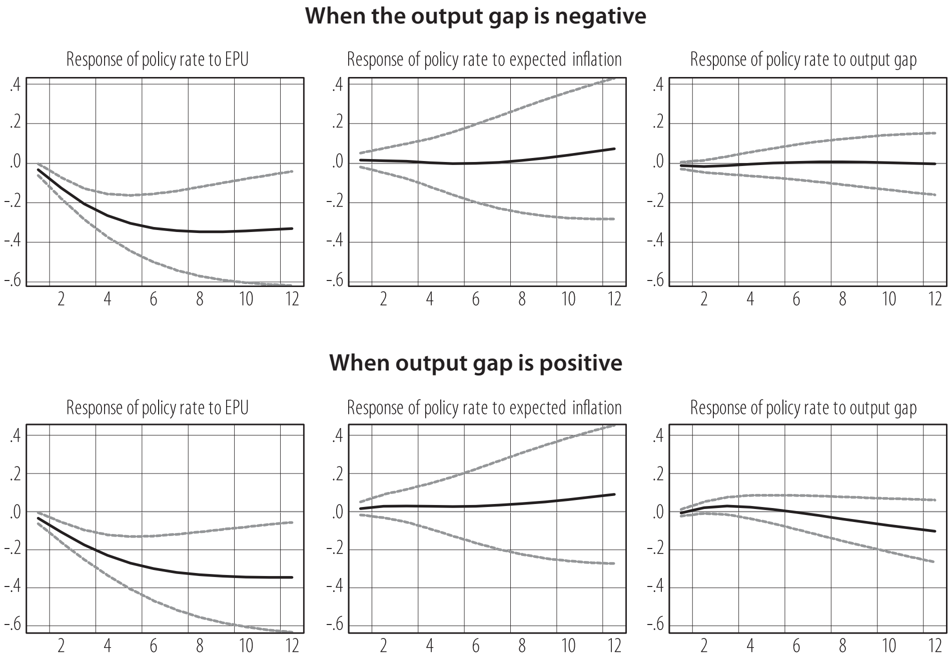


Figure 6: Response of the policy interest rate to structural one standard deviation positive innovations using current inflation after inflation targeting



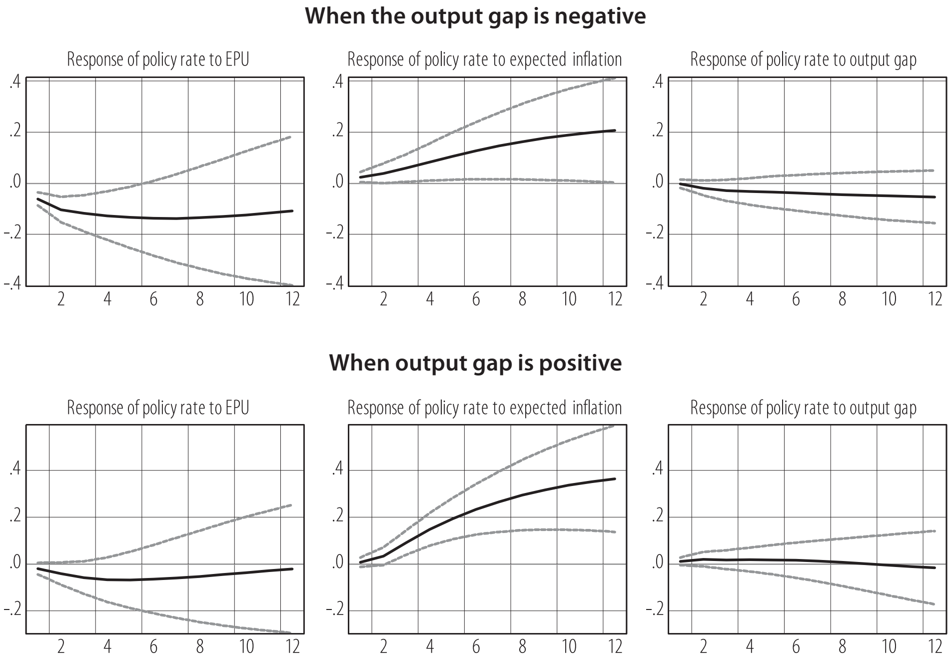
When expected inflation is used, the policy rate responses to positive shocks in other variables are given in Figure 7 for the pre-inflation-targeting periods and in Figure 8 for the post-inflation-targeting. Before the inflation targeting regime, when the output gap was both negative and positive, the policy rate responses to positive shocks in the uncertainty index were negative and these responses were found to be statistically significant. On the other hand, the policy rate responses to positive shocks to both current inflation and the output gap are not statistically significant. These results show that the Fed reacted to the uncertainty index before inflation targeting, and that these responses did not differ in the periods when the output gap was negative and positive.

Figure 7: Response of the policy interest rate to structural one standard deviation positive innovations using expected inflation before inflation targeting



In periods when the output gap is negative after inflation targeting, the policy rate responses to positive shocks in the uncertainty index are negative and these responses are statistically significant for the first five forecast periods. In addition, the policy rate response to positive shocks to expected inflation is positive, and although these responses are statistically insignificant in the first two forecast periods, they are statistically significant in the following forecast periods. On the other hand, the response of the policy rate to positive shocks in the output gap is found to be statistically insignificant. On the other hand, in periods when the output gap is positive, only the responses of the policy rate to positive shocks to expected inflation are statistically significant. These results indicate that the Fed reacts to uncertainty in the short term and expected inflation in the long run when the output gap is negative after inflation targeting, and that it responds to expected inflation in both short and long run when the output gap is positive.

Figure 8: Response of the policy interest rate to structural one standard deviation positive innovations using expected inflation after inflation targeting



5. Conclusions

In this study, using monthly data between 1992 and 2024, the Federal Reserve's asymmetric reaction function relative to inflation and output gap was examined based on threshold SVAR models for two subsamples, covering the periods before the inflation targeting regime corresponding to the periods before 2012 and the inflation targeting regime corresponding to the periods after 2012. Taking into account the inflation rate targeted by the Fed, the threshold value for inflation was chosen as 2%, and the threshold value for the output gap was chosen as zero, which corresponds to the level of full employment. Thus, before and after inflation targeting, the questions of whether the Fed's monetary policy is determined according to the linear Taylor rule, or the nonlinear Taylor rule were addressed. In addition, empirical results were examined by using the expected inflation variable as well as real inflation in the threshold SVAR model to answer the question of which is more dominant in the Fed`s monetary policy between the backward-looking and forward-looking Taylor rule.

The empirical findings indicate that the Fed reacted to economic instability rather than to inflation and the output gap before inflation targeting. The Fed's response to economic instability is more aggressive if inflation exceeds the target rate of 2% before the inflation targeting regime. On the other hand, the Fed's responses to economic instability are the same when the output gap is negative or positive before the inflation targeting regime. These results indicate that the Fed's monetary policy was symmetrical with respect to inflation and output gaps before inflation targeting, and asymmetrical with respect to economic instability depending on whether inflation was low or high. Findings from the impulse-response functions show that the policy rate reacts negatively to positive shocks in economic instability. These results show that since the risk factor brought by economic uncertainties will have restrictive consequences for producers and consumers, the Fed has turned to expansionary policy and while doing this, it has aceds with producer and consumer expectations rather than current data. This policy, which is called `Greenspan policy` put in the literature and accepted as the Federal Reserve's protective attitude by injecting liquidity into the market against macroeconomic volatility, can create a moral hazard by leading to uncontrolled risk-taking in the market (Bornstein and Lorenzoni, 2018).

Empirical findings indicate that in the periods after the inflation targeting regime, if inflation is greater than 2%, the Fed reacts more aggressively to inflation in the long run, the output gap in the short term, and economic instability both in short and long term. Also, when inflation is greater than 2%, the Fed reacts to expected inflation more than to the actual inflation. In addition, when inflation rises above 2% after inflation targeting, the Fed's response to positive shocks in current inflation is lagged, while its response to expected inflation is instantaneous. The empirical findings show that after the inflation targeting regime, the Fed`s monetary policy reactions are asymmetrical according to both inflation and output gap. In addition, the fact that the reactions based on expected inflation rather than actual inflation in the Fed's monetary policy are stronger indicates that the forward-looking Taylor rule is more explanatory for the Fed. These results show that the Fed has implemented a forward-looking policy to guide long-term inflation dynamics, and that current inflation has remained in the background against inflation expectations in the Fed's monetary policy decisions during the inflation targeting period.

According to the output gap, it was determined that the Fed's monetary policy reactions were symmetrical before inflation targeting and asymmetrical afterward. Empirical findings indicate that the Fed reacts more aggressively to inflation (or expected inflation) when the output gap is positive after inflation targeting, and to economic instability when the output gap is negative. The empirical results show that the Fed's monetary policy responses are asymmetrical due to both inflation and the output gap, especially after the transition to the inflation targeting regime. On the other hand, another finding of the study is that when the output gap is negative during the inflation targeting period, economic instability has a greater effect on the policy rate. This result indicates that the Federal Reserve intervenes more aggressively in the face of increased uncertainties when the economy is below its potential than in other alternative situations.

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