# US Fiscal Regimes and Optimal Monetary Policy

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(Preliminary and Incomplete)

**Abstract**

A closed economy dynamic stochastic general equilibirum model is employed to model optimal monetary for the US when fiscal policy switches regimes over time. Fiscal policy in the US is allowed to switch between a Ricardian and a non-Ricaridian regime. Contrary to the existing literature I do not examine the effects of monetary and fiscal policy regime swithces. Instead, I focus on the optimal monetary policy conditional on the fiscal regime. Estimating the Markov-switching DSGE model and performing countefractual exercises I show that inflation in the US could have been better controlled if the Fed had adjusted its policy according to the fiscal regime.

Keywords: Markov-switching DSGE, Optimal monetary policy, Bayesian Estimation

# 1 Introduction

Fiscal policy regime switches in DSGE models have attracted much research over the last years ([9], [5], [2]). The main focus of this literauture, so far, is on the resulting equilibria following different monetary and fiscal policy regime mixes and on the different effects of shocks depending on the regime of each policy. There is not much evidence, though, as regards the way monetary policy should react to fiscal regimes, given its flexibility compared to fiscal policy. Should monetary policy react to fiscal regimes, and if so, how? This paper addresses those two questions.

A closed economy model with monopilistic competition and nominal rigidities, allowing for regime switches in monetary and fiscal policies, is estimated. In particular, the fiscal authority (e.g. government) follows a fiscal feedback rule *à la* [7] and is found to switch between a Ricardian and a non-Ricardian Regime. Before the design of the optimal monetary policy, the monetary authority is assumed to follow a standard Taylor rule where the feedback coefficients on inflation and output gap are found to switch between an active and a passive regime.[1]

In order to address the two questions of this paper, the optimal policy problem of the monetary authority, conditional on fiscal policy, is designed. In particular, an optimal interest rate rule is derived where the feedback coefficients are functions of the estimated structural parameters of the model.

The first result from the optimal policy problem of the moentary authority is that the Fed should adjust its policy appropriately according to the fiscal regime. In particular, a non-Ricardian fiscal regime should be always accmpanied by an active monetary policy. Similarly, a Ricardian fiscal policy should be accompanied by an active monetary policy as well, but now the reaction to inflation fluctuations must be significantly lower, than under a fiscal non-Ricardian regime.

The second result of the paper comes from a counterfactual exercise. In particular, the time variant optimal interest rate feedback rule is imposed into the estimated Markov-switching DSGE model and the new impulse response functions and moments are derived. Following this counterfactual exercise it is shown that the Fed could have controlled inflation and output gap fluctuations better. Inflation expectations are well anchored, which implies lower sensitivity of inflation and output to regime switches in fiscal policy.

The paper is organized as follows. In section 2, using quarterly data for the US, empirical evidence in favour of a fiscal feedback rule for the US is provided. The theoretical model along with the solution and the estimation algorithm are illustrated in sections 3 to 4, while optimal policy design is shown in section 5, along with the counterfactual exercise. Section 6 concludes.

# 2 The model

The model is a standard New-Keynesian with habits in consumption and endogenous persistence in inflation. In order to study the intereaction between fiscal regimes and monetary policy, I develop a Blanchard-Yaari type model of overlapping generations in the spirit of [**?**]. This specification allows for departures from Ricardian equivalence which implies that debt finance increases in transfers (or decreases in taxes) affects the economy.

Every period new households are born with a fraction $1-\delta$ of the total population and die with probability $1-\delta$. Under this structure a debt-finance increase in transfers (or decrease in taxes) will cause a rise in spending since part of the debt will be paid back by future generations. In this

[1] Active regime refers to the case where the Taylor principle is satisfied, while passive refers to the case where the latter is not satisfied.

respect, the increase in transfers will result in inflationary pressures giving reason for the central bank to intervene in order to keep inflation on target.

Households derive utility from the conumption of goods and supply labor to firms. Each household is the owner of a firm producing a differentiated good. Households receive a wage from labor and profits from firm ownership. Firms operate in a monopolistically competitive market with price stickiness as in [4]. The government imposes lump-sum taxes to households in order to finance its expenditures. The latter is also financed through one period nominal government bond issuance.

## 2.1 Households

The size of generation $i$ at time $t$ is $(1-\delta)\,\delta^{t-i}$ and total population is of measure 1. Households in each generation $i$ choose $\left\{C_t^i,\ H_t^i,\ B_t^i\right\}$ to maximize

$$U_t = E_t \sum_{s=t}^{\infty} (\beta\delta)^{s-t} \left[ \frac{(C_s^i - hC_{s-1})^{1-\sigma}}{1-\sigma} - \frac{(H_s^i)^{1+\gamma}}{1+\gamma} \right] \tag{1}$$

where $C_t^i, H_t^i$ and $B_t^i$ are consumption, hours worked and government bonds of households of generation $i.\sigma$ is the degree of relative risk aversion and $h$ the degree of habits in consumption. Per capita consumption $C_t$ is a composite consumption index described as

$$C_t = \left[ \int_0^1 c_t(j)^{\frac{\theta-1}{\theta}} dj \right]^{\frac{\theta}{\theta-1}}, \tag{2}$$

where $\theta$ captures the intratemporal elasticity of substitution between home and foreign goods. The household in each generation $i$ chooses $c_t^i(j)$ to minimize its total expenditure, which implies a demand function for each good $j$ described by

$$c_t^i(j) = \left( \frac{p_t(j)}{P_t} \right)^{-\theta} C_t^i, \tag{3}$$

where $P_t$ is price index defined as

$$P_t = \left[ \int_0^1 p_t(j)^{1-\theta} dj \right]^{\frac{1}{1-\theta}} \tag{4}$$

Capital markets are complete. The household purchases state uncontingent bonds $B_t$ at price $Q_t$. The budget constraint of the household is summariazed as

$$P_t C_t^i + Q_t B_t^i = \frac{1}{\delta} B_{t-1}^i + W_t H_t^i + \Pi_t^i - T_t^i \tag{5}$$

where $W_t$ is the nominal wage, $\Pi_t^i$ are nominal profits that generation $i$ receives, $T_t^i$ are lump-sum taxes imposed by the government to generation $i$ while $Q_t = R_t^{-1}$ .

The first order conditions at an interior solution are written as

$$H_t^i = C_t^{i-\frac{\sigma}{\gamma}} w_t^{\frac{1}{\gamma}} \tag{6}$$

$$1 = \beta E_t \left[ \frac{R_t P_t}{P_{t+1}} \left( \frac{C_t^i}{C_{t+1}^i} \right)^{\sigma} \right] \tag{7}$$

## 2.2 Aggregation

Given the overlapping generations structure of the model a variable $\varsigma_t^i$ has the following aggregate representation

$$\varsigma_t = \sum_{i=-\infty}^{t} (1-\delta)\,\delta^{t-i}\varsigma_t^i$$

Therefore, the aggregate representation of the Euler equation receives the following form

$$\beta E_t \frac{R_t P_t}{P_{t+1}} C_t^{\sigma} = E_t \left[ \frac{(1-\delta)\,B_t}{\delta P_{t+1}} \right] + E_t C_{t+1}^{\sigma} \tag{8}$$

The aggregate budge constraint is specified as

$$P_t C_t + Q_t B_t = B_{t-1} + W_t H_t + \Pi_t - T_t \tag{9}$$

## 2.3 Firms

Each firm is the only producer of its good and sets its price in a staggered way as in [4] with a linear production technology

$$Y_t(j) = A_t L_t(j) \tag{10}$$

where $A_t$ is a country specific productivity shock at date $t$ which is assumed to follow a log stationary AR(1) process. Given the Calvo price setting mechanism the price level can be summarized as

$$P_t = \left[\omega P_{t-1}^{1-\theta} + (1-\omega)\widetilde{p_t}(j)^{1-\theta}\right]^{\frac{1}{1-\theta}} \tag{11}$$

At each date, each firm changes its price with a probability $1-\omega$ , regardless of the time since it last adjusted its price. The probability of not changing the price, thus, is $\omega$. There are two kinds of firms, a fraction $1-\zeta$ of backward looking and a fraction $\zeta$ of forward looking as in [1]. When they reset their price, backward looking firms do not solve any maximization problem, but follow a rule-of-thumb sepcified as.

$$p_t^B(j) = P_{t-1} + \pi_{t-1} \tag{12}$$

On the other hand forward looking firms set their price by maximizing the expected discounted value of their profits

$$maxE_t \sum_{s=0}^{\infty} \omega^s Q_{t,t+s} \left\{ p_t^F(j) y_{t+s}(j) - (1-\tau) W_{t+s} L_{t+s} \right\} \tag{13}$$

Therefore the newly set price at date $t$ is a weighted average

$$\widetilde{p_t}(j) = (1-\zeta) p_t^B(j) + \zeta p_t^F(j) \tag{14}$$

## 2.4 Fiscal authority

The fiscal authority imposes lump-sum taxes and issues government debt in order to finance expenditures and pay back its debt. The flow budget constraint of the federal government is given by:

$$B_t = B_{t-1}(1+r_{t-1}) - T_t + G_t$$

where $B_t$ is government debt, $T_t$ is lump-sum taxes and $G_t$ is government expenditures. Expressing the variables as an output ratio the flow budget constraint receives the following form:

$$b_t = \left(b_{t-1}(1 + r_{t-1})\right) / \left(\Pi_t Y_t / Y_{t-1}\right) - \tau_t + g_t$$

where all variables are expressed as a fractionof output (GDP), while $\Pi_t$ is CPI inflation.

### 2.5 Monetary and Fiscal rules

The monetary authority uses the nonimal interest rate (i.e. the federal funds rate) as its instrument in order to control inflation and output gap according to the interest rate rule described in (2), which allows the feedback coefficients on inflation and output to switch between two regimes.

The federal fiscal authority sets taxes according to rule (1) with the feedback coefficients switch between two regimes.

### 2.6 The model in loglinear form

The model is loglinearized around the zero inflation unique steady state.[2] The set of loglinearized equilibrium conditions are summarizied in the following table

| Loglinearized equations |
|---|
| Phillips Curve |
| $\pi_t = \gamma^f E_t \pi_{t+1} + \gamma^b \pi_{t-1} + \kappa \hat{x}_t$ |
| Demand curve |
| $\hat{Y}_t = E_t \hat{Y}_{t+1} - (i_t - E_t \pi_{t+1}) - \frac{1-\delta}{\delta(1-g_y)} b_t + \frac{1}{1-g_y} E_t \left(\hat{g}_{t+1} - \hat{g}_t\right)$ |
| Government Budget Constraint |
| $b_t = \frac{1}{\beta} b_{t-1} + \frac{1}{\beta} b(i_{t-1} - \pi_t - \hat{Y}_t + \hat{Y}_{t-1} - a_t) - \hat{\tau}_t + \hat{g}_t$ |
| Monetary policy rule |
| $i_t = \rho i_{t-1} + (1-\rho)\left(\phi_x(s_t)\hat{x}_t + \phi_\pi(s_t)\pi_t\right) + \sigma_i \varepsilon_{i,t}$ |
| Fiscal rule |
| $\tau_t = \rho_\tau(s_t^F)\tau_{t-1} + (1-\rho_\tau)\left[\gamma_b(s_t) b_{t-1} + \gamma_g(s_t) g_t\right] + \gamma_x(s_t) x_{t-1} + \sigma_\tau \varepsilon_{\tau,t}$ |
| Resource constraint |
| $\hat{Y}_t = \hat{C}_t + \frac{1}{1-g_y} \hat{g}_t$ |

# 3 Solution and Estimation algorithms (incomplete)

Given the Markov-Switching structure of the model, standard solution techniques cannot be applied in order to find a solution. In the recent literature on markov-switching DSGE models, various alternative techniques for solving such models have been suggested ([6], [10], [13], [8]). The technique I use is that of [8]. The virtue of that technique is that it is able to find all possible minimal state variable (MSV) solutions. Moreover, the algorithm is able to find whether the MSV solution is

[2]In the appendix I provide the conditions that are necessary and sufficient to guarantee that the steady state is unique and independent of regime switches.

stationary (mean square stable).[3] The model can be written in the following form

$$A(s_t)X_t = B(s_t)X_{t-1} + \Psi(s_t)\varepsilon_t + \Pi(s_t)\eta_t \tag{15}$$

where $\varepsilon_t$ is a $4\times1$ vector of i.i.d. stationary exogenous shocks and $\eta_t$ is an $2\times1$ vector of endogenous random variables. According to that technique the MSV equilibrium of the model takes the form

$$X_t = g_{1,s_t}X_{t-1} + g_{2,s_t}\varepsilon_t \tag{16}$$

In order for the above minimal state variable solution to be stationary it must be that the the eigenvalues of

$$(P \otimes I_{24^2})diag\left[\Gamma_1 \otimes \Gamma_1, \Gamma_2 \otimes \Gamma_2\right] \tag{17}$$

where $\Gamma_j = A(j)V_j$ for $j = 1,2$. And where $V_j$ is a $11 \times 6$ matrix resulting from the Schur decomposition of $A(j)^{-1}B(j)$. In the present model the largest eigenvalue was found to be equal to 0.81, implying, thus, that the MSV solution is stationary. The impulse responses and the moments of the variables of interest are then derived from that stationary solution.

## 4 Parameterization

The model is calibrated using the estimated values for the structural parameters as estimated in [2] for the US. The initial regime is a mix of passive monetary and active fiscal policy.

Table 1

| | AMPF | PMAF |
|---|---|---|
| Inflation | 0.7621 | 1.3461 |
| Output Gap | 0.7370 | 1.4009 |
| Interest Rate | 0.8056 | 1.2448 |

The epxectation of a switch towards the passive monetary-active fiscal policy (PMAF) regime makes inflation and output gap less volatile relative to the absorbing state. On the other hand they become more volatile relative to the absorbing state when the possibility of a switch to the active monetary-passive fiscal policy (AMPF) regime is introduced. The results are summarized at table 1 above. This result is in contrast to the standard result in the MSDSGE literature in which the possibility of a switch of monetary policy to the dovish regime makes inflation and output gap more volatile. The results at table 1 show that if passive monetary policy is accompanied with an active fiscal policy, then this implies a less volatile inflation and output gap.

The above result is also illustrated by the impulse responses in figure 1. The green dashed line captures the PMAF regime, while the blue the AMPF regime. Impulse responses are dampened in the former regime relative to the latter.

## 5 Optimal monetary policy when fiscal policy switches regimes

The monetary authority seeks to minimize the welfare loss derived from a second order approximation to the utility function of the respresentative household in the spirit of [11]. The welfare

[3]For an extensive argument regarding the merits of the solution technique used in this paper over the alternative ones see Farmer et al. (2011) and the references therein.

criterion, thus, is specified as follows:

$$L_t = \chi_\pi \pi_t^2 + \chi_x x_t^2 + \lambda i_t^2 \tag{18}$$

where the weights $\chi_\pi$ and $\chi_x$ are functions of the structural parameters of the model. Note, that given the cashless economy assumed, the second order welfare loss function does not assign a weight on interest rate fluctuations. However, the latter are introduced in an ad hoc manner in the second order welfare criterion. This is so because the Central bank is also interested in minimizing the variability in the federal funds rate.

The focus in this paper is on optimal discretionary policy. Under discretion the central bank takes the future path of variables as given. However, the present model introduces persistence in output and inflation. This implies that the central bank actions today affect the path of the variables tomorrow, even though, a discretionary policy is followed.[4] Consequently, the optimal policy problem of the central bank can be solved using dynamic programming. The approach followed is that of [3], while the algorithm to solve the optimal policy problem is that of [12] extended to account for regime switches.

**Formulation.** The policy maker chooses the control $i_t$ (i.e. the interest rate rule) which minimizes the expected value of the intertemporal loss function, stated in the previous section and summarized as

$$\sum_{t=0}^{\infty} \beta^t L(h_t, i_t) \tag{19}$$

subject to $h_0$, $s_0$ given, and the model describing the economy

$$h_{t+1} = A(s_{t+1})h_t + B(s_{t+1})i_t + C\varepsilon_{t+1} \qquad t \geq 0 \tag{20}$$

where $L(h_t, i_t)$ is the period loss function, $\beta$ is the discount factor, $h_t$ is a $11 \times 1$ vector of state variables, $i_t$ is the control variable (i.e. the interest rate) and $\varepsilon_t$ is a $4 \times 1$ vector of white noise shocks with variance covariance matrix $\Sigma_\varepsilon$ and $C$ is a $11 \times 4$ .The loss function (13) can be conveniently expressed as follows

$$L(h_t, i_t) = h_t^{'} R h_t + i_t Q i_t \tag{21}$$

where $R$ is a $11 \times 11$ positive definite matrix and $Q$ is a scalar. The matrices $A$ and $B$, as already mentioned, are stochastic and take on different values depending on the regime $s_t$, $t = 1, 2$.

**The Bellman equation.** The policy maker in a markov-switching environment needs to find the interest rate rule that is state-contigent. This rule describes the way that the control variable, the interest rate, should be set as a function of both the state variables and the regime occurring at date $t$. Therefore, a Bellman equation is associated with each regime. The regime $j$ dependent Bellman equation is specified, thus, as follows

$$V(h_t, j) = max_{i_t} \left\{ L(h_t, i_t) + \beta \Sigma_{i=1}^2 p_{ji} E_t \left[ V(h_{t+1}, i) \right] \right\} \tag{22}$$

where $V(h_t, j)$ is a function of the state variables $h_t$, the regime prevailing at date $t$ and represents the continuation value of the optimal dynamic programming problem at $t$. The value function for this problem is

$$V(h_t, j) = h_t^{'} P_j h_t + d_j, \quad j = 1, 2 \tag{23}$$

[4] For a more detailed analysis of this issue under discretion see [14]

where $P_j$ is a $11 \times 11$ symmetric positive semidefinite matrix, while $d_i$ is a scalar. The optimal policy is described by

$$i(h_t, j) = -F_j h_t, \quad j = 1, 2 \tag{24}$$

where $F_j$ is a $11 \times 1$ matrix, depending on $P_j$. That is, matrix $F_j$ specifies the coefficients in the policy rule of the central bank. Those coefficients are regime specific. Maximizing, thus, the Bellman subject to the constraints, the matrix $F_j$ is specified as

$$F_j = \left(Q + \beta p_{j1} B_1^{'} P_i B_1 + \beta p_{j2} B_2^{'} P_i B_2\right)^{-1} \beta \left(p_{j1} A_1^{'} P_i B_1 + p_{j2} A_2^{'} P_i B_2\right) \tag{25}$$

where matrix $P_i$ has been already determined by a set of interrelated Riccati equations, which specify a system with the following form

$$\begin{aligned} P_j &= R + \beta p_{j1} A_1^{'} P_i A_1 + \beta p_{j2} A_2^{'} P_i A_2 - \ldots \\ &-\beta^2 \left(p_{j1} A_1^{'} P_i B_1 + p_{j2} A_2^{'} P_i B_2\right) \left(Q + \beta p_{j1} B_1^{'} P_i B_1 + \beta p_{j2} B_2^{'} P_i B_2\right)^{-1} \left(p_{j1} B_1^{'} P_i A_1 + p_{j2} B_2^{'} P_i A_2\right) \end{aligned} \tag{26}$$

### 5.1 Optimal rule

In this section the results on the optimal interest rate rule prescribed by (26) are presented for different degrees of inflation targeting. Under strict inflation targeting (zero weight on output gap stabilazation in (20)), the central bank has to be active when fiscal policy is passive (i.e. weight on inflation greater than one) and passive when fiscal policy is active (i.e. weight on inflation less than one). However, this result no longer holds under flexible inflation targeting. In this case monetary policy has to be always active to inflation fluctuations. The results are summarized at table 2 below.

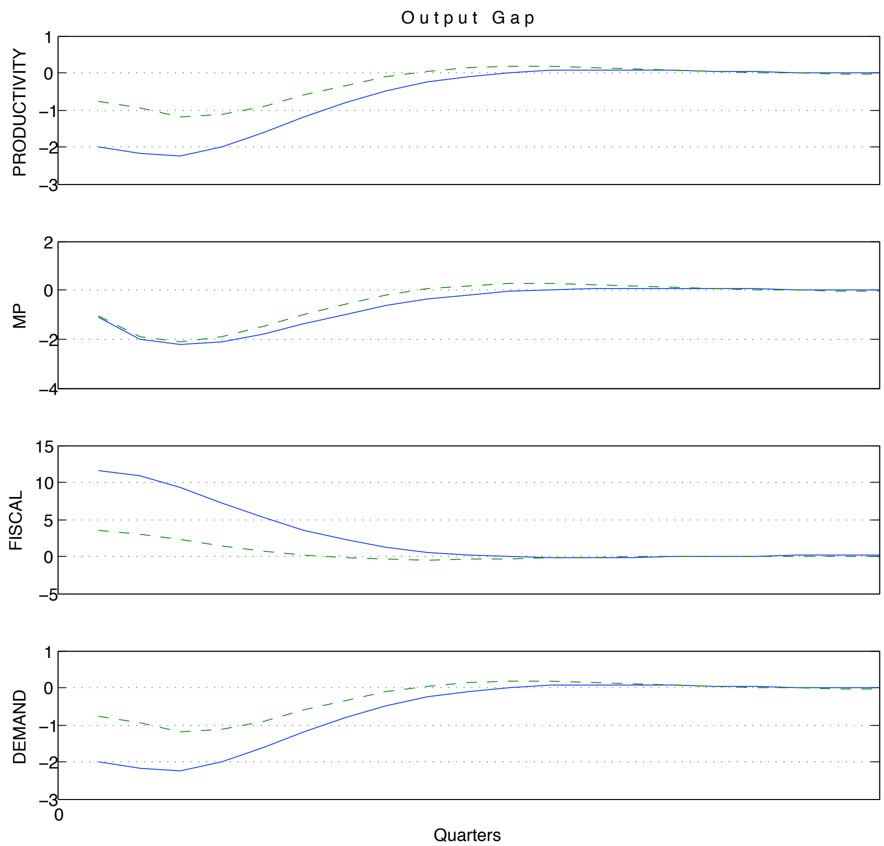
Table 2

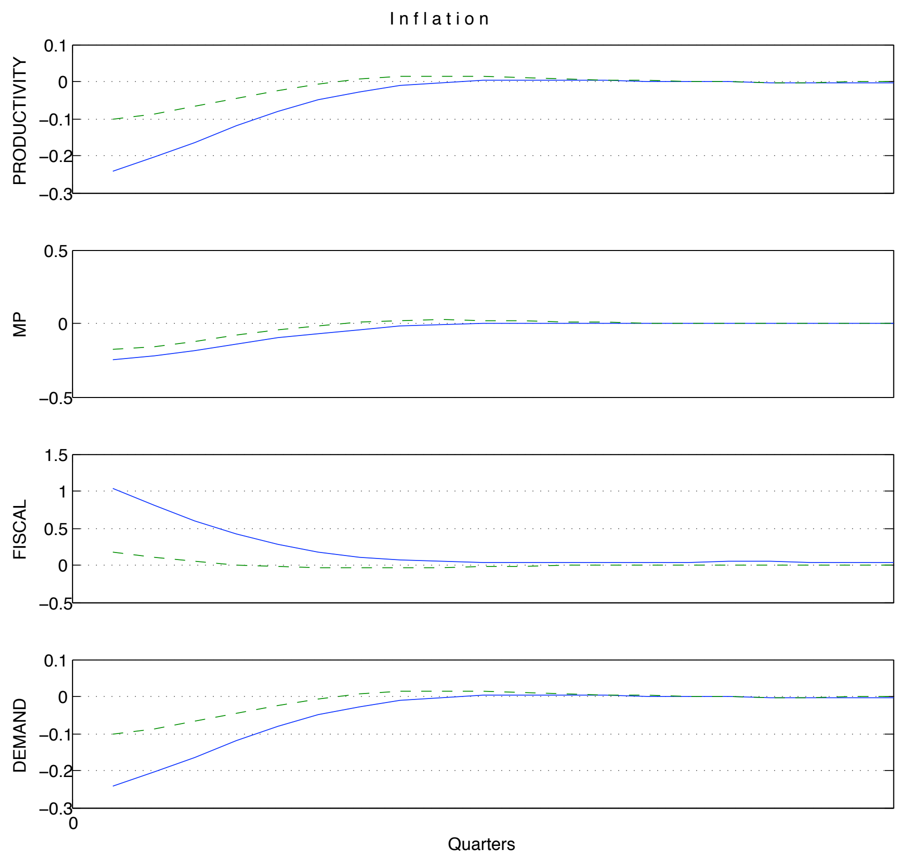
| | | $\phi_\pi$ | $\phi_y$ | $\phi_b$ | $\phi_c$ | $\phi_\tau$ |
|---|---|---|---|---|---|---|
| strict inflation targeting | PF | 1.7758 | -0.0007 | 0.0503 | -0.2457 | -0.0812 |
| | AF | 0.1712 | 0.0148 | 0.3683 | -0.3996 | 0.3518 |
| Flexible Inflation Targeting | PF | 1.0244 | -0.0002 | 0.0174 | -0.7459 | -0.0271 |
| | AF | 1.0056 | -0.0009 | 0.0221 | -0.7461 | -0.0215 |

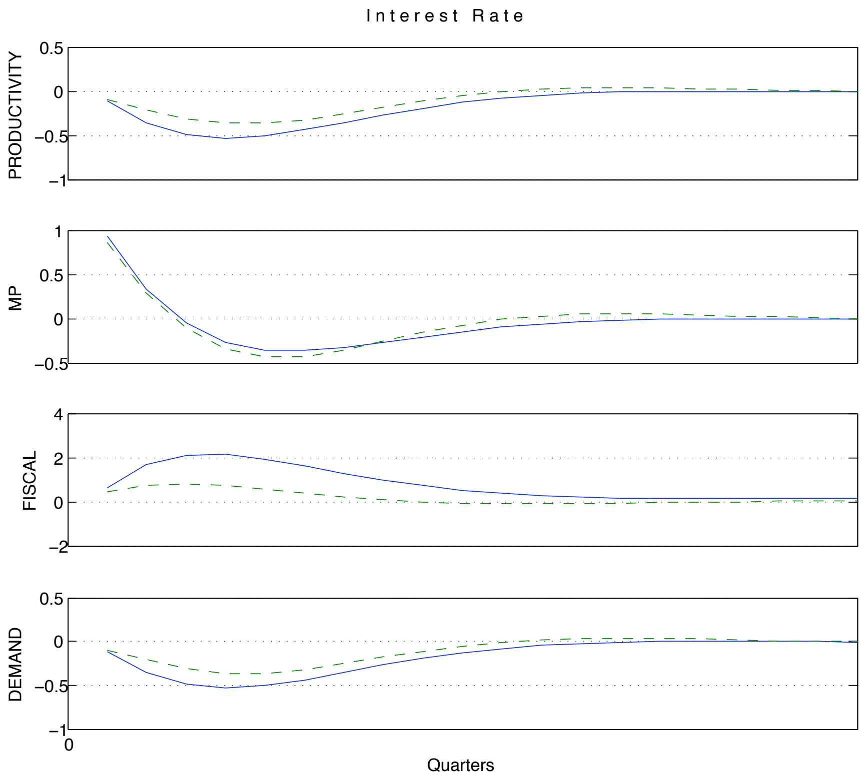
## 6 Conclusions (incomplete)

**Appendix A.1**

**Figure 1: Impulse Responses**




Inflation
PRODUCTIVITY
0.1
0
−0.1
−0.2
−0.3
MP
0.5
0
−0.5
FISCAL
1.5
1
0.5
0
−0.5
DEMAND
0.1
0
−0.1
−0.2
−0.3
0
Quarters


Interest Rate
PRODUCTIVITY
MP
FISCAL
DEMAND
0.5
0
−0.5
−1
1
0.5
0
−0.5
4
2
0
−2
0.5
0
−0.5
−1
0
Quarters

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