Optimal Monetary Policy Regime Switches*

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Abstract

Given structural shifts in the economy, optimal simple monetary policy rules may respond with switches in their policy parameters. When the growth rate, inter-temporal preferences, or volatilities switch, the monetary authority chooses regime-dependent policy parameters to maximize welfare. These optimized policy parameters may differ across regimes and from the optimal choice of parameters for economies with fixed regimes. Rules that are more flexible by allowing more parameters to synchronously switch produce welfare gains, with switches in the degree of interest rate inertia producing the largest gains.

Keywords: optimal policy; regime switching; Taylor rule; inflation target

JEL Codes: C63, E31, E52

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1 Introduction

The recent financial crisis and slow recovery has prompted a renewed debate about objectives and conduct of monetary policy. In particular, given the structural changes experienced by the economy, some economists argued that the Federal Reserve should alter its implicit rule to allow either a higher inflation target, a less aggressive response to inflation deviations, or a more aggressive response to the output gap. For example, Rogoff (2008), Blanchard et al. (2010), and Ball (2013) called for an explicit move to an inflation target from 2 percent to the range of 4-6 percent. Others, such as Taylor (2012), saw changes in the implicit policy rule and called for a return to rules used at an earlier time.

This paper studies optimal simple rules for monetary policy when the structural economy experiences regime shifts. Using a standard New Keynesian model with three different types of regime switching, it finds optimal simple rules that are fully regime dependent, and compares their performance against optimized rules that constrain some or all of the policy parameters to be identical across regimes. The three types of switching all tend to generate low nominal rates in one regime, which causes the monetary authority to need to adjust its policy rule.

For the optimal rules, the policy parameters differ from those that would be chosen if each regime occurred in isolation, indicating that modifying the rule due to the presence of regime switching is important to the conduct of optimal policy. Further, even conditional on starting from an environment with a fixed policy rule that does not adjust with regime changes, changing to rules with switching parameters increases welfare. A rule where all policy parameters switch is welfare-preferred, but rules that only allow a subset of policy parameters to change increase welfare as well, with switching in the degree of interest rate inertia providing the biggest gains. These results suggest that allowing flexibility for monetary policy in the face of shifts in the structural economy is an important aspect of conducting monetary policy, and constraining policy to follow a single rule regardless of the regime can generate inferior economic outcomes.

Much of the literature on optimal monetary policy with simple rules assumes constant rules over time. For example, Schmitt-Grohe and Uribe (2007) characterize optimal simple rules in an economy without instability in the structural economy, and show these rules nearly replicate.
welfare achieved by a Ramsey planner. In the context of regime switches in the structural economy, this paper shows simple rules that switch alongside the structural economy welfare dominate fixed rules. More recently, Billi (2011), Coibion et al. (2012), and Blanco (2015) consider the optimal inflation target in the presence of the zero lower bound on nominal interest rates. In these cases, the monetary authority sets a constant inflation target that weighs the costs of higher inflation against the chance of hitting the zero lower bound. The optimal simple rules considered in this paper allow this trade-off to be regime-dependent, which enables the authority to set a higher inflation target in regimes where hitting the zero bound is relatively more likely. Further, this paper shows that constraining the simple rule to only allow switching in the inflation target or the response coefficients—but not both—distorts the optimal parameters relative to the case when all parameters switch.

Papers studying switching in monetary policy rules often have non-optimal switches that are independent of any underlying change in the economy. For example, Davig and Leeper (2007) and Bianchi (2013) consider switches in the coefficients dictating how the monetary authority responds to deviations from its targets, Schorfheide (2005) and Liu et al. (2011) allow for switches in the inflation target, and Foerster (2016) considers both types. However, in each of these frameworks, changes in the monetary policy rule occur randomly and without regard to the state of the private economy. In contrast, this paper motivates regime switching in the policy rule as an optimal response to switches in the private economy.

In the case where papers consider optimal policy with regime switching in the private economy, the monetary authority may face a reduced-form representation of the structural economy as in Blake and Zampolli (2011). On the other hand, Debortoli and Nunes (2014) interpret regime switching in monetary policy as coming from explicit changes in the authority’s loss function. Davig (2016) shows how regime switches in price-setting behavior in the structural economy map into switches in the loss function when the authority operates with discretion. In contrast to these frameworks, this paper considers optimal simple rules, and how changes in the structural economy affect the optimal choice of policy parameters.

The remainder of the paper proceeds as follows: Section 2 presents the model, Section 3
discusses computation of the optimal policy rules, Section 4 contains the results, and Section 5 concludes.

2 Model

This section describes a prototypical New Keynesian model. The five key features of the model are: (i) nominal rigidities that create a role for inflation stabilization, (ii) a markup shock that generates a trade-off between output and inflation stabilization, (iii) a preference shock that affects the inter-temporal decisions of the household, (iv) regime switching that affects the growth rate, the rate of time preference, and volatility of the economy, and (v) a planner with access to only lump-sum taxes and a nominal interest rate.

The following presents the model’s several parts: households, final and intermediate goods firms, fiscal policy, the monetary authority, and how regimes switch.

2.1 Households

Households maximize lifetime expected discounted utility of the form

$$E_0 \sum_{t=0}^{\infty} \beta^t d_t \left( \log C_t - H_t \right),$$

where $E_0$ is the expectations operator conditional on information at time 0, $\beta \in (0, 1)$ is the discount factor, $d_t$ is an inter-temporal preference shifter, $C_t$ is consumption, and $H_t$ is hours worked. Households face the budget constraint

$$C_t + \frac{B_t}{P_t} + \frac{T_t}{P_t} = W_t H_t + R_{t-1} \frac{B_{t-1}}{P_t} + D_t,$$

where $B_t$ denotes bonds purchased at time $t$ that pay out a gross nominal interest rate $R_t$ at $t + 1$, $T_t$ is nominal lump-sum taxes paid to the government, $W_t$ is the real wage rate, and $D_t$ is real dividend payments from firms. The inter-temporal preference shifter follows

$$\log d_t = (1 - \rho_d) \log \delta (s_t) + \rho_d \log d_{t-1} + \sigma_d (s_t) \varepsilon_{d,t},$$
where \( s_t \) denotes the regime, \( \delta(s_t) \) denotes the regime-dependent level of the shifter, and \( \sigma_d(s_t) \) denotes the regime-dependent standard deviation of the shock.

Standard optimality conditions for the household produce an Euler equation of the form

\[ \beta \mathbb{E}_t \left( \frac{C_t}{C_{t+1}} \right) \left( \frac{d_{t+1}}{d_t} \right) \frac{R_t}{\Pi_{t+1}} = 1, \]

which highlights how, all else equal, shocks and regime shifts that increase \( d_{t+1}/d_t \) or \( C_t/C_{t+1} \), will tend to lower nominal interest rates. Given the autoregressive process in equation (3), negative shocks \( \varepsilon_{d,t} \) will then tend to raise \( R_t \), as will being in a low \( \delta(s_t) \) regime with expectations of switching to a higher \( \delta(s_{t+1}) \).

### 2.2 Firms

There are two types of firms: intermediate goods firms that produce with labor, and final goods firms that bundle intermediate goods into a final output to be consumed by households and the government.

#### 2.2.1 Final Good Firms

A competitive final good producer combines a continuum of intermediate goods \( Y_{j,t}, j \in [0, 1] \) by constant elasticity of substitution technology to produce a final good

\[ Y_t = \left( \int_0^1 Y_{j,t} \frac{1}{1+m_t} \, dj \right)^{1+m_t}, \]

where \( m_t \) denotes the time-varying net markup. This specification implies the demand for a good \( Y_{j,t} \) depends on its relative price, the markup, and aggregate demand by

\[ Y_{j,t}^d = \left( \frac{P_{j,t}}{P_t} \right)^{-\frac{1+m_t}{m_t}} Y_t. \]

The net markup \( m_t \) follows an autoregressive process with regime-dependent volatility

\[ \log m_t = (1 - \rho_m) \log m_{ss} + \rho_m \log m_{t-1} + \sigma_m(s_t) \varepsilon_{m,t}, \]

where \( \sigma_m(s_t) \) denotes the regime-dependent standard deviation of the shock. Positive markup shocks \( \varepsilon_{m,t} \) produce opposite movements in inflation and output, generating a trade-off for their stabilization.
2.2.2 Intermediate Goods Firms

Intermediate goods producers are indexed by $j$ and have production functions

$$Y_{j,t}^s = A_t H_{j,t},$$

(8)

where total factor productivity nests stationary and unit root components:

$$\log A_t = \log \omega (s_t) + \log A_{t-1} + a_t,$$

(9)

$$a_t = \rho a_{t-1} + \sigma_a (s_t) \varepsilon_{a,t}.$$  

(10)

In this case, the mean growth rate of TFP $\omega (s_t)$ and the volatility $\sigma_a (s_t)$ switches along with the regime $s_t$.

Intermediate goods firms adjust prices according to Rotemberg pricing without indexation of prices to inflation. Consequently, the firm’s maximization problem is to choose $H_{j,t}$ and $P_{j,t}$ to maximize

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_t \frac{\lambda_t}{\lambda_0 P_t} \left( \left( \frac{P_{j,t}}{P_t} \right)^{-\frac{1}{\omega_t}} Y_t - W_t H_{j,t} - \frac{\phi_p}{2} \left( \frac{P_{j,t}}{P_{j,t-1}} - 1 \right) Y_t \right)^2$$

(11)

where $\lambda_t$ denotes the marginal utility of consumption for the household. Firms are also subject to the constraint that supply (8) must meet demand (6) at the posted price. The price adjustment generates a cost of inflation in output terms, as deviations from price stability generate progressively higher losses in output.

2.3 Fiscal Policy

The government purchases a fraction $\zeta_t$ of aggregate output $Y_t$, so

$$G_t = \zeta_t Y_t.$$  

(12)

The fraction of goods purchased satisfies

$$g_t = \frac{1}{1 - \zeta_t}.$$  

(13)
where $g_t$ follows an autoregressive process

$$\log g_t = (1 - \rho_g) \log g_{ss} + \rho_g \log g_{t-1} + \sigma_g(s_t) \varepsilon_{g,t}$$ \hspace{1cm} (14)

and $\sigma_g(s_t)$ denotes the regime-dependent standard deviation of the shock.

The government collects lump-sum taxes to cover spending, and nominal bonds are in zero net supply. Hence the aggregate resource constraint is given by

$$Y_t = C_t + G_t + \frac{1}{2} (\Pi_t - 1)^2 Y_t.$$ \hspace{1cm} (15)

This resource constraint again highlights the cost of inflation, as deviations from price stability produce losses in output that cannot go to consumption or the government. Importantly, fiscal policy does not have access to a production subsidy to firms that eliminates the distortions associated with monopolistic competition; the inefficiency from imperfect competition must be taken into account by the monetary authority when setting interest rates (Woodford (2003)).

### 2.4 Monetary Policy

The monetary authority follows a Taylor rule of the form

$$\frac{R_t}{R^* (s_t)} = \left( \frac{R_{t-1}}{R^* (s_t)} \right)^{\rho_r (s_t)} \left( \frac{\Pi_t}{\Pi^* (s_t)} \right)^{\psi_x (s_t)} \left( \frac{\tilde{Y}_t}{Y_{ss}} \right)^{\psi_y (s_t)}.$$ \hspace{1cm} (16)

This form allows for regime switches in the inflation target $\Pi^* (s_t)$, the degree of interest rate inertia $\rho_r (s_t)$, and the responsiveness to the inflation and output gaps, $\psi_x (s_t)$ and $\psi_y (s_t)$, respectively. The output gap is in terms of de-trended output $\tilde{Y}_t = Y_t / A_t$. The neutral nominal rate switches, and is made up of the inflation target and the steady state real rate that would prevail if each regime occurred in isolation, so

$$R^* (s_t) = \Pi^* (s_t) \frac{\omega (s_t)}{\beta}.$$ \hspace{1cm} (17)

### 2.5 Regime Switching

To summarize the regime switching in the model, the structural economy experiences switches in the growth rate ($\omega (s_t)$), inter-temporal preference ($\delta (s_t)$), and volatilities ($\sigma_d (s_t)$, $\sigma_m (s_t)$),
\(\sigma_a(s_t), \sigma_g(s_t)\). The results in Section 4 consider each of these cases independently, and Section 3 discusses the parameterization of each case. At the same time, the monetary policy rule switches parameters \((\rho_r(s_t), \psi_x(s_t), \psi_y(s_t), \Pi^*(s_t))\). In all cases, the regime follows a Markov process governed by a transition matrix with elements \(P_{i,j} = \Pr(s_t = j|s_{t-1} = i)\). Assuming two regimes with symmetric probabilities given by \(p = \Pr(s_t = s_{t-1})\), the transition matrix is given by

\[
P = \begin{bmatrix}
P_{1,1} & 1 - P_{1,1} \\
1 - P_{2,2} & P_{2,2}
\end{bmatrix} = \begin{bmatrix}
p & 1 - p \\
1 - p & p
\end{bmatrix}.
\] (18)

3 Computation and Welfare

Given the model previously described, this section turns to the calibration and solution method, how the monetary authority sets optimal implementable rules, and the welfare calculations.

3.1 Calibration and Solution

The first set of parameters, shown in Table 1, describe preferences and production and are constant across the three separate models considered. The unit of time is a quarter, and these parameters largely follow the estimates in a similar model by Schorfheide (2005).

Table 2 shows how the remaining parameters vary across the three different models considered. The three models have either switches in (i) the growth rates, (ii) the level of the intertemporal preference shifter, or (iii) the volatilities. Since each model has some parameters that do not switch, for these the dependence on \(s_t\) is dropped for notational convenience.

The first model, shown in Panel A, is an economy that experiences growth rate switches. The only switching behavior in this economy is the trend component of TFP, \(\omega(s_t)\). In particular, in the first, high growth regime, the economy grows at 2.5% annually, while in the second, low growth regime, the economy grows at 0.5% annually. These two regimes capture concerns about faster technical progress in previous decades giving way to slower growth in the future (for example, Gordon (2012)), as well as a lower real interest rate (Summers (2014)). The presence of growth rate switches affects the household’s Euler equation (4) and the firms problem via
<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount Factor</td>
<td>$\beta = 0.9987$</td>
</tr>
<tr>
<td>Steady State Fraction of Government Purchases</td>
<td>$\zeta_{ss} = 0.2$</td>
</tr>
<tr>
<td>Steady State Net Markup</td>
<td>$m_{ss} = 0.10$</td>
</tr>
<tr>
<td>Cost of Price Adjustment</td>
<td>$\phi_p = 160$</td>
</tr>
<tr>
<td>Technology Shock Persistence</td>
<td>$\rho_a = 0.8$</td>
</tr>
<tr>
<td>Government Spending Shock Persistence</td>
<td>$\rho_y = 0.9$</td>
</tr>
<tr>
<td>Inter-temporal Preference Shock Persistence</td>
<td>$\rho_d = 0.9$</td>
</tr>
<tr>
<td>Markup Shock Persistence</td>
<td>$\rho_m = 0.9$</td>
</tr>
<tr>
<td>Transition Probability</td>
<td>$p = 0.95$</td>
</tr>
</tbody>
</table>

technology (8). In addition, lower growth, by affecting the real interest rate, also changes the neutral nominal rate in the monetary policy rule (17). In the low growth regime, the real rate tends to be low, which corresponds to lower—and hence a greater chance of negative—nominal rates.

The second economy, shown in Panel B, experiences switches in the mean of the inter-temporal preference shifter process (3). In the high preference regime, the mean of the preference process exceeds one, while the low preference regime has a mean below one. All else equal, the values of $\delta(1) = 1.023$ and $\delta(2) = 0.977$ generate real rates equalling those in the growth rate regime switching economy, but without the differences in trend growth. These changes in the preference shock process, through the household’s Euler equation (4), affect the trade-off between consumption in the current and future periods. In the low preference regime, marginal utility is low given a fixed consumption level, which encourages savings and pushes the market clearing interest rate down. This lower rate means nominal rates are more likely to enter negative territory.

The third economy, shown in Panel C, has switches in the standard deviations of the shocks. In particular, in the first regime the economy faces relatively low volatility—with standard de-
viations of shocks half their values in the other economies—for all the shocks, while the second regime has high volatility—with standard deviations of shocks one-and-a-half times their baseline values.\(^1\) In the first regime then, the monetary authority faces relatively small shocks that they need to stabilize, and in the second regime, stabilization will be harder. Larger volatility may generate bigger movements in nominal rates, which will in turn increase the likelihood of negative rates.

Given the multiple sources of switching in the structural economy and the monetary policy rule, as well as a need to perform welfare calculations, the results in Section 4 use the perturbation method for Markov-switching DSGE models from Foerster et al. (2013). This methodology allows for second-order approximations to the decision rules, which enable accurate welfare calculations and capture the certainty non-equivalence generated by Markov-switching, especially in the monetary policy rule (see Foerster (2016)). In addition, perturbation allows for checking determinacy generated by the monetary policy rule, which is key for policy to be implementable.

3.2 Optimal Implementable Rules

Given the three switching economies described by the parameterizations in Table 2, the monetary authority sets the policy parameters for each regime \(\{\rho_r (s_t), \psi_{\pi} (s_t), \psi_y (s_t), \Pi^* (s_t)\}\) in the simple rule given by equation (16) to be optimal within the class of implementable rules. The following two definitions detail these terms.

**Definition 1 (Implementable)** For a policy rule to be implementable, it must meet the following three conditions:

1. The policy parameters must generate a unique equilibrium when considering mean square stability (MSS) of minimum state variable (MSV) solutions.

\(^1\)Estimates of models with switching volatilities, such as Bianchi (2013), indicate the presence of high and low volatility regimes. These estimates show different relative magnitudes between the low and high volatility regime depending on the shock. The parameterization here abstracts from this feature for simplicity, instead focusing on all shocks showing symmetric behavior in each regime.
Table 2: Switching Parameters

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter Values</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: Economy with Growth Rate Switches</strong></td>
<td></td>
</tr>
<tr>
<td>Growth Rate</td>
<td>( \omega (1) = 1.025^{1/4}, \omega (2) = 1.005^{1/4} )</td>
</tr>
<tr>
<td>Preference Shock Level</td>
<td>( \delta = 1 )</td>
</tr>
<tr>
<td>Technology Shock Std Dev</td>
<td>( \sigma_a = 0.003 )</td>
</tr>
<tr>
<td>Government Spending Shock Std Dev</td>
<td>( \sigma_g = 0.012 )</td>
</tr>
<tr>
<td>Inter-temporal Preference Shock Std Dev</td>
<td>( \sigma_d = 0.01 )</td>
</tr>
<tr>
<td>Markup Shock Std Dev</td>
<td>( \sigma_m = 0.01 )</td>
</tr>
</tbody>
</table>

| **Panel B: Economy with Preference Switches** | |
| Growth Rate | \( \omega = 1.015^{1/4} \) |
| Preference Shock Level | \( \delta (1) = 1.023, \delta (2) = 0.977 \) |
| Technology Shock Std Dev | \( \sigma_a = 0.003 \) |
| Government Spending Shock Std Dev | \( \sigma_g = 0.012 \) |
| Inter-temporal Preference Shock Std Dev | \( \sigma_d = 0.01 \) |
| Markup Shock Std Dev | \( \sigma_m = 0.01 \) |

| **Panel C: Economy with Volatility Switches** | |
| Growth Rate | \( \omega = 1.015^{1/4} \) |
| Preference Shock Level | \( \delta = 1 \) |
| Technology Shock Std Dev | \( \sigma_a (1) = 0.0015, \sigma_a (2) = 0.0045 \) |
| Government Spending Shock Std Dev | \( \sigma_g (1) = 0.006, \sigma_g (2) = 0.018 \) |
| Inter-temporal Preference Shock Std Dev | \( \sigma_d (1) = 0.005, \sigma_d (2) = 0.015 \) |
| Markup Shock Std Dev | \( \sigma_m (1) = 0.005, \sigma_m (2) = 0.015 \) |
2. The stochastic steady state in each regime must admit nonnegative dynamics for the net nominal interest rate. If $\mu_R(s_t)$ and $\sigma_R(s_t)$ are the mean and standard deviations for the log of the gross interest rate in regime $s_t$, respectively, then this condition requires $\mu_R(s_t) - 2\sigma_R(s_t) > 0$ for each $s_t$.

3. The policy coefficients are required to be in the following intervals for each $s_t$: $\rho_r(s_t) \in [0, 1)$, $\psi_\pi(s_t) \in [0, 5]$, and $\psi_y(s_t) \in [0, 5]$.

Condition (1) requires that the policy parameters across regimes produce a unique equilibrium when considered as a whole. The stability concept MSS allows temporarily explosive regimes as long as the entire system has finite first and second moments. Under these circumstances, satisfying determinacy regime-by-regime is neither necessary nor sufficient for achieving determinacy overall, and determinacy regions can be complex functions of all the policy parameters (Foerster (2016)).

Condition (2) imposes that hitting negative net nominal interest rates should be at least a two standard deviation event, which ensures a sufficiently low probability of that occurring. Note that the perturbation solution approach allows these negative dynamics, and this condition requires a low volatility relative to the average value in each regime.²

Lastly, condition (3) restricts to intervals that are the correct sign and within reasonable bounds. In particular, the monetary authority increases rates with inflation and the output gap, but there is a limit on how strongly they can respond, and interest rates can have positive inertia.³

²From a technical standpoint, perturbation does not easily handle the occasionally binding zero lower bound constraint; an alternative would be to solve the model globally (for example, Coibion et al. (2012)), but this procedure would be too slow given the number of policy parameters to optimize over.

From an economic standpoint, recent experience in Europe and Japan shows that policy rates can indeed go below zero, and there may be an effective lower bound that is negative. Perturbation has the benefit of not explicitly taking a stand on a hard bound for nominal rates, by simply seeking to limit the probability that they are negative.

³In general, high values of $\Pi^*(s_t)$ coupled with values of $\psi_\pi(s_t)$ near indeterminacy regions generate numerical inaccuracies that distort the welfare calculation. As a result, the planner does not have bounds on $\Pi^*(s_t)$, but
Among the set of policy parameters that generate an implementable rule, the monetary authority chooses those that are optimal in the sense that they maximize the household’s expected lifetime utility given an initial condition.

**Definition 2 (Optimal)** For an implementable policy to be optimal, it must maximize the household’s value function

\[ V_0 = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t d_t (\log C_t - H_t) \]  

(19)

given initial conditions.

By using the household’s preferences, the monetary authority is making optimal policy from the household’s view, rather than holding its own objective function.

### 3.3 Measuring Welfare

In order to compute and compare welfare, the planner maximizes the expected lifetime utility of the household conditional on an initial condition. The benchmark case for each model is one in which the economy experiences regime switches, but the planner sets a constant rule—that is, a rule with policy parameters that do not vary with the regime. Alternative cases allow various portions of the policy parameters to switch with the regimes. Table 3 lists the alternative cases and which portions of the rule can switch.

For the initial state, the planner uses the steady state of the switching economy with a constant rule. Since the regime-independent inflation target is a policy choice and in steady state the inflation rate equals the inflation target, the planner implicitly chooses the starting condition when selecting the inflation target for the constant rule. This assumption puts the constant rule on the best possible welfare terms, as the planner in alternative cases will possibly face transition dynamics to different steady state choices. For the initial regime, the planner instead searches for maxima around a net inflation rate of zero. An alternative, following Schmitt-Grohe and Uribe (2004), would be to restrict the policy parameters to be sufficiently far from an indeterminacy border. Given the number of policy parameters, along with the complexity of finding indeterminacy regions with regime switching, this restriction would be prohibitively difficult to check.
Table 3: Different Rules and the Parameters that Switch

<table>
<thead>
<tr>
<th>Rule</th>
<th>$\Pi^*(s_t)$</th>
<th>$\rho_r(s_t)$</th>
<th>$\psi_\pi(s_t)$</th>
<th>$\psi_y(s_t)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant Rule</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Target Only</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Inertia Only</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Inflation Response Only</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Out Gap Response Only</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>All Coefficients</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Full Switching</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

chooses coefficients before realizing the regime, and forms expectations according to the ergodic distribution of regimes.

As a result, the planner in the constant rule case picks policy coefficients to maximize the conditional expectation

$$V^{cr}(x_{ss}^{cr}) = \mathbb{E}\left[ \sum_{t=0}^{\infty} \beta^t d_t (\log C_t^{cr} - H_t^{cr}) \right] | x_{-1} = x_{ss}^{cr}$$  \hspace{1cm} (20)

where $cr$ denotes constant rule, and $C_t^{cr}$ and $H_t^{cr}$ respectively denote the optimal consumption and hours choices under the optimized constant rule. Note that the state $x_{-1} = x_{ss}^{cr}$ highlights that the initial state is the steady state that in turn depends on policy parameters in the constant rule. Denoting the ergodic distribution across regimes by $\xi = [\xi_1, \xi_2]$, this expectation can be expressed as

$$V^{cr}(x_{ss}^{cr}) = \sum_{s=1}^{2} \xi_s \mathbb{E}\left[ \sum_{t=0}^{\infty} \beta^t d_t (\log C_t^{cr} - H_t^{cr}) \right] | x_{-1} = x_{ss}^{cr}, s_0 = s$$  \hspace{1cm} (21)

In the alternative policy rule specifications, the planner maximizes

$$V^{a}(x_{ss}^{cr}) = \sum_{s=1}^{2} \xi_s \mathbb{E}\left[ \sum_{t=0}^{\infty} \beta^t d_t (\log C_t^{a} - H_t^{a}) \right] | x_{-1} = x_{ss}^{cr}, s_0 = s$$  \hspace{1cm} (22)

where $a$ denotes the alternative specification, while $C_t^{a}$ and $H_t^{a}$ denote the optimal consumption and hours choices under this rule, respectively. Again, the dependence on the constant rule steady state $x_{ss}^{cr}$ highlights that the constant rule steady state is the point of comparison.
Given the above definitions, the welfare cost associated with a move from policy specification \( cr \) to \( a \) is implicitly given by \( \Upsilon^a \), where \( \Upsilon^a \) satisfies

\[
V^a (x_{ss}^{cr}) = \sum_{s=1}^{2} \xi_s \mathbb{E} \left[ \sum_{t=0}^{\infty} \beta^t d_t \left( \log \left( C_t^{cr} (1 + \Upsilon^a) \right) - H_t^{cr} \right) \right] \left| x_{-1} = x_{ss}^{cr}, s_0 = s \right].
\] (23)

Under this definition, positive values of \( \Upsilon^a \) indicate the alternative policy welfare-dominates the constant rule policy, while negative values indicate a preference for the constant rule. Since the absolute values of these welfare numbers tend to be small, the results show figures relative to the absolute value of the full switching \( (fs) \) case \( (|\Upsilon^a| / |\Upsilon^{fs}|) \). The full switching case gives the monetary authority the most flexibility in terms of setting its rule, making it a useful benchmark.

4 Results

This section presents the main set of results on optimal rules in the presence of regime switches for the three different economies described by the parameters in Tables 1-2. In each economy, the monetary authority sets an optimal implementable rule, where the rule varies in which parameters can change as shown in Table 3.

Given the framework discussed in Section 2, the monetary authority faces a number of trade-offs when setting policy. First, the presence of nominal rigidities without price indexation implies a need to keep inflation low and stable; in particular, exact price stability minimizes the resource cost from inflation in equation (15). However, given the authority only has access to lump-sum taxes and a nominal interest rate and not a production subsidy to eliminate the distortion from monopolistic competition, the first-best inflation rate will not necessarily be zero (Schmitt-Grohe and Uribe (2007)). In the case of non-zero inflation targets, the model does not contain features such as quality improvements or heterogeneity among individuals that might warrant higher inflation targets, so these inflation targets will tend to be low in absolute terms (Schmitt-Grohe and Uribe (2010)). Second, the presence of a markup shock generates opposing co-movement between inflation and output, which in turn creates a trade-off for stabilization policy. Third, the constraint for nonnegative dynamics for the net nominal interest rate imposed
by the implementability condition creates an incentive to raise the inflation target and hence
the neutral nominal rate, as well as make interest rates more inertial to limit the ability of rates
to move drastically in response to shocks.

A final trade-off more unique to the current setup is that the presence of regime switches—in
both the private economy and in monetary policy—generates expectational effects (Liu et al.
(2009), Foerster (2016)) that the monetary authority must internalize when setting optimal
policy. For example, in the case when the inflation target may switch between regimes, firms and
households will internalize this switching, leading to differences in behavior and hence realized
inflation relative to the case when regime changes do not exist. Under these circumstances,
realized inflation in each regime may differ from that regime’s inflation target, and the authority
sets policy knowing this result will occur.

4.1 Economy with Growth Rate Switches

The first economy, described in Panel A of Table 2, experiences high and low growth regimes. In
the high growth regime, TFP grows at an annual rate of 2.5%, while in the low growth regime
it grows at 0.5%. These growth regimes matter for both households and firms: growth affects
the inter-temporal consumption decision made by households as seen in the Euler equation (4),
as well as firms’ production function (8) and hence the forward-looking nature of price setting.
Experiencing high and low growth therefore affects output, inflation, and interest rates directly.
In particular, expectations for low growth lower the real rate; by extension, the nominal rate will
tend to be lower, which increases the chance of negative nominal rates. In addition, expectations
of regime switches also affect behavior by households and firms, as they take into account the
fact that future regimes may differ from the current one. As a result, regime switches affect the
optimal implementable monetary policy rules.

4.1.1 Optimal Monetary Policy Rules with Growth Rate Switches

Table 4 shows the optimal monetary policy parameters under the several different policy rule
types. In the no switching cases, the economy experiences either the high or low growth regimes
Table 4: Optimal Policy Rules, Economy with Growth Rate Switches

|                        | High.Growth.Regime | Low Growth Regime | Welfare \(\gamma^a/|\gamma^I|\) |
|------------------------|--------------------|-------------------|-------------------------------|
|                        | \(\rho_r\) \(\psi_\pi\) \(\psi_y\) \(\Pi^*\) | \(\rho_r\) \(\psi_\pi\) \(\psi_y\) \(\Pi^*\) |                               |
| No Switching Cases     |                    |                   |                               |
| High Growth Only       | 0.63 0.05 0.02     | – – – –           | –                             |
| Low Growth Only        | – – – –            | 0.96 0.09 0.27    | –                             |
| Regime Switching Cases |                    |                   |                               |
| Non-Optimized          | 0.63 0.05 0.02     | 0.96 0.09 0.27    | *                             |
| Constant Rule          | 0.94 0.09 0.18     | 0.94 0.09 0.18    | 0                             |
| Real Rate Only         | 0.93 0.08 0.17     | 0.93 0.08 0.17    | 0.583                         |
| Target Only            | 0.93 0.07 0.02     | 0.93 0.07 0.28    | 0.641                         |
| Inertia Only           | 0.73 0.08 0.24     | 0.95 0.08 0.24    | 0.938                         |
| Inflation Resp Only    | 0.93 0.08 0.17     | 0.93 0.08 0.17    | 0.583                         |
| Out Gap Resp Only      | 0.93 0.10 0.18     | 0.93 0.06 0.18    | 0.590                         |
| All Coefficients       | 0.67 0.07 0.26     | 0.95 0.08 0.26    | 0.939                         |
| Full Switching         | 0.65 0.07 0.10     | 0.95 0.08 0.31    | 1                             |

Note: * denotes the Non-Optimized rule under regime switching is not implementable.

Inflation target expressed in percentage points at an annualized rate.

exclusively rather than experiencing regime switching. In the high-growth regime only case, the optimized rule is similar to the results in Schmitt-Grohe and Uribe (2007): interest rates respond as strongly as possible to inflation, very little to the output gap, and they exhibit a moderate degree of interest rate inertia. In addition, the optimal inflation target is nearly zero, which in steady state almost eliminates any output loss generated by positive inflation.

In the low growth only case, households face lower consumption growth, which lowers the real interest rate. Since the optimal implementable rule must limit the probability of hitting negative net nominal rates, the optimized coefficients produce a strong degree of inertia and an above-zero inflation target. The higher inflation target attempts to counteract the decrease in
the real rate, while the higher inertia component makes interest rates less volatile and hence less likely to become negative. If the monetary authority had to maintain a moderate level of interest rate inertia, it would generate a higher probability of negative interest rates, and hence the inflation target would need to be raised further to maintain an implementable policy. In other words, by jointly altering the inertia parameter and the inflation target relative to their values in the high growth only case, the monetary authority can move each by a smaller amount while producing better welfare outcomes than if they could only adjust one.

Turning to the economy with regime switching, the non-optimized rule simply uses the optimal rules from the no switching cases when the economy does experience high and low growth regimes. In this case, expectational effects cause excess nominal rate volatility, which in turn violates the implementability definition. The following subsection shows this violation occurs in the high growth regime; expectations of a switch to a lower growth regime overwhelm the low inflation target and low interest rate inertia, generating nominal rates that are negative too often. As a result, using the rules from the no switching cases—even if they are optimal in that context—produces sub-optimal outcomes in an environment with structural change.

In the case of the constant rule, the economy experiences regime switches, but the monetary authority does not respond with switches in policy and keeps the policy parameters fixed. The optimal choice of parameters then has to balance the outcomes in each regime. Since the low growth regime has lower real rates and is hence more likely to produce negative nominal rates, the constant rule has a high degree of inertia and a positive inflation target. In these circumstance the monetary authority is effectively weighing the probability of negative nominal rates during the low growth regime versus a loss of output in the high growth regime.

An additional rule available to the authority only in the presence of growth rate switches is to simply alter the real rate used in its rule without changing the policy parameters. Relative to the constant rule case, the monetary authority under this real rate only rule makes slight adjustments to its inertia and output gap response, and raises its inflation target slightly to help ensure positive nominal rates when the real rate is depressed in the low growth regime.

When only one parameter can switch, forcing the other parameters to stay constant across
regimes, the optimal values of these parameters differ from the constant rule. In addition, the parameter that is allowed to switch has to compensate for the other parameters being fixed. For example, when the interest rate inertia parameter can switch, the monetary authority simultaneously increases the fixed inflation target.

The full switching rule allows all parameters to change and has many of the features of both the high and low growth only cases, as well as the cases when only one parameter can switch. During the high growth regime, the optimal rule has a moderate degree of interest rate inertia and a relatively low but positive value of the inflation target. During the low growth regime, the optimal rule increases the persistence of interest rates and raises the inflation target as it attempts to minimize the probability of hitting negative nominal rates. In both cases, the regime switching does have expectational effects, which lead to slightly different policy parameters than in the no switching cases. For example, the full switching model has a higher inflation target in the high regime than if only the high regime occurred, since the possibility of switching to lower growth regimes tends to decrease the real interest rate.

The final column of Table 4 shows the welfare cost measure in the regime switching cases. These welfare costs start from the constant rule specification, meaning the constant rule has welfare cost of zero; in addition, they are normalized so the full switching rule has an absolute value of one. All switching rules have positive welfare numbers, showing they are welfare-preferred even conditional on starting from the constant rule’s steady state. The full switching case has the largest welfare gains, as giving the authority flexibility to change all parameters produces the most benefit. In addition, changing the interest rate inertia component produces the largest welfare gains; the inertia only switching rule produces around 94% of the increase from the constant rule to the full switching rule. Higher interest rate inertia helps keep nominal rates positive with relatively low inflation targets, giving the monetary authority the best possible trade-off between avoiding negative nominal rates and avoiding the output loss from high inflation targets.
4.1.2 Economic Performance under Optimal Monetary Policy Rules with Growth Rate Switches

In order to shed light on the effects of the optimal monetary policy rules, Figure 1 displays how output, inflation, and nominal rates respond under the different rules. The plots show the mean and two standard deviation intervals for each regime across rules. In the case of the non-optimized rule, the figure shows how in the high growth regime, the combination of a low inflation target and moderate inertia combined with more volatility due to expectational effects...
generates a non-implementable rule, as negative rates occur within a two-standard deviations of the mean.

Comparing the economic performance of the various optimal rules gives a good indication as to why ones that are more flexible perform better in welfare terms. While the differences in output are minor, the levels and volatility of inflation and nominal rates vary more across rules. In the high growth regime, the policy rules that allow interest rate inertia switches— inertia only, all coefficients, and full switching—have relatively lower inertia components, which translates to more volatile interest rates and less volatile inflation. The low growth regime, by contrast, has a higher degree of inertia and often more volatile inflation as a consequence of smaller fluctuations in the interest rate.

The importance of negative rates for implementable policy is striking in that, for each rule, the optimal policy sets parameters such that in the low growth regime the nonnegative dynamics constraint nearly exactly binds. In the cases where portions of the rule are constrained to not switch, the high growth regime has nominal rate intervals that are much farther away from the nonnegative rates restriction. The coefficient switching and full switching rule, and to a lesser extent the inertia switching rule, are the rules that achieve the highest welfare gains and have the nonnegativity constraint for both regimes much closer to binding. Therefore, a main reason why these rules perform the best is that the monetary authority can maximize the trade-off between keeping interest rates positive and not producing too much distortion through inflation fluctuations.

4.2 Economy with Preference Switches

The second economy experiences different preference rate regimes and is described in Panel B of Table 2. In the high preference regime, the mean of the preference shock exceeds 1, while in the low preference regime it is less than 1. These preference regimes distort the household’s inter-temporal consumption decision as highlighted in the Euler equation (4). In the low preference regime, the household will tend to have low marginal utility of consumption; expectations of a switch to the high preference regime increase the expectation of future marginal utility. As
Table 5: Optimal Policy, Economy with Preference Switches

| Regime Switching Cases | High Pref Regime | Low Pref Regime | Welfare γ^α / |γ|^{f^s} |
|------------------------|-----------------|-----------------|----------------|
| No Switching Cases     |                 |                 |                |
| High Pref Only         | ρ_r = 0.88, ψ_π = 0.07, ψ_y = 0.07 | – – – – | – |
| Low Pref Only          | – – – – | ρ_r = 0.88, ψ_π = 0.07, ψ_y = 0.07 | – |
| Regime Switching Cases |                 |                 |                |
| Non-Optimized          | 0.88 5 0.08 0.07 | 0.88 5 0.07 0.07 | * |
| Constant Rule          | 0.92 5 0.08 0.15 | 0.92 5 0.08 0.15 | 0 |
| Target Only            | 0.91 5 0.07 0.12 | 0.91 5 0.07 0.26 | 0.032 |
| Inertia Only           | 0.75 5 0.06 0.13 | 0.92 5 0.06 0.13 | 0.995 |
| Inflation Resp Only    | 0.92 5 0.08 0.15 | 0.92 5 0.08 0.15 | 0 |
| Out Gap Resp Only      | 0.92 5 0.10 0.12 | 0.92 5 0.05 0.12 | 0.008 |
| All Coefficients       | 0.75 5 0.06 0.13 | 0.92 5 0.06 0.13 | 0.995 |
| Full Switching         | 0.76 5 0.07 0.09 | 0.92 5 0.07 0.15 | 1 |

Note: * denotes the Non-Optimized rule under regime switching is not implementable.

Inflation target expressed in percentage points at an annualized rate.

As a result, the household will tend to want to save, which lowers the real and nominal interest rate, increasing the chance of negative rates. Importantly, in contrast to the case with growth regimes, the high and low preference regimes by themselves do not have an impact on behavior since they simply scale marginal utility; instead, it is the presence of switches between these two regimes that matter.

4.2.1 Optimal Monetary Policy Rules with Preference Switches

Table 5 displays the optimal parameters for the different monetary policy rules. In the no switching cases, both the high and low preference regimes have the same optimal rules. Since the level of the preference shock simply scales utility, being in the high or low preference regime
forever simply scales the household’s utility without affecting their decisions. Both cases then have high inertia, a strong inflation response and weak output gap response, and a small but nonzero inflation target.

In the cases when there is regime switching, the changes between high and low preferences generate fluctuations in the real interest rate that require a response by optimal monetary policy. The non-optimized rule, which is constant and optimal for both high and low preferences in isolation, is no longer implementable, as it generates interest rate fluctuations that produce negative rates too frequently. The next subsection shows that, because in the low preference regime the real rate is depressed, nominal rates hit negative territory within two standard deviations. Again, this result highlights the fact that in the presence of regime switching, optimal rules from the case without switching will not necessarily be optimal. In fact, the preference switching application is notable because both regimes in isolation have an identical optimal rule, but this rule is not implementable when regime switches occur.

The optimal constant rule with regime switches, on the other hand, takes into account the fluctuations in the real interest rate generated by the high and low preference regimes. As noted, the non-optimized rule violates implementability by generating too frequently negative rates in the low preference regime, so the optimal constant rule responds to this fact by having a higher inflation target and a higher inertia component. As with the growth rate switches, these raise the mean of nominal rates and decrease their standard deviation.

In the cases when only one of the parameters can switch, the results mimic those seen for the growth rate switches case. However, while growth rate switches directly affected the household’s Euler equation and the price setting equation for firms, the preference switches only directly alter the Euler equation. Consequently, the numerical differences tend to be smaller. For example, when interest rate inertia is the only parameter that can switch, the response to the output gap and the inflation target decline, but only slightly. In addition, for the inflation response switching case, the optimal policy does not actually change, which produces an identical rule as in the constant rule case.

The full switching rule combines many of the features from the cases where only one para-
meter can switch. In the high preference regime, the inflation target is lower and the interest rate inertia is lower than in the low preference regime. These changes help keep nominal rates higher and less volatile when the real rate is low so that the policy rule is implementable.

The final column of Table 5 again shows the welfare cost measure from the regime switching cases. All of the welfare costs are nonnegative despite starting from the constant rule specification, implying that instituting a switching rule either raises welfare or keeps it the same. The ability to switch inflation responses, as noted, generates no differences in the optimal rule, so the welfare gain is zero. For the other switching rule specifications the welfare change is positive, and most of the gains come from switches in the interest rate inertia. Despite the fact that optimal policy primarily affects the inflation target and the inertia component, simply having the inertia component switch generates 99.5% of the gains from a fully switching rule. These results all suggest that more flexibility in the monetary policy rule produces better welfare outcomes, and that most of this gain is due to changes in how strongly policy responds to current conditions versus moving only gradually.

4.2.2 Economic Performance under Optimal Monetary Policy Rules with Preference Switches

Figure 2 shows how output, inflation, and nominal rates react to the different optimized policy rules in the two preference regimes. For the non-optimized rule, as discussed, the low preference regime has lower real rates that in turn produce low nominal rates. These nominal rates fall below zero too frequently, which imply the rule is not implementable.

Similar to the results for growth rate switching, the behavior of nominal rates and inflation give a good indication as to what drives optimal policy. In the low preference regime, the real rate is lower, which tends to lower the nominal rate; the monetary authority attempts to offset this effect, primarily through a higher inflation target and a larger degree of interest rate inertia. For each rule, the optimal policy implies that in the low preference regime the implementability restriction on nonnegative rate dynamics just binds. For the rules that achieve the highest welfare—the inertia, coefficient, and full switching—this constraint also binds for the
Figure 2: Economic Outcomes under Optimal Rules, Economy with Preference Switches

Note: Mean values and two-standard deviation intervals shown for the high preference regime in red, and the low preference regime in black. Inflation and the nominal rate expressed in percentage points at an annualized rate.

high preference regime. For these rules, in high preference regime the monetary authority lets interest rates fluctuate more, which in turn produces lower volatility of inflation and hence higher welfare gains.

4.3 Economy with Volatility Switches

The final economy, parameterized according to Panel C of Table 2, has switching in the standard deviations of all the shocks. In the low volatility regime, the standard deviations of shocks are
half their magnitude of the first two economies, while the high volatility regime has standard deviations that are one-and-a-half their original magnitudes. Volatility switching generates periods of smaller and larger fluctuations in all the exogenous processes that spill over into output, inflation, and interest rates. In addition, because household and firms are forward looking in their consumption and pricing decisions, they internalize the possibility for different volatilities when making their decisions. So whereas the growth rate and preference switching economies had implementability issues arising from the level of the real rate, in the volatility switching economy the main impediment to implementability will be strictly from the volatility of shocks.

4.3.1 Optimal Monetary Policy Rules with Volatility Switches

Similar to the previous economies, Table 6 displays the optimal parameters for the different monetary policy rules. In the low volatility only case, the optimal inflation target is zero, and there is a moderate degree of inertia in interest rates. Absent a policy change, the high volatility only case would be more likely to hit negative nominal rates, so the optimal policy rule maintains nonnegative rates by increasing the inflation target and making nominal rates much more inertial.

Turning to the regime switching cases, again the non-optimized rule does not satisfy the nonnegative rates constraint, as it generates too frequent of negative rates in the high volatility regime. This result highlights the importance of expectational effects of regime switches on policy. In this high volatility regime, households and firms internalize the possibility of switching to the low volatility regime with a lower inflation target and less interest rate inertia. These expectations generate sufficiently lower and greater fluctuations in the nominal rate to lead to non-implementable policy.

With this feature in mind, the optimized constant rule curiously achieves implementability by having an inflation target slightly less than the high volatility only case. In other words, while in other economies increasing the inflation target usually helped achieve implementability, in this case lowering the target helps achieve it. Instead, the fact that the constant rule maintains a
Table 6: Optimal Policy, Economy with Volatility Switches

|                        | Low Vol Regime |                      | High Vol Regime |                      | Welfare | $\gamma^a/|\gamma^s|$ |
|------------------------|----------------|----------------------|-----------------|----------------------|---------|------------------------|
|                        | $\rho_r$       | $\psi_\pi$           | $\psi_y$        | $\Pi^*$              |         | $\gamma^a/|\gamma^s|$ |
| No Switching Cases     |                |                      |                 |                      |         |                        |
| Low Vol Only           | 0.49 5 0.05 0 |                      |                 | 0.95 5 0.09 0.17     | -       |                        |
| High Vol Only          | - - - -        |                      | 0.95 5 0.09 0.17| -                    | -       |                        |
| Regime Switching Cases |                |                      |                 |                      |         |                        |
| Non-Optimized          | 0.49 5 0.05 0 | 0.95 5 0.09 0.17     | *               |                      |         |                        |
| Constant Rule          | 0.95 5 0.08 0.15| 0.95 5 0.08 0.15    | 0               |                      |         |                        |
| Target Only            | 0.95 5 0.08 0.07| 0.95 5 0.08 0.18    | 0.075           |                      |         |                        |
| Inertia Only           | 0.98 5 0.08 0.14| 0.93 5 0.08 0.14    | 0.947           |                      |         |                        |
| Inflation Resp Only    | 0.95 5 0.08 0.15| 0.95 5 0.08 0.15    | 0               |                      |         |                        |
| Out Gap Resp Only      | 0.95 5 0.05 0.15| 0.95 5 0.09 0.15    | 0.071           |                      |         |                        |
| All Coefficients       | 0.98 5 0.06 0.14| 0.93 5 0.09 0.14    | 0.974           |                      |         |                        |
| Full Switching         | 0.98 5 0.06 0.08| 0.93 5 0.09 0.18    | 1               |                      |         |                        |

Note: * denotes the Non-Optimized rule under regime switching is not implementable.

Inflation target expressed in percentage points at an annualized rate.

higher inflation target and a high inertia coefficient in the low volatility regime helps counteract the adverse effects of expectations. In other words, the high volatility regime is kept consistent with implementable policy through expectational effects about future policy in the low volatility regime.

When only one parameter can switch, the results show very slight differences in the coefficients from the constant rule. In the inertia only switching rule, the low volatility regime actually has a higher inertia value than in the high volatility regime, which contrasts with the results in the no switching cases. Again, this result follows from the expectational effects of policy, as a higher degree of inertia in the low volatility regime helps the authority lower the inflation target by a slight amount relative to the constant rule.
The full switching rule once again combines many features from the one parameter only cases. In the low volatility regime, the inflation target is lower than in the high volatility regime, but interest rates are more inertial to counteract expectational effects. The monetary authority finds it more effective to fight fluctuations in the high volatility regime indirectly through expectational effects by altering the inertia parameter in the low volatility regime, rather than directly by altering that parameter in the high volatility regime.

Finally, in the last column the welfare numbers show similar results to the economies with growth rate and preference switches. Even conditional on starting from a constant rule, moving to a rule with switches in some of the parameters tends to be welfare increasing; the exception once again is the inflation response only switching rule, which does not differ from the constant rule. The full switching rule again achieves the highest welfare, highlighting the importance of flexibility for the monetary authority. Most of this gain in welfare comes from the inertia switching, which by itself generates 94.7% of the gains in the full switching model.

4.3.2 Economic Performance under Optimal Monetary Policy Rules with Volatility Switches

Figure 3 displays means and two standard deviation intervals for output, inflation, and nominal rates for the various policy rules. As discussed, the non-optimized rule generates too much fluctuation in rates in the high volatility regime, leading it to be non-implementable. Along the lines of the economies with growth rate and preference switches, in all the cases the optimal policy makes the nonnegative dynamics restriction just bind in the high volatility regime.

In contrast to the previous economies, however, the monetary authority does not have this constraint binding in the low volatility regime. In this case, the authority does not face as severe of spillover effects into the low volatility regime, so it is less encumbered by the possibility of negative nominal rates. The same rules that produce the highest welfare—the inertia, coefficients, and full switching rules—now generate the lowest volatility of nominal rates, which in turn produce a wider range of inflation values in the low volatility regime. In these cases, the monetary authority can generate welfare gains in this case by having the flexibility to allow
inflation to fluctuate by slightly more than when it is constrained.

5 Conclusion

When the private economy faces regime switches, optimal simple monetary policy rules should respond with changes in the policy parameters. When the economy experiences switching in the growth rate, intertemporal preferences, or volatilities, the optimized monetary policy rule changes as well, and the optimal rule should account for the impact of switching on behavior.
rather than setting the policy parameters as if that regime occurred in isolation. Allowing even one part of the rule to change improves welfare, with switching in the interest rate inertia producing the largest gains. These results all provide warning against inflexible policy rules that do not account for shifts in the economy.
References


