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# STRUCTURAL SHOCKS AND THE FISCAL THEORY OF THE PRICE LEVEL IN THE STICKY PRICE MODEL

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This paper examines the effects of various structural shocks in the passive monetary-active fiscal regime in which the fiscal theory of the price level is valid, and compares these effects to those suggested by conventional theory (the active monetary-passive fiscal regime), within a framework of the New Keynesian sticky price model. The results suggest that the effects of structural shocks are substantially different in the passive monetary-active fiscal regime. First, a monetary contraction (an increase in the interest-rate) increases the inflation rate persistently, and increases output with lags. Second, a positive government spending shock leads to a consumption rise in the model that predicts a consumption fall based on conventional theory. Third, in response to aggregate-demand and aggregate-supply shocks, a period of inflation above (or below) the steady-state is followed by a period of inflation below (or above) the steady-state. This inflation reversal is also found in the impulse responses of the estimated VAR models during the 1940's and 1950's, which suggests that the passive monetary-active fiscal regime seems to be actually in place during that period.

**Keywords:** Fiscal Theory of Price Level, Structural Shocks, Inflation Reversal, Sticky Price, VAR

## 1. INTRODUCTION

Initiated by Sims (1988, 1994), Leeper (1991, 1993), and Woodford (1995, 1996), the literature on "the fiscal theory of the price level" has been growing rapidly.[1] This literature asserts that there are two equilibrium relations determining the price level: one that is consistent with conventional models in which Ricardian equivalence holds, and another that depends on the government budget constraint and fiscal policy. Which relation is in effect depends on how monetary and fiscal policy are designed. In the regime in which fiscal policy has the burden of satisfying

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the government budget constraint, the former is in effect ("Ricardian regime," "monetary dominance regime," or "active monetary-passive fiscal regime") and conventional theory holds. However, in the regime in which monetary policy has the burden, the latter is in effect and the fiscal theory of the price level is valid ("non-Ricardian regime," "fiscal dominance regime," or "passive monetary-active fiscal regime").

Although there have been numerous extensions of the theory, there has been less attention to how the passive monetary-active fiscal regime works in the presence of various structural shocks. This paper examines how various structural shocks are transmitted in the passive monetary-active fiscal regime, compared to the conventional analysis in the active monetary-passive fiscal regime. By examining how each variable responds to various structural disturbances, we can better understand the workings of the passive monetary-active fiscal regime. More importantly, we can examine how business-cycle features are different in both regimes, which may provide an important clue in determining which regime was in place historically. Consequently, we may address whether the passive monetary-active fiscal regime was actually adopted for some periods or if it is only a theoretical possibility. To address such questions, some predictions of the theoretical model are compared to the estimated effects in the structural VAR (vector autoregression) model.

A theoretical model incorporating Calvo (1983) style of price stickiness is used. As discussed in many past studies [e.g., Goodfriend and King (1997) and Clarida et al. (1999)], this New Keynesian model has been the standard workhorse for monetary policy analysis (mostly in the active monetary-passive fiscal regime). The model is extended here to consider the passive monetary-active fiscal regime. Since not only the price level but also real economic activities are endogenous in this model, realistic dynamic effects of each structural shock can be examined.[2]

Two popular sources of business cycles are considered: shocks to the aggregate-demand equation and shocks to the aggregate-supply equation. In addition, the effects of monetary-policy and government-spending shocks are examined. Though there are a few past studies such as Leeper (1991, 1993) and Woodford (1996) that have examined the effects of monetary policy and net tax shocks in the passive monetary-active fiscal regime, no studies have been done on the effects of other structural shocks such as government-spending, aggregate-demand, and aggregate-supply shocks considered in this paper. The effects of monetary policy shocks are also discussed because past studies such as Leeper (1991, 1993) discussed the effects only in the flexible price model and the model with a traditional expectation-augmented Phillips curve, but results in the New Keynesian model are somewhat different.

The results suggest that the effects of structural shocks in the passive monetary-active fiscal regime are substantially different from conventional theory in the active monetary-passive fiscal regime. First, "inflation reversal" [a period of inflation above (or below) the steady-state that is followed by a period of inflation below (or above) the steady-state] is observed in the presence of aggregate-demand and aggregate-supply shocks. A simple structural VAR model that identifies aggregate-demand and supply shocks shows that "inflation reversal" is found in the 1940's and 1950's, suggesting that the passive monetary-active fiscal regime seems to be actually adopted historically. Second, the effects of monetary policy and government spending shocks are also substantially different. In this regime, a positive government spending shock leads to a consumption rise, although the same model predicts a consumption fall in conventional analysis. Furthermore, a monetary contraction (an increase in the interest-rate) increases inflation persistently, and increases output with lags, though it decreases inflation and output in conventional analysis. All these results can be explained by the fact that the government budget constraint works as an equilibrium condition for the price level (and output in the sticky price model), and the price level adjustment is the key mechanism to satisfy the government budget constraint in this regime.

The rest of the paper is organized as follows. Section 2 develops the model and explains the active monetary-passive fiscal and the passive monetary-active fiscal regimes. Section 3 analyzes the effects of various structural shocks in the two regimes and compare them to the estimated effects in the structural VAR model. Section 4 summarizes the results and concludes.

## 2. MODEL

A typical New Keynesian sticky price model is constructed. There are four types of structural shocks in the model: aggregate-demand shocks, aggregate-supply shocks, monetary policy shocks, and fiscal policy shocks. Calvo (1983)-style price stickiness is introduced. Since the model is discussed in detail by many past studies such as King and Wolman (1996), Woodford (1996), and Yun (1996), here the model is only briefly sketched.

### 2.1. Model

The economy consists of a continuum of identical infinitely lived households, indexed by $j \in [0, 1]$. Each household specializes in the production of a single differentiated good, of which it is the monopoly supplier. There is also a continuum of differentiated goods each period, indexed by $z \in [0, 1]$, with $z = j$ denoting the good supplied by household $j$. The (household) consumption index is defined by

$$C_t^j \equiv \left\{ \int_0^1 \left[ c_t^j(z) \right]^{\frac{\theta-1}{\theta}} dj \right\}^{\frac{\theta}{\theta-1}}, \qquad \theta \succ 1, \tag{1}$$

where $c_t^j(z)$ indicates household $j$'s consumption of good $z$ in period $t$, and $\theta$ is the elasticity of substitution among alternative goods. The government consumption index $G_t$ is defined in a similar way. The corresponding index of prices of goods

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at date $t$ is defined by

$$P_t \equiv \left\{ \int_0^1 [p_t(z)]^{1-\theta} \, dz \right\}^{\frac{1}{1-\theta}}, \tag{2}$$

where $p_t(z)$ is the price of good $z$ at date $t$. The consumption demand function of household $j$ is given by

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

for each good $z$ at time $t$. The government's consumption demand function is also described in a similar way. Then, the aggregate-demand for each good $j$ is given by

$$y_t(j) = Y_t \left[ \frac{p_t(j)}{P_t} \right]^{-\theta}, \tag{4}$$

where $C_t + G_t = Y_t$, and $C_t \equiv \int_0^1 C_t^h dh$ is an index of aggregate (household) consumption demand at date $t$.

In each period, each household maximizes its expected lifetime utility subject to his intertemporal budget constraint. The utility of each household depends positively on the real money balance ($M_t^j / P_t$), and the consumption index ($C_t^j$) and depends negatively on the supply of its product $[y_t(j)]$. That is,

$$\max E \sum_{t=0}^{\infty} \beta^t K_t \left\{ u\left(C_t^j\right) + v\left(\frac{M_t^j}{P_t}\right) - X_t w\,[y_t(j)] \right\},$$

where $u$ and $v$ are increasing concave functions, $w$ is an increasing convex function, $\beta$ is a discount factor between 0 and 1, and $K_t$ and $X_t$ are exogenous shocks, interpreted as aggregate-demand shocks and aggregate-supply shocks, respectively.[3]

It is assumed that each period, households can trade securities that completely span all states of natures.[4] The budget constraint of each household $j$ is

$$\begin{aligned} &P_t C_t^j + M_t^j - M_{t-1}^j + E_t\left[\delta_{t,t+1} B_t^j\right] - B_{t-1}^j \\ &\quad = p_t(j) y_t(j) + P_t T_t^j, \qquad \text{for } t = 0, 1, 2 \ldots. \end{aligned} \tag{5}$$

Asset accumulation consists of increases in money holdings and bond holdings. $M_t^j$ indicates the money holding at the end of date $t$. $B_t^j$ represents the nominal value at date $t$ of the bond portfolio that the household holds at the end of period $t$; $\delta_{t,t+k}$ indicates the stochastic discount factor, such that the market price at date $t$ of a portfolio yielding a random nominal value $Q_{t+k}$ at subsequent date $t+k$ is given by $E_t[\delta_{t,t+k} Q_{t+k}]$. Each household receives income by selling goods $[p_t(j) y_t(j)]$. Finally, each household is subject to a net government (lump-sum) tax ($T_t^j$, where $T_t^i = T_t^j$) and consumes ($C_t^j$).

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The first-order conditions are

$$\beta^k \frac{u'(C_{t+k})K_{t+k}P_t}{u'(C_t)K_t P_{t+k}} = \delta_{t,t+k} \tag{6}$$

for any date $t$ and any subsequent date $t+k$,

$$\frac{v'\left(M_t^j/P_t\right)}{u'\left(C_t^j\right)} = \frac{R_t}{1+R_t} \tag{7}$$

for each date $t$, where $1+R_t \equiv [E_t(\delta_{t,t+1})]^{-1}$ is the nominal interest-rate on a riskless one-period bond purchased in period $t$.

The household's optimal pricing decisions, in its capacity as supplier of the differentiated goods, are discussed. It is assumed that, each period, each supplier gets to set a new price with probability $1-\alpha$ while he must continue to sell at his previously posted prices with probability $\alpha(0 \prec \alpha \prec 1)$. In period $t$, the price $[p_t(j)]$ is therefore chosen to maximize

$$\sum_{k=0}^{\infty} \alpha^k (\Lambda_t E_t[\delta_{t,t+k} p_t(j) y_{t+k}(j)] - \beta^k E_t\{w[y_{t+k}(j)]\}) \tag{8}$$

subject to the demand equation (4), where $\Lambda_t$ denotes the marginal utility to the household of additional money income at date $t$.

The first-order condition is

$$E_t \sum_{k=0}^{\infty} \alpha^k_{t,t+k} \delta Y_{t+k}[p_t(j)/P_{t+k}]^{-\theta}[p_t(j) - \mu S_{t+k,t}] = 0, \tag{9}$$

where $\mu \equiv \theta/(\theta-1) \succ 1$ is the factor by which price exceeds marginal revenue as a result of the household's market power, and $S_{t+k,t}$ denotes the marginal cost of production at date $t+k$ of a good, the price of which was set at $t$, given by

$$S_{t+k,t} = \frac{X_{t+k} w'\{Y_{t+k}[p_t(j)/P_{t+k}]^{-\theta}\}}{u'\left(C^j_{t+k}\right)} P_{t+k}. \tag{10}$$

Further, using equation (2), it can be shown that the price index evolves according to

$$P_t = \left[\alpha P_{t-1}^{1-\theta} + (1-\alpha) q_t^{1-\theta}\right]. \tag{11}$$

The government budget constraint is

$$M_t - M_{t-1} + B_t - (1+R_{t-1})B_{t-1} + P_t T_t - P_t G_t = 0. \tag{12}$$

The government issues one-period nominal bonds or debt ($B_t$), prints money ($M_t$), collects lump-sum (net) taxes ($T_t$), and consumes ($G_t$).[5] The fiscal authority is

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assumed to set the net lump-sum tax level as a feedback rule from outstanding government debt in real terms (or real government debts):

$$T_t = \phi_T + \phi_b \frac{B_{t-1}}{P_{t-1}}. \qquad \textbf{(13)}$$

Government spending, $G_t$, is assumed to be an AR-1 process with a stochastic disturbance term ($\eta_t$):

$$\log G_t = (1 - \phi_G) \log G + \phi_G \log G_{t-1} + \eta_t, \qquad \textbf{(14)}$$

where $G$ is the steady-state value of government spending. The monetary authority is assumed to set the interest-rate in reaction to the current inflation rate with a stochastic disturbance term ($\varepsilon_t$);

$$\log(1 + R_t) = \phi_R + \phi_\pi \log\left(\frac{P_t}{P_{t-1}}\right) + \log \varepsilon_t, \qquad \textbf{(15)}$$

where $R$ is the steady-state value of the nominal interest-rate. For simplicity, and to be realistic, it is assumed that $0 \preceq \phi_b$, $0 \preceq \phi_\pi$, and $0 \preceq \phi_G$ in the policy rules.

### 2.2. Linearized Model, Fiscal Theory of the Price Level, Calibration

The model is loglinearized around the steady-state. For simplicity, the inflation rate, the money growth rate, and the output growth rate are assumed to be zero in the steady-state. For details on deriving the following equation system, refer to King and Wolman (1996), Woodford (1996), and Yun (1996). The system of equations is summarized as

$$\hat{Y}_t = E_t \hat{Y}_{t+1} + \sigma \left(1 - \frac{G}{Y}\right)(-\hat{r}_t + E_t \hat{\pi}_{t+1} + \hat{K}_t - E_t \hat{K}_{t+1}) + \frac{G}{Y}(\hat{G}_t - E_t \hat{G}_{t+1}) \qquad \textbf{(16)}$$

$$\hat{\pi}_t = \beta E_t \hat{\pi}_{t+1} + \gamma_0 \hat{Y}_t + \gamma_1 \hat{C}_t + \gamma_2 \hat{X}_t \qquad \textbf{(17)}$$

$$\hat{m}_t = \chi \left(\sigma^{-1} \hat{C}_t - \frac{\beta}{1 - \beta} \hat{r}_t\right) \qquad \textbf{(18)}$$

$$\hat{r}_t = \phi_\pi \hat{\pi}_t + \hat{\varepsilon}_t \qquad \textbf{(19)}$$

$$\hat{b}_t + \frac{m}{b} \hat{m}_t + \left(\frac{1}{\beta} + \frac{m}{b}\right) \hat{\pi}_t - \frac{G}{b} \hat{G} = \left(\frac{1}{\beta} - \phi_b\right) \hat{b}_{t-1} + \frac{m}{b} \hat{m}_{t-1} + \frac{1}{\beta} \hat{r}_{t-1} \qquad \textbf{(20)}$$

$$\hat{Y}_t = \left(1 - \frac{G}{Y}\right) \hat{C}_t + \frac{G}{Y} \hat{G}_t \qquad \textbf{(21)}$$

$$\hat{G}_t = \phi_G \hat{G}_{t-1} + \hat{\eta}_t, \qquad \textbf{(22)}$$

where $\pi_t = P_t / P_{t-1}$, $m_t = M_t / P_t$, $b_t = B_t / P_t$, $r_t = 1 + R_t$, $\sigma = -[u'(C)]/[u''(C)C]$, $\chi = -[v'(m)]/[v''(m)m]$, $\gamma_0 = [(1-\alpha)(1-\alpha\beta)\sigma]/[\alpha(\varpi + \theta)]$, $\gamma_1 = [(1-\alpha)$

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$(1-\alpha\beta)\varpi]/[\alpha\sigma(\varpi+\theta)]$, $\gamma_2=[(1-\alpha)(1-\alpha\beta)\varpi]/[\alpha(\varpi+\theta)]$, $\varpi=[w'(Y)]/[w''(Y)Y]$, and each variable without a time subscript is the steady-state value, and each variable with a "hat" is the percentage deviation from the steady-state value. Equation (16) is the aggregate-demand equation. The current output positively depends on the future expected output, but negatively depends on the real interest-rate, reflecting households' intertemporal decisions. $\hat{K}_t$ is a positive shock to the aggregate-demand equation; households discount more of future utility and increase aggregate-demand today. Also, note that government consumption stimulates the aggregate-demand. Equation (17) is the aggregate-supply equation, which is similar to the traditional expectation-augmented Phillips curve, but it is different in one important aspect: Current expectation on future inflation rates, instead of the past expectation on the current inflation rate, affects the current inflation rate. $\hat{X}_t$ is a negative shock to aggregate-supply.[6] If the cost of production or disutility from production increases, or productivity decreases, aggregate-supply decreases. For detailed explanations for these two equations, refer to Woodford (1996), Clarida et al. (1999), and Gali (in press). Equation (18) is the money demand equation. The real money balance is a function of real consumption and the nominal interest-rate (the opportunity cost of holding money). Equation (19) is the monetary policy rule, equation (20) is the government budget constraint combined with the tax policy rule, equation (21) is the equilibrium condition for goods market, and equation (22) is the process for government spending.

In this system, there are two different regions of monetary and fiscal policy parameters ($\phi_\pi$ and $\phi_b$) in which a unique solution can be obtained.[7] First, one set of solutions is obtained when $1/\beta - 1 \prec \phi_b$ and $\phi_\pi \succ 1$ (the strong reaction of monetary policy to the inflation rate and the strong reaction of fiscal policy to real government debt): active monetary-passive fiscal regime. Second, the other set of solutions is obtained when $0 \preceq \phi_b \prec 1/\beta - 1$ and $0 \preceq \phi_\pi \prec 1$ (the weak reaction of both policies): passive monetary-active fiscal regime. In the former, output and inflation rate are determined without reference to the government budget constraint and fiscal policy [equation (20)], and conventional analysis is valid. In the latter, output and the inflation rate are determined by considering all equations above, including fiscal policy and the government budget constraint, and the fiscal theory of the price level is valid.[8]

The key difference between the two regimes is the method of financing government debts or, in other words, the method of keeping the government budget constraint satisfied. Direct taxation is the key mechanism to finance real government debt changes in the active monetary-passive fiscal regime while an inflation tax on nominal government liabilities is used in the passive monetary-active fiscal regime. In this regard, it is useful to rewrite the (linearized) government budget constraint [equation (20)] in the following form showing the evolution of the real government debts:

$$b\hat{b}_t = -(rb+m)\hat{\pi}_t - (T\hat{T}_t - G\hat{G}_t) - m(\hat{m}_t - \hat{m}_{t-1}) + rb\hat{r}_{t-1} + rb\hat{b}_{t-1}. \quad \textbf{(23)}$$

The first term on the RHS is the inflation tax on total nominal government liabilities, the second term is the primary budget surplus, the third term represents changes in the real money balance, and the fourth term represents the changes in debt service due to the interest-rate change. Note that changes in any component on the RHS can change the real government debt. A change or shock to the government real debt or to one of the components on the RHS is financed by current and future changes in the second term on the RHS, primary budget surplus (in the current model, net tax only) in the active monetary-passive fiscal regime. However, it is mostly financed by current and future changes in the first term, inflation tax, in the passive monetary-active fiscal regime.

To provide further explanations particularly relevant to discussing how the fiscal theory works in the sticky price model in which not only the price level but also real variables are endogenous, it is useful to rewrite the government budget constraint [equation (5)] in the following form (by imposing the transversality condition and the restrictions that $M_t \succeq 0$ and $B_t \succeq 0$ for all $t$)[9]:

$$\frac{W_t}{P_t} = \sum_{k=0}^{\infty} \beta^k E_t \frac{u'(C_{t+k})}{u'(C_t)} \left[ (T_t - G_t) + \frac{R_{t+k}}{1+R_{t+k}} \frac{M_{t+k}}{P_{t+k}} \right], \qquad \textbf{(24)}$$

where $W_t = M_{t-1} + B_{t-1}(1 + R_{t-1})$ and $W_t$ is the nominal government liabilities at the beginning of date $t$. This condition states that the real value of current nominal government liabilities must equal the present value of expected current and future primary budget surpluses, corrected to take into account the government's interest saved on the part of its liabilities that the public is willing to hold in monetary form. The above equation works as the constraint of fiscal policy in the active monetary-passive fiscal regime (i.e., fiscal policy should satisfy the equation) while the equation is an equilibrium condition in the passive monetary-active fiscal regime (i.e., the price-level changes keep the equation satisfied). For example, an increase in the nominal value of government liabilities or a decrease in the present value of the adjusted expected current and future primary budget surpluses make the real value of government liabilities exceed the present discounted value (given the price level). That is, the value of government liabilities is not backed up enough (at given price level) by current and future government surplus schedules. Therefore, households try to convert the government liabilities into current consumption, which increases the aggregate-demand for goods. The aggregate-demand increase pushes up the price level (and output in the sticky price model), which restores the equilibrium.

To examine the effects of each structural shock under the two regimes, the model is calibrated, and solved following Sims (1995). For calibration, the following parameter values are assumed: $\sigma = 1/5$, $\beta = 0.99$, $\chi = 1/5$, $\varpi = 1$, $\alpha = 0.75$, $\theta = 10$, $m/b = 0.2$, $G/Y = 0.2$, and $G/b = 0.07$.[10] Finally, it is assumed that all structural disturbances (except for government spending shocks since government spending itself is assumed to be an AR-1 process) follow AR-1 processes. The AR-1 coefficients of the process of shocks and government spending are assumed to be 0.8.

## 3. RESULTS

### 3.1. Effects of Structural Shocks in the Benchmark Case

A constant-tax ($\phi_b = 0$) and a constant-interest-rate policy ($\phi_\pi = 0$) are considered as the benchmark case for the passive monetary-active fiscal regime whereas positive feedbacks ($\phi_b = 0.1$ and $\phi_\pi = 1.1$) in both policies are considered as the benchmark case for the active monetary-passive fiscal regime. The benchmark parameter values for monetary policy are chosen on the basis of empirical estimates of the monetary policy rule in various subperiods since 1947.[11] A constant-tax policy is the natural benchmark case for the passive monetary-active fiscal regime because the policy rule implies that tax (and the primary budget surplus) is set without reference to the size of the government debt (or liabilities).[12] On the other hand, an arbitrary number is chosen for $\phi_b$ because the dynamics of all variables except for fiscal variables are the same in the active monetary-passive fiscal regime (as long as $1/\beta - 1 \prec \phi_b$).

First, the effects of government spending shocks are analyzed. Figure 1 reports the responses of each variable to a positive government spending shock.

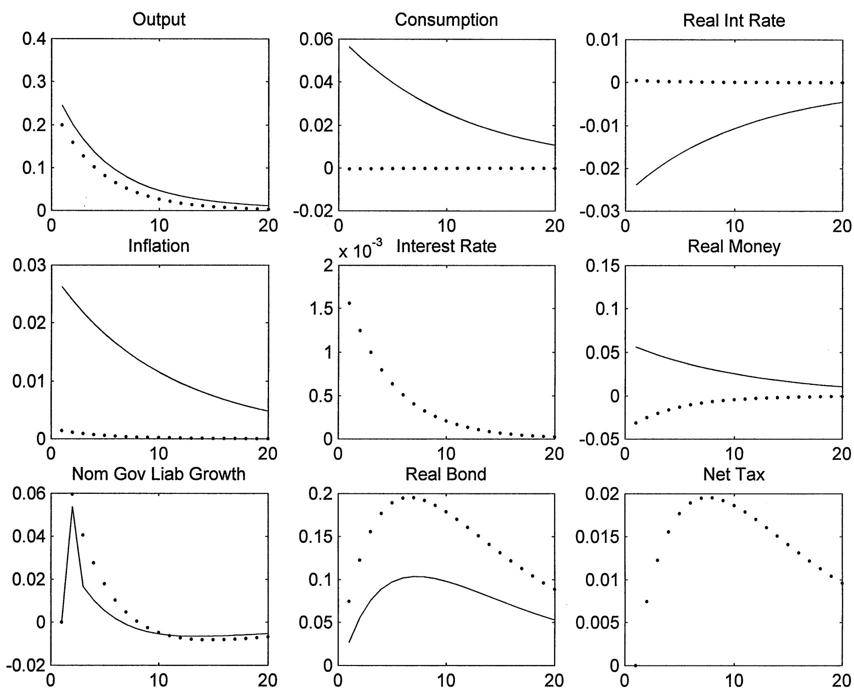


**FIGURE 1.** Impulse responses to government spending shocks (government spending increases): (——) passive monetary-active fiscal regime ($\phi_\pi = 0$, $\phi_b = 0$); (......) active monetary-passive fiscal regime ($\phi_\pi = 1.1$, $\phi_b = 0.1$).

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The dotted lines are those in the active monetary-passive fiscal regime whereas the solid lines are those in the passive monetary-active fiscal regime. In the active monetary-passive fiscal regime, increases in government spending stimulate aggregate-demand for goods, which increases output and the inflation rate. The aggregate-demand increase bids up the price of current consumption in terms of future consumption, or the real interest-rate, so that households decrease current consumption, though the effects are small quantitatively. As a result, the output change in response to increases in government spending is less than one to one. Note that, in this regime, the fiscal variables are adjusted to satisfy the government budget constraint. In response to government spending shocks that increase the government deficit, the real bond (debt) of the government rises, which increases net taxes and decreases government deficit, to keep the government budget constraint satisfied. In discussion of the goods market equilibrium, the government budget constraint does not play an explicit role.

However, in the passive monetary-active fiscal regime, the government budget constraint plays an explicit role for goods market equilibrium. Increases in government spending decrease the present discounted value of the (adjusted) current and future primary surplus below the real value of nominal government liabilities, given the price level. Since, at a given price level, the value of nominal government liabilities is not backed up enough by the primary surplus schedule (which is given in this regime), households convert the government liabilities into current consumption of goods. Therefore, the consumption increases, and the aggregate-demand is further stimulated. Overall, the responses of output to the increase in government spending are larger than one-to-one in the passive monetary-active fiscal regime. In addition, this aggregate consumption demand increase further pushes up the inflation rate, so that the inflation-rate increase is also larger.[13]

Next, the effects of monetary shocks are analyzed. Figure 2 reports the responses of each variable to monetary policy shocks (increases in the interest-rate). In the active monetary-passive fiscal regime, increases in the interest-rate push up the real interest-rate because prices are sticky. The increases in the real interest-rate decrease the current consumption demand, which decreases output and the inflation rate. Again, the government budget constraint does not play any explicit role here because it is satisfied by adjustments in fiscal variables.

On the other hand, when the interest-rate increases in the passive monetary-active fiscal regime, the nominal government liabilities grow more rapidly without changing the present value of current and future government deficits.[14] Therefore, in the next period, the real value of government liabilities exceeds the present value at the given price level, which induces households to convert the government liabilities into consumption of goods. This aggregate-demand increase pushes up the inflation rate and output in the next period. The inflation rate also increases in the current period because the price decision is forward looking and prices are set sluggishly while consumption and output fall in the current period because the real interest-rate increases in the current period following the interest-rate jump.[15]

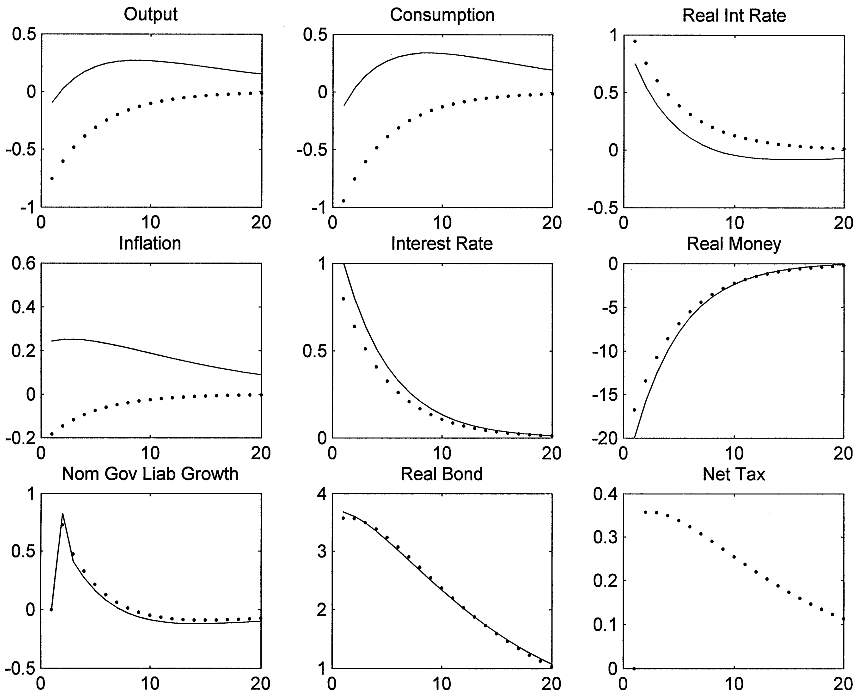


**FIGURE 2.** Impulse responses to monetary policy shocks (interest-rate increases): (——) passive monetary-active fiscal regime ($\phi_\pi = 0, \phi_b = 0$); (......) active monetary-passive fiscal regime ($\phi_\pi = 1.1, \phi_b = 0.1$).

It is striking that increases in the interest-rate increase the inflation rate and output in this regime, which is completely the opposite of the predictions in the active monetary-passive fiscal regime. Another way to explain the inflation rate increase is as follows. Following the interest-rate rise, the government debts grow faster. In this regime, the increase in the government debt should be financed by a positive inflation tax. Therefore, the inflation rate rises. To summarize, a rise in the interest-rate chokes off aggregate-demand by increasing the relative price of current consumption in terms of future consumption in the active monetary-passive fiscal regime whereas it raises aggregate-demand by causing the government liabilities to grow faster without inducing any change in fiscal policy in the passive monetary-active fiscal regime. Therefore, the effects on output and inflation rate are completely different in the two regimes.

Figures 3 and 4 report the impulse responses to aggregate-supply and aggregate-demands shocks. Aggregate-demand shocks increase both output and inflation initially whereas aggregate-supply shocks decrease output and increase inflation initially in both regimes. One interesting difference between the two regimes is inflation dynamics. The initial rise in the inflation rate smoothly dies out over time in the active monetary-passive fiscal regime, but the initial increase in the inflation

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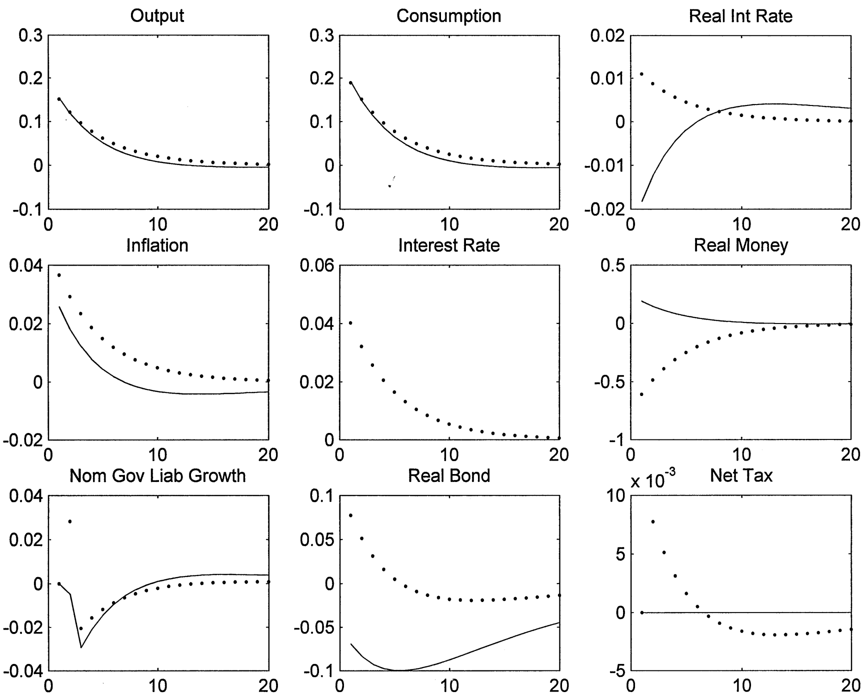


**FIGURE 3.** Impulse responses to aggregate-demand shocks: (——) passive monetary-active fiscal regime ($\phi_\pi = 0$, $\phi_b = 0$); (......) active monetary-passive fiscal regime ($\phi_\pi = 1.1$, $\phi_b = 0.1$).

rate above the steady-state is followed by the subsequent fall in the inflation rate below the steady-state in the passive monetary-active fiscal regime. Such "inflation reversal" is found because the inflation tax plays the key role in satisfying the government budget constraint in the passive monetary-active fiscal regime. The initial increase in the inflation rate creates a positive inflation tax on the government's nominal liabilities, which decreases the real government debt. In response to this favorable shock to the real government debt, negative inflation is necessary to collect a negative inflation tax on the government nominal liabilities and keep the government budget constraint satisfied. Therefore, the inflation rate is reversed in the later period. In contrast, in the active monetary-passive fiscal regime, the net tax level responds to the real value of government debt to satisfy the government budget constraints, and inflation reversal is not found.[16] In other words, the increase in the inflation rate decreases the real value of government liabilities. Since the fiscal policy does not adjust taxes and government spending at all, the real value of government liabilities falls below the present value of current and future budget surpluses. That is, government liabilities are underpriced, compared to the budget surplus schedule at a given price level, which makes households obtain more government liabilities by giving up consumption of goods. This fall

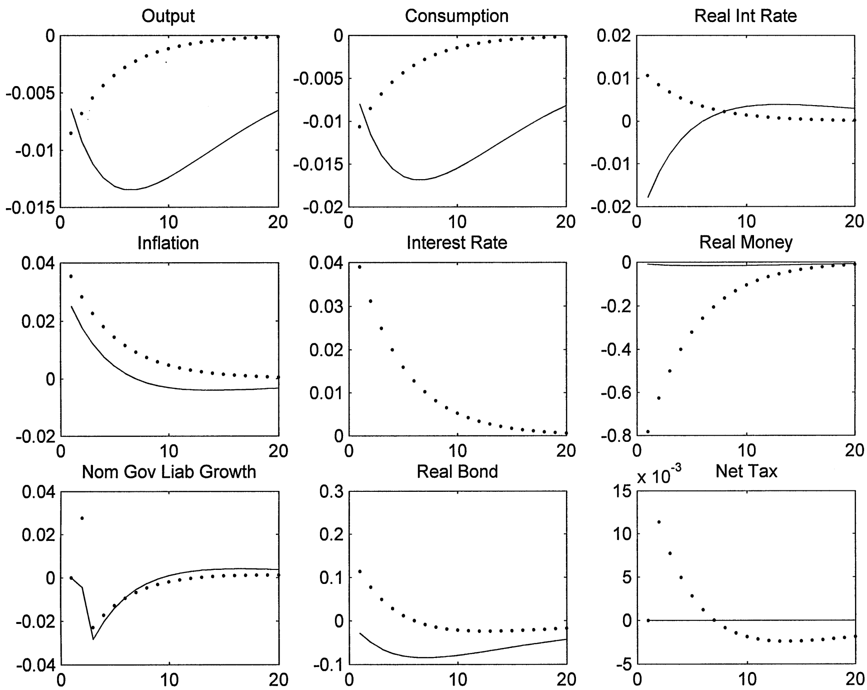


**Figure 4.** Impulse responses to aggregate-supply shocks: (——) passive monetary-active fiscal regime ($\phi_\pi = 0$, $\phi_b = 0$); (. . . . . .) active monetary-passive fiscal regime ($\phi_\pi = 1.1$, $\phi_b = 0.1$).

in aggregate-demand decreases the inflation rate in the later periods, and inflation reversal is found. It also explains why output and consumption responses are lower in this regime in the later periods.[17] In the case of aggregate-demand shocks, such decreases in aggregate-demand in the later periods lead output below the steady-state, and "output reversal' is also observed, though it is quantitatively small.

## 3.2. Other Policy Rules

In this section, other policy rules are experimented with to examine whether the main results in the previous section are robust. First, a positive feedback from output is allowed in the tax rule since net tax may respond to output. The following rule is considered:

$$T_t = \phi_T + \phi_b \frac{B_{t-1}}{P_{t-1}} + \frac{T}{Y}\phi_{TY} Y_t, \qquad \textbf{(25)}$$

where $\phi_{TY}$ is assumed to be 0.26, based on the empirical estimate.[18] Figure 5 reports the impulse responses. G, M, AD, and AS (in the title of each graph) suggest that

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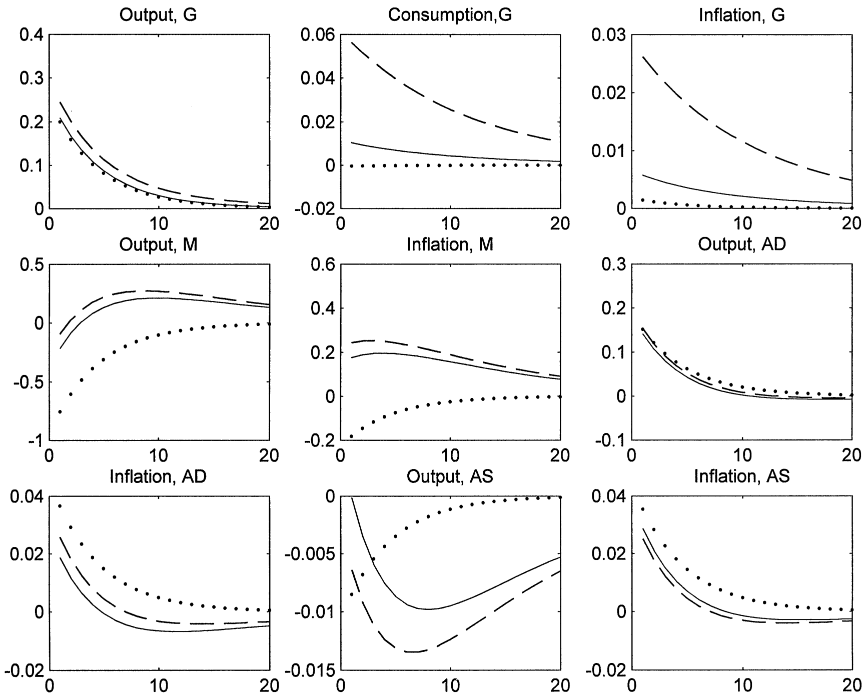


**FIGURE 5.** Impulse responses under modified tax rule ($\phi_{TY} = 0.26$): (——) modified rule (passive monetary-active fiscal, $\phi_{TY} = 0.26$, $\phi_\pi = 0$, $\phi_b = 0$); (– – –) benchmark rule (passive monetary-active fiscal, $\phi_{TY} = 0$, $\phi_\pi = 0$, $\phi_b = 0$); (. . . . . .) modified rule (active monetary-passive fiscal, $\phi_{TY} = 0.26$, $\phi_\pi = 1.1$, $\phi_b = 0.1$); (· – · – ·) benchmark rule (active monetary-passive fiscal, $\phi_{TY} = 0$, $\phi_\pi = 1.1$, $\phi_b = 0.1$).

they are responses to government-spending, monetary-policy, aggregate-demand, and aggregate-supply shocks, respectively. The solid lines are impulse responses under the modified tax rule in the passive monetary-active fiscal regime; the dashed lines are impulse responses under the benchmark tax rule in the passive monetary-active fiscal regime. The dotted lines are impulse responses in the active monetary-passive fiscal regime (note that the tax rule change does not affect impulse responses of any variable except for fiscal variables in the active monetary-passive fiscal regime).

Qualitative results are similar to the benchmark case. A positive government spending shock increases consumption, and so, the output increase is more than one-to-one. Interest-rate rises increase inflation persistently, and increase output with lags. Aggregate-demand shocks and aggregate-supply shocks lead to inflation reversal. A little output reversal is found in response to aggregate-demand shocks.

However, the results change quantitatively. Increases in government spending raise aggregate consumption demand and output by decreasing the present

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value of current and future budget surpluses, but now the output rise increases the net tax level, which partly offsets the initial fall in the present value. Therefore, the effects of government spending shocks on consumption, output, and inflation rate are weaker than the benchmark case. Similarly, the interest-rate shocks and the aggregate-demand shocks have weaker effects on output and inflation rate since these shocks tend to increase output by boosting aggregate-demand, but now, the net tax level increases in response to output increase, which partially offsets the initial aggregate-demand increase. On the other hand, a negative aggregate-supply shock decreases output, which decreases the net tax level. The fall in net tax level pushes up aggregate-demand by increasing the present value of current and future budget surplus. Therefore, the output and inflation-rate responses move upward from those in the benchmark case. Note that inflation reversal and output reversal are now stronger in the case of aggregate-demand shocks whereas inflation reversal is weaker in the case of aggregate-supply shocks.

Some modifications of monetary policy rules are also considered. First, nonzero feedback from output is allowed in the monetary policy rule since such rules are claimed to well describe recent monetary policy rules [e.g., Taylor (1993)]. The following rule is assumed:

$$\log(1+R_t) = \phi_R + \phi_\pi \log\left(\frac{P_t}{P_{t-1}}\right) + \phi_{RY}\frac{Y_t - Y}{Y} + \log\varepsilon_t. \quad \textbf{(26)}$$

Based on the estimate for the period of 1982–2000 and Taylor (1993), $\phi_{RY}$ is assumed to be 0.5.[19] Second, a higher degree of feedback from the inflation rate is assumed. In the passive monetary-active fiscal regime, $\phi_\pi$ is assumed to be 0.8, which is the estimate for the period of 1960–1982. In the active monetary-passive fiscal regime, $\phi_\pi$ is assumed to be 1.5, which was suggested by Taylor (1993).

Figures 6 and 7 report the results. The solid and dashed lines are impulse responses under the modified and the benchmark rules in the passive monetary-active fiscal regime, respectively. The dotted and dot-dashed lines are impulse responses under the modified and the benchmark rules in the active monetary-passive fiscal regime, respectively. In most cases, the results are qualitatively similar. One difference is that inflation reversal and output reversal are not observed in response to aggregate-demand shocks in the passive monetary-active fiscal regime when the positive feedback from output is allowed in the monetary policy rule (Figure 6). Aggregate-demand shocks increase output and inflation initially. As discussed, the initial positive inflation decreases the real value of government liabilities and aggregate-demand later, which leads to negative inflation and output in the later periods in the benchmark case. However, with the positive feedback from output in the monetary reaction function, the monetary authority now increases the interest-rate since output rises, which makes the government liabilities grow faster, and boosts, aggregate-demand in the later periods (as discussed earlier—the effects of interest-rate changes). When $\phi_{RY}$ is 0.5, the latter effect dominates the

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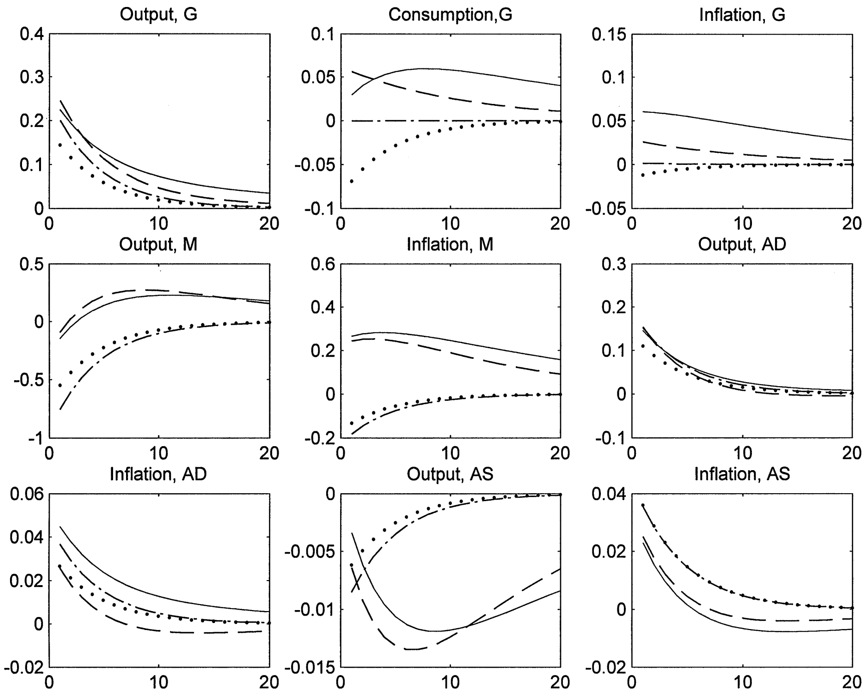


**FIGURE 6.** Impulse responses under modified monetary policy rule ($\phi_{RY} = 0.125$): (——) modified rule (passive monetary-active fiscal, $\phi_{RY} = 0.125$, $\phi_\pi = 0$, $\phi_b = 0$); (– – –) benchmark rule (passive monetary-active fiscal, $\phi_{RY} = 0$, $\phi_\pi = 0$, $\phi_b = 0$); (. . . . . .) modified rule (active monetary-passive fiscal, $\phi_{RY} = 0.125$, $\phi_\pi = 1.1$, $\phi_b = 0.1$); (· – · – ·) benchmark rule (active monetary-passive fiscal, $\phi_{RY} = 0$, $\phi_\pi = 1.1$, $\phi_b = 0.1$).

former effect and inflation reversal is not observed.[20] On the other hand, inflation reversal in response to aggregate-supply shocks becomes stronger with a similar reason.

## 3.3. Empirical Analysis

In the preceding experiments, an interesting empirical implication of the passive monetary-active fiscal regime, namely inflation reversal, is found in response to aggregate-demand and aggregate-supply shocks. Under some policy rules and in the presence of structural shocks other than aggregate-demand and aggregate-supply shocks, the reversal may not be observed in the passive monetary-active fiscal regime. However, if the reversal is found in the data, it is supporting evidence of the passive monetary-active fiscal regime since the reversal is less likely to be observed in the active monetary-passive fiscal regime. At least in all our experiments, inflation reversal is not found at all in the active monetary-passive fiscal regime. This section examines whether inflation reversal is observed historically,

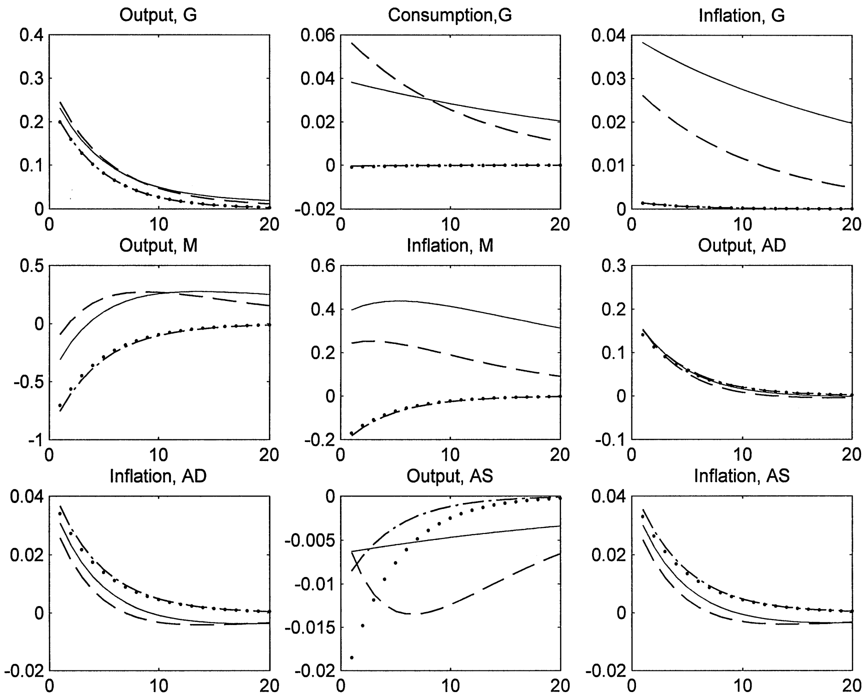


**FIGURE 7.** Impulse responses under modified monetary policy rule ($\phi_\pi = 0.8, 1.5$): (——) modified rule (passive monetary-active fiscal, $\phi_\pi = 0.8$, $\phi_b = 0$); (– – –) benchmark rule (passive monetary-active fiscal, $\phi_\pi = 0$, $\phi_b = 0$); (......) modified rule (active monetary-passive fiscal, $\phi_\pi = 1.5$, $\phi_b = 0.1$); (· – · – ·) benchmark rule (active monetary-passive fiscal, $\phi_\pi = 1.1$, $\phi_b = 0.1$).

to explore the possibility that the passive monetary-active fiscal regime was in place historically.

To compare the predictions of the model with data, a simple two-variable VAR model is constructed. The empirical model includes two variables: output growth rate and the inflation rate. To identify aggregate-demand and aggregate-supply shocks, a long-run identifying assumption a la Blanchard and Quah (1989) is imposed: Aggregate-demand shocks do not affect the level of output in the long run. Such an identifying assumption is consistent with the current model and many other macro models. The following equation system summarizes the basic model:

$$\begin{bmatrix} d\log(Y_t) \\ d\log(P_t) \end{bmatrix} = \begin{bmatrix} \Psi_1 \\ \Psi_2 \end{bmatrix} + \begin{bmatrix} \Psi_{11}(L) & \Psi_{12}(L) \\ \Psi_{21}(L) & \Psi_{22}(L) \end{bmatrix} \begin{bmatrix} \varepsilon_{AS,t} \\ \varepsilon_{AD,t} \end{bmatrix}, \qquad \Psi_{12}(1) = 0 \qquad \textbf{(27)}$$

where $\Psi_i$ is a constant, $\Psi_{ij}(L)$ is a polynomial in the lag operator in $L$, $\varepsilon_{AD,t}$ is the aggregate-demand shock, and $\varepsilon_{AS,t}$ is the aggregate-supply shock.[21] Three subperiods are considered: 1947:1–1959:4, 1960:1–1982:4, 1983:1–2000:4. The

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subperiods are chosen in reference to monetary policy rule changes since there is less clear-cut evidence on fiscal policy rule changes [refer to Blanchard and Perotti (1999)]. The last subperiod is chosen since it is commonly argued that monetary-policy operating procedure was changed in the late 1970's or early 1980's. The first sample is taken separately since the monetary operating procedure in the 1940's and 1950's is thought to be different from that in later periods. To examine the robustness of the results in the earlier sample period, various end dates are experimented with, but results are qualitatively similar. The estimation results for the period of 1947–1966 are also reported.[22]

Figure 8 reports the impulse responses of output $[\log(Y_t)]$ and the inflation rate $[d\log(P_t)]$ with 90% probability bands. The names of responding variables (inflation or output) and the nature of shocks (AD or AS) are denoted at the far left of each row; the estimation periods are denoted at the top of each column. First, aggregate-demand shocks affect inflation and output in the same direction on impact whereas aggregate-supply shocks affect inflation and output in opposite directions on impact. These impact effects are consistent with the general theoretical predictions on the effects of aggregate-demand and aggregate-supply shocks, which supports the validity of the empirical model.

The impulse responses are similar for the periods of 1960–1982 and 1983–2000. Inflation responses die out smoothly over time, and the inflation reversal is not found. However, for the periods of 1947–1959 and 1947–1966, the sign of inflation responses is reversed. In response to aggregate-demand shocks, the initial positive inflation response is reversed in about five quarters, and the negative inflation response in about two years is different from zero with more than 90% probability. In response to aggregate-supply shocks, the initial negative inflation response is reversed in about two quarters, and the positive inflation responses at three and five quarters are different from zero with 90% probability. Output reversal is also found in response to aggregate-demand shocks. To summarize, the inflation reversal is found in the 1940's and 1950's, which suggests that the passive monetary-active fiscal regime seems to be actually in place in the 1940's and 1950's. The result is consistent with that of Woodford (2001) claiming that the passive monetary-active fiscal regime was in place during those periods.

Finally, past studies on the effects of monetary shocks [e.g., Christiano et al. (1999)] typically examined the effects after the 1960's, and found that results are broadly consistent with the predictions in the active monetary-passive fiscal regime. However, the results in this paper suggest that completely different effects may be found in the periods before the 1960's. Also, past studies on the effects of government spending shocks [e.g., Blanchard and Perotti (1999) and Edelberg et al. (1999)] did not examine the effects in the periods before the 1960's separately. The results in this paper suggest that the effects may be quite different in the periods before and after the 1960s. Overall, a careful analysis on the effects of monetary policy and government spending shocks in the earlier period may be worthwhile, although such analysis is beyond the scope of this paper.

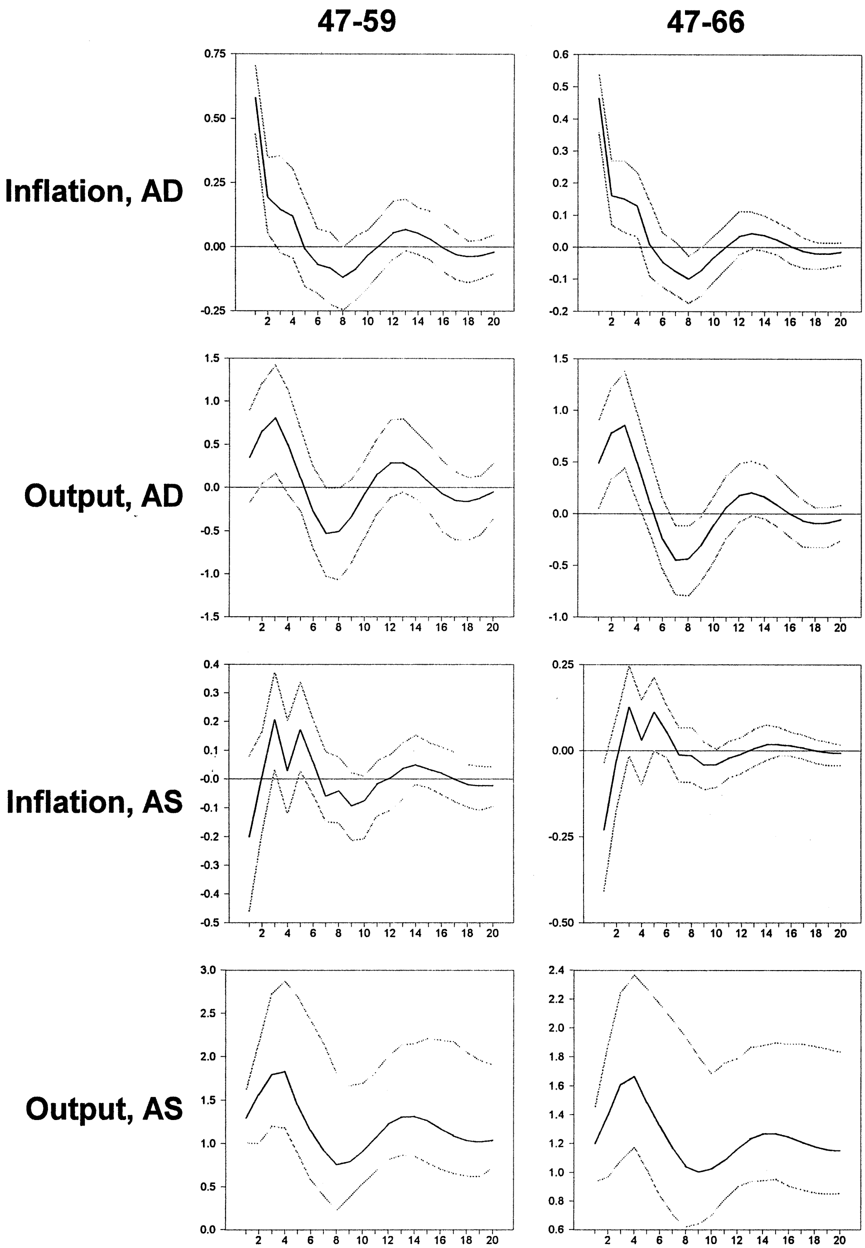


**FIGURE 8.** Impulse responses in the VAR model.

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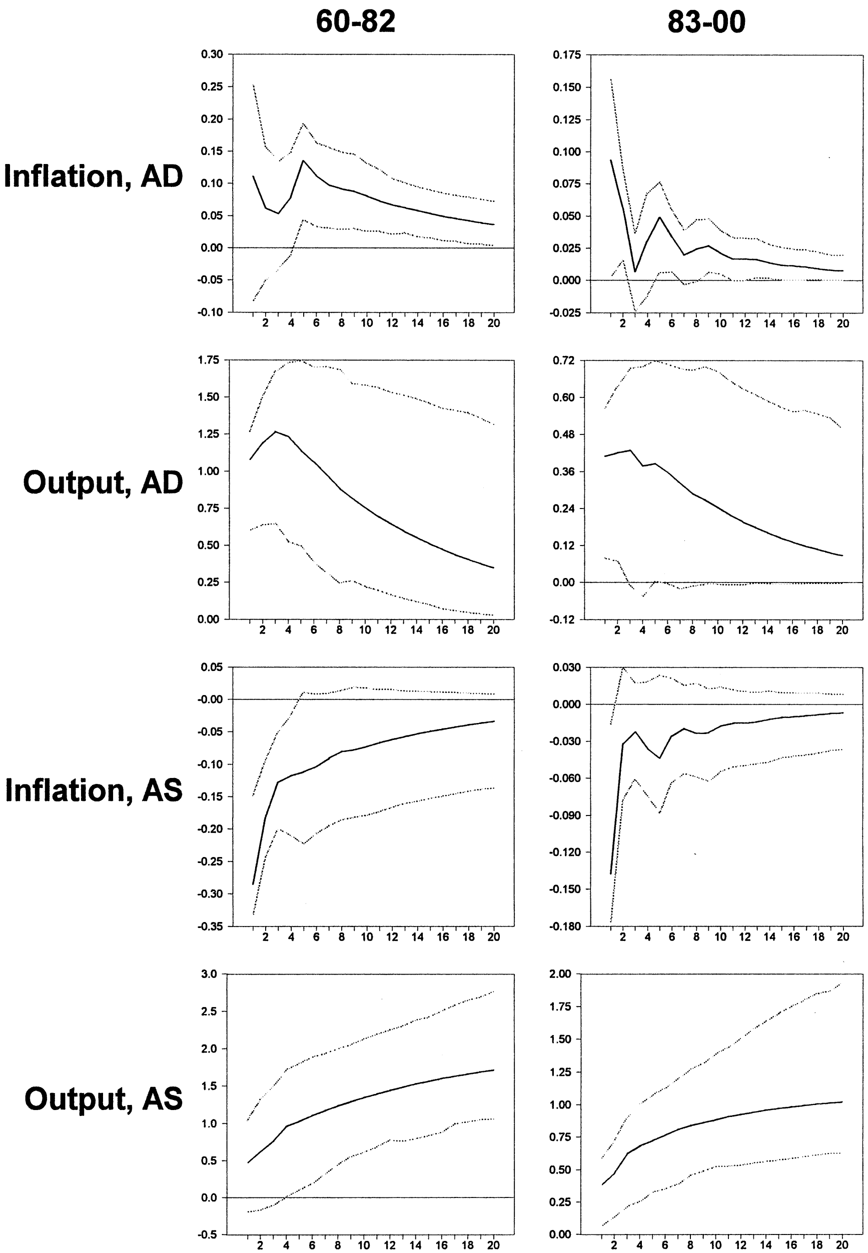


FIGURE 8. (Continued.)

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## 4. CONCLUSION

Within the framework of the New Keynesian sticky price model, the effects of various structural shocks are examined in the passive monetary-active fiscal regime. The effects are substantially different from conventional analysis in the active monetary-passive fiscal regime. The difference originates from the different method of satisfying the government budget constraint, and whether the government budget constraint works as a constraint for fiscal policy or an equilibrium condition.

In response to an increase in government spending, the present discounted value of current and future budget surplus falls below the real value of current nominal government liabilities at a given price level, so that households convert the government liabilities into consumption of goods. Such a boost in aggregate consumption demand makes the effects on output and inflation stronger. An increase in the interest-rate leads to a higher growth of government liabilities, which makes the real value of government liabilities exceed the present discounted value of current and future budget surplus. As a result, households convert the government liabilities into consumption, which increases aggregate-demand, inflation, and output. Therefore, a monetary contraction (an increase in the interest-rate) increases the inflation rate persistently, and increases output with lags. Aggregate-demand and aggregate-supply shocks lead to inflation reversal. An increase in the inflation rate (due to a positive aggregate-demand shock and a negative aggregate-supply shock) decreases the real value of nominal government liabilities. Since the government does not change the fiscal schedule in this regime, a future decrease in the inflation rate is necessary to offset the initial effect. A simple structural VAR model that identifies aggregate-demand and aggregate-supply shocks is used to examine whether such inflation reversal is found historically. The results suggest that the inflation reversal is found in the 1940's and 1950's, which implies that the passive monetary-active fiscal policy seems to be actually in place historically.

As suggested by Cochrane (1998) and Christiano and Fitzgerald (2000), there is no easy way to test the fiscal theory of the price level empirically. A number of past studies, such as those by Cochrane (1998, 2001), Woodford (1998), Loyo (2000), and Canzoneri et al. (2002), concentrate on the dynamics of the fiscal variables such as the government budget surplus and government liabilities in the presence of fiscal shocks such as shocks to government budget surplus (or deficits) by assuming that the government surplus is statistically exogenous. In contrast, this paper describes the fiscal theory of the price level as an endogenous transmission mechanism to explain the effects of nonfiscal shocks on nonfiscal variables. Further studies along this line may be worthwhile.

### NOTES

1. See Christiano and Fitzgerald (2000) and Woodford (2001) for various studies in this literature.
2. Kim (2001) provides closed-form solutions on the effects of various structural shocks in the flexible price endowment economy model.

3. There are many different ways to introduce government spending in the model. Considered here is the simplest case, where government spending is purely dissipative and does not affect private utility. Note that the dynamic effects of government spending shocks would be the same if government spending entered separably into preferences.

4. Different households have different price-setting experiences with the Calvo pricing scheme. Without the assumption of complete markets, the distribution of wealth across households would be a state variable, which generates massive computational difficulties. The assumption of complete markets makes household wealth constant over time, which eliminates the distribution of wealth as a state variable and makes the computation of equilibrium easy.

5. Only one-period government nominal bonds are considered for simplicity, as in Woodford (1995, 1996, 2001), among others. Refer to Cochrane (2001) for the model considering long-term government bonds.

6. If we assume that $C$ and $G$ are perfect substitutes [as in Woodford (1996)], only $Y$ would appear in the equation. However, in the current model, both $C$ and $Y$ appear since marginal cost of production depends on $Y$, but the discount factor depends on marginal utility of consumption, which does not depend on $G$ in the current model.

7. Refer to Leeper (1991) and Woodford (1996) for details of conditions on the uniqueness and root calculations in this system.

8. In this model with the simple interest-rate rule, the money demand equation only determines money, and the other equations determine other variables such as consumption, output, inflation rate, and interest-rate. However, with more general monetary policy rules (e.g., a monetary policy rule setting a combination of the interest-rate and the money growth rate), all other equations matter for output and inflation determination.

9. Refer to Woodford (1995, 2001) and Christiano and Fitzgerald (2000), among many others, for the derivation.

10. All values are quarterly rates. The values of $G/Y$, $m/b$, and $G/b$ approximate the U.S. data since 1947. Monetary base and net federal debt are used for $m/b$, output and government spending are used for $G/Y$, and purchases of goods and services for federal government and net federal debt are used for $G/b$. Data are obtained from the Macro database of the Federal Reserve Bank of St. Louis and Citibase. The values of other parameters are in the range of standard values used in the literature.

11. When the three-month treasury bill rate is used as the interest-rate, the OLS estimates of $\phi_\pi$ are $-0.02$ (0.04), 0.80 (0.08), and 1.06 (0.17) for the periods of 1947–1959, 1960–1982, and 1983–2000, respectively (the numbers in the parentheses are standard errors). Regarding the subperiod choices, refer to Section 3.3. When the Federal Funds rate (call money rate for the period of 1947–1959) is used, the estimates are $-0.04$ (0.05), 1.02 (0.09), and 1.17 (0.20). The GDP deflator inflation rate is used for all estimations. Therefore, during the first subperiod, a passive monetary policy rule such as the constant-interest-rate rule seems to be appropriate while an active monetary policy rule seems to be appropriate for the periods of 1983–2000. For the periods of 1960–1982, the evidence is mixed.

12. Under the benchmark parameterization of the model, $\phi_b$ should not be greater than 0.01 in the active monetary-passive fiscal regime.

13. Past studies [e.g., Baxter and King (1993)] implicitly assuming the active monetary-passive fiscal regime found that temporary government spending shocks decrease consumption in the neoclassical growth model. Some recent studies, such as that by Devereux et al. (1996), have proposed a model of monopolistic competition and increasing returns in which an increase in government spending can raise productivity and private consumption. The passive monetary-active fiscal regime combined with sticky prices may be viewed as another way to obtain the positive effect of government spending on private consumption. Empirical evidence is mixed in this regard: Blanchard and Perotti (1999) documented a positive effect whereas Edelberg et al. (1999) found a negative effect.

14. There are two reasons. First, the increase in the interest-rate make households exchange money for bonds since the opportunity cost of holding money increases. Therefore, a larger fraction of government liabilities is subject to the interest payments. Second, the increase in the interest-rate increases the government debt services.

15. In Leeper (1991, 1993), using the flexible price model and the model with traditional expectation-augmented Phillips curve, the positive effect of monetary shocks on inflation is simply delayed. The difference comes from the forward-looking nature of price setting in this New Keynesian model, which is represented by the forward-looking Phillips curve. Loyo (2000), explaining Brazilian hyperinflation with the active monetary-active fiscal regime, presented a similar dynamic effect of the interest-rate changes on the inflation rate.

16. In the active monetary-passive fiscal regime, the interest-rate increases sharply (due to policy reaction to the inflation-rate increase) on impact, which has two effects on real government debts. First, it increases debt services. Second, it decreases the real money balance. These negative effects on real government debts are stronger than the positive inflation tax, and the real government debt increases initially.

17. The degree of price stickiness affects the timing of inflation reversal. More immediate inflation reversal is found when a lower degree of price stickiness is assumed.

18. Real GDP is regressed on real net federal tax (both in log forms). Net federal tax is constructed as follows: federal receipts – federal grants-in-aid – federal net transfer payments to persons – federal net interest paid. Data are collected from CITIBASE.

19. The estimate for the period of 1983–2000 is 0.3, but a larger value of 0.5 suggested by Taylor (1993) is assumed to highlight the changes. The estimates for the other two periods are far smaller, and not much different from zero. In all estimations, the inflation rate is also included as another explanatory variable. With the smaller value of the parameter, the impulse responses change less.

20. With a lower value of $\phi_{RY}$, the former dominates the latter, and inflation and output reversal are observed, though they are weaker than those in the benchmark case.

21. For the price measure, a GDP deflator is used. For output measure, private output (GDP-government spending) is used to minimize the role of government spending shocks that do not generate any inflation reversal. Still, government spending shocks may play some roles in the model; in addition, monetary shocks and other structural shocks that do not generate inflation reversal may be regarded as aggregate-demand and aggregate-supply shocks. In that sense, the fact that inflation reversal is not found does not necessarily provide evidence against the passive monetary-active fiscal regime.

22. One natural breakpoint may be the 1951 Treasury–Federal Reserve Accord, but data points before 1951 are too short in that way. Before the Treasury–Federal Reserve Accord, the monetary policy rule may be regarded as a constant-interest-rate rule (passive monetary policy) since the monetary authority tried to keep the value of government bonds [refer to Woodford (2001) and articles in *Economic Quarterly* of the Federal Reserve Bank of Richmond (2001)]. The policy rule in some periods after the Treasury–Federal Reserve Accord may be also regarded as passive-monetary policy since, as discussed by Taylor (1999) and Friedman and Schwartz (1963), monetary policy was implemented without clear underlying rules or guidelines in the 1950's even after Treasury–Federal Reserve Accord, and the guidelines were being searched for until the mid-1960's. All these are consistent with the empirical estimate of $\phi_{\pi}$ (close to zero) during these periods. I experimented with various end dates between 1955 and 1966. The results are qualitatively similar.

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