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Macroeconomic fluctuations and welfare cost of stabilization policy

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Abstract

This paper uses an extended Real-Business-Cycle (RBC) model including money and government spending to analyze US macroeconomic policy and business cycles. There exist two kinds of exogenous shocks: nominal random disturbance (money) and real random disturbance (technology, government spending and tax rate). In addition, the welfare cost of business cycles is measured and different stabilization policies are discussed and compared.

The results of the calibration indicate that this model can mimic the characteristics of post-war business cycles well and that it does a good job of explaining the dynamic interactions of money and real variables. It is obvious that monetary and fiscal shocks play important roles in the explanation of post-war business cycles.

According to the welfare cost of different stabilization policies, it can be found that (1) monetary policy may be a better stabilization policy than other policies, (2) there may exist a kind of "Laffer curve" patterns for the feedback coefficient of government consumption, and (3) tax smoothing induces lower welfare cost than variable tax rate.

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1. Introduction

The business cycle is typically an important issue in the macroeconomics research. In recent years, there are three essential theories under the rational expectation framework: monetary business cycle theory, New Keynesian business cycle theory and Real-Business-Cycle (RBC) theory.

The prototypical RBC model is marked by stochastic shocks and intertemporal propagation mechanisms. The former is the catalyst of the cycle, and the latter is the agitation of fluctuations. To put it more precisely, after the economy is disturbed by random shocks, the change of intertemporal relative prices will change individuals optimal decision. Furthermore, it will cause persistent fluctuations in macroeconomic variables such as output, consumption and investment.

Although people frequently assume technology shocks are main sources of business cycles in the prototypical RBC model, Christiano and Eichenbaum (1992) point out that technology shocks can not explain the fluctuations completely. Hence, many researchers have modified the basic model by allowing various shocks, such as taste (preference) shocks, depreciation shocks, and government spending shocks, to influence the cyclical behavior of economy. Consideration of the public sector is important because of the many roles played by government. Firstly, government spending is one part of aggregate demand; thus, the shock is no longer from the supply side. In addition, the crowding out (in) effect of public purchasing, bond financing and tax distortion enrich the analysis.

King, Plosser, and Rebelo (1998b), Christiano and Eichenbaum (1992), Hansen and Wright (1994) and Braun (1994) all introduce government purchasing to the basic model, and find the fit of the model is better, especially with respect to the relationship between wages and hours worked. The reason is intuitive: technology shocks can directly influence labor demand only, but labor supply will also shift after considering government spending and taxes. Thus, the fluctuation of labor market should be bigger when government is included in the model.

In view of "only real side matter" in the RBC model, it could be thought as "ultra-classical."[1] It is, however, no reason to neglect the role of money. The early work considering money in the RBC model is King and Plosser (1984). They use the concept of "inside money" and model two production sectors: final goods and financial goods. Cooley and Hansen (1989, 1995) use cash in advance (CIA) constraint to introduce outside money in the RBC model. As shown in Cooley and Hansen (1995), however, introducing CIA constraint into a RBC model fails to capture the procyclical behavior of inflation rate.

In this paper, I try to use an extended RBC model with money and the public sector to interpret post-war business cycle. Moreover, I will discuss the welfare cost of different stabilization policies and give some inferences and suggestions on the policy making. The paper is organized as follows. Section 2 develops an extended

[1] See McCallum (1987).

RBC model. In Section 3, I present the empirical analysis and calibration results of alternative models, and compare the model's prediction with data to evaluate the extended model's fit. In Section 5, the welfare cost of business cycles is measured and different stabilization policies are discussed and compared. Finally, Section 5 concludes.

2. The model

2.1. Basic structure

2.1.1. Utility function

I assume the utility function is function of consumption c_t, leisure l_t and real balances m_t:

$$u(c_t, l_t, m_t) = V(c_t, m_t) + \Lambda(l_t) = \left[\frac{(c_t^{\varphi_1} m_t^{1-\varphi_1})^{1-\sigma} - 1}{1-\sigma}\right] + \Phi \frac{l_t^{\eta}}{1-\eta}, \tag{1}$$

where $\sigma > 0$, $\eta > 0$, and β is the discount factor; σ is the coefficient of relative risk aversion.

2.1.2. Technology and law of motion

$$y_t = A_t f(k_t, n_t x_t, k_{gt}) = A_t k_t^{\alpha 1} (n_t x_t)^{\alpha 2} k_{gt}^{\alpha 3}, \tag{2}$$

$$k_{t+1} = (1-\delta)k_t + i_t, \qquad k_{gt+1} = (1-\delta)k_{gt} + i_{gt}, \tag{3}$$

where A_t is temporary technology shock; x_t is permanent technology change factor. Assume that the technology exhibits Harrod-neutral growth (labor-augmenting growth) and x_t grows at a constant rate γ, such that $x_{t+1}/x_t = \gamma$. k_t and i_t represent the capital stock and private sector investment, respectively. k_{gt} and i_{gt} represent the capital stock and government investment. Here, I assume there are constant return to scale over inputs: $\alpha_1 + \alpha_2 + \alpha_3 = 1$.

2.1.3. Resource constraints

$$n_t + l_t \leq 1, \tag{4}$$

$$p_t c_t + p_t i_t + (M_{t+1} - M_t) + \tau_t p_t y_t + p_t T_t \leq p_t y_t, \tag{5}$$

$$p_t G_t = p_t(i_{gt} + g_t) = (M_{t+1}^{\mathrm{S}} - M_t^{\mathrm{S}}) + \tau_t p_t y_t + p_t T_t. \tag{6}$$

Listed above are, in order, time constraint, budget constraint and government budget constraint. Where, τ_t denotes the tax rate on output (or, equivalently, the uniform tax rate on labor and capital income) and $p_t T_t$ is lump-sum tax. $p_t G_t$ and M_t^{S} are total nominal government spending and nominal money supply, respectively.

2.2. Model analysis

First, I make a stationary transformation. That is, I divide all of the real variables in the model by x_t, such that $\tilde{h}_t = h_t/x_t$, $h = \{c, m, k, i_g, g, T\}$. Thus, the utility function becomes

$$E_0 U = \sum_{t=0}^{\infty} \beta^t u(\tilde{c}_t, l_t, \tilde{m}_t) = E_0 (x_0)^{1-\sigma} \sum_{t=0}^{\infty} \beta^{*t} \left[\frac{(\tilde{c}_t^{\varphi_1} \tilde{m}_t^{1-\varphi_1})^{1-\sigma} - 1}{1-\sigma} \right] + \Phi \sum_{t=0}^{\infty} \beta^t \frac{l_t^{\eta}}{1-\eta},$$

where $\beta^* = \beta\gamma^{1-\sigma}$, $x_t^{1-\sigma} = (x_0 \gamma^t)^{1-\sigma}$.

Eqs. (2) and (3) become

$$\tilde{y}_t = A_t f(\tilde{k}_t, n_t, \tilde{k}_{gt}) = A_t \tilde{k}_t^{\alpha_1} n_t^{\alpha_2} \tilde{k}_{gt}^{\alpha_3}, \tag{7}$$

$$\tilde{i}_t = \gamma \tilde{k}_{t+1} - (1-\delta)\tilde{k}_t, \tag{8}$$

$$\tilde{i}_{gt} = \gamma \tilde{k}_{gt+1} - (1-\delta)\tilde{k}_{gt}. \tag{9}$$

Define the expected inflation rate as

$$\pi_t = \frac{E_t p_{t+1} - p_t}{p_t},$$

then the efficient conditions are as follows:

- First order conditions[2]

$$E_t\{u_c(t) - \lambda_t\} = 0, \tag{10}$$

$$E_t \left\{ \beta^* \left[\frac{u_m(t+1) + \lambda_{t+1}}{p_{t+1}} \right] - \gamma \frac{\lambda_t}{p_t} \right\} = 0, \tag{11}$$

$$E_t\{u_l(t) - (1-\tau_t) A_t f_2(t) \lambda_t\} = 0, \tag{12}$$

$$E_t\{\beta^* \lambda_{t+1} [A_{t+1}(1-\tau_{t+1}) f_1(t+1) + (1-\delta)] - \gamma \lambda_t\} = 0, \tag{13}$$

$$(1-\tau_t)\tilde{y}_t + \tilde{m}_t - \tilde{c}_t - \gamma \tilde{k}_{t+1} + (1-\delta)\tilde{k}_t - \frac{M_{t+1}}{p_t x_t} - \tilde{T}_t = 0, \tag{14}$$

  where λ_t is the Lagrangian multiplier.
- Transversality condition

$$E_t \lim_{t\to\infty} (\beta)^{*t} \lambda_t \tilde{k}_{t+1} = 0, \tag{15}$$

$$E_t \lim_{t\to\infty} (\beta)^{*t} \lambda_t (1+\pi_t) \tilde{m}_{t+1} = 0. \tag{16}$$

[2] I define $u_c(t) = \partial u(\tilde{c}_t, l_t, \tilde{m}_t)/\partial \tilde{c}_t$, $u_l(t) = \partial u(\tilde{c}_t, l_t, \tilde{m}_t)/\partial l_t$, $u_m(t) = \partial u(\tilde{c}_t, l_t, \tilde{m}_t)/\partial \tilde{m}_t$, and $f_1(t) = \partial f(\tilde{k}_t, n_t, \tilde{k}_{gt})/\partial \tilde{k}_t$, $f_2(t) = \partial f(\tilde{k}_t, n_t, \tilde{k}_{gt})/\partial n_t$.

- Definition: general equilibrium

  Given $\tilde{k}_0$, and $\{A_t, \tilde{G}_t, \tilde{M}_t, \tau_t, \tilde{T}_t\}_{t=0}^{\infty}$, the optimal sequences $\{\tilde{c}_t, n_t, \tilde{k}_{t+1}, \tilde{m}_{t+1}, \pi_t\}_{t=0}^{\infty}$ satisfy:

  1. The equilibrium prices and quantities solve (10)–(14).
  2. Market clearing (goods market and money market).

I apply the approximation method used by King, Plosser, and Rebelo (1998a). At first, define $\hat{h} = \ln(h_t/h)$ as the percentage of deviation from the steady state value of the variable h, and log-linearize the Euler equations and market clearing conditions around the steady state value. Then, by those linear simultaneous equations, the policy function of $\hat{k}_{t+1}$ and $\hat{m}_{t+1}$ can be solved as:

$$\begin{bmatrix} \hat{k}_{t+1} \\ \hat{m}_{t+1} \end{bmatrix} = \begin{bmatrix} K_{kk} & K_{km} & K_{ke} \\ M_{mk} & M_{mm} & M_{me} \end{bmatrix} \begin{bmatrix} \hat{k}_t \\ \hat{m}_t \\ \hat{e}_t \end{bmatrix}, \tag{17}$$

where $\hat{e}_t = [\hat{A}_t \hat{i}_{gt} \hat{g}_t \hat{\Omega}_t \hat{\tau}_t]'$. $\Omega_t = 1 + \mu_t$, μ_t is the growth rate of nominal money supply.

In addition, it is easy to find the decision rule of $B = [\hat{y}_t \hat{c}_t \hat{i}_t \hat{n}_t \pi_t - \pi]$ from (17)

$$B = \Pi \begin{bmatrix} \hat{k}_t \\ \hat{m}_t \\ \hat{e}_t \end{bmatrix}, \tag{18}$$

where Π is a 5×7 coefficient matrix. Finally, solve for the real wage from taxed marginal labor product,

$$w_t = (1 - \tau_t) A_t f_2(t),$$

for the real interest rate from intertemporal marginal rate of substitution,

$$r_t = \frac{\gamma u_c(t)}{\beta^* E_t u_c(t+1)} - 1,$$

and for the nominal interest rate from Fisher equation,

$$R_t = r_t + \pi_t.$$

Therefore, real wage and real interest rate can also be written as

$$\begin{bmatrix} \hat{w}_t \\ r_t - r \\ R_t - R \end{bmatrix} = \Psi \begin{bmatrix} \hat{k}_t \\ \hat{m}_t \\ \hat{e}_t \end{bmatrix}, \tag{19}$$

where Ψ is a 3×7 coefficient matrix.

3. Empirical analysis

3.1. The data

I use quarterly data from 1959:1 to 2000:4. All the data except tax rate have the same definition described in Stock and Watson (1998).

A measure of the tax rate (τ) is calculated from the BEA national income and product accounts data by following Jones (2001). As pointed out by Jones, the approach adopted here is similar to McGrattan (1994) and McGrattan, Rogerson, and Wright (1997), with the main difference being that they estimate the tax rate as a marginal rate from tax records, rather than as an average rate from the national accounts. All the names, sources and characteritics of data are provided in Table 1.

After collecting the original data, I apply the following data processing procedure:

(1) I convert all the nominal variables to real variables by dividing GDP deflator.
(2) I convert monthly data to quarterly data.
(3) Since this is a representative agent model, I divide all the variable except average wage and average hours worked by civilian noninstitutional population with 16 years old and over.
(4) After taking the natural logarithm of each variable (except nominal interest rate and inflation rate), I use the Hodrick–Prescott (HP) filter to isolate the cyclical components.

Table 1
Description of data

Variable	Description	Sources
Y	Real GDP	BEA: NIPA Table 1–2
I	Real investment	BEA: NIPA Tables 1 and 2
C	Real consumption	BEA: NIPA Table 1–2
POP	Population (16 and over)	Fed in St. Louis: FRED database Data code: CNP16OV
g	Real government spending	BEA: NIPA Table 3-1
I_g	Real government investment	BEA: NIPA Table 3-1
M^s	Money supply (MB)	Fed in St. Louis: FRED database Data code: AMBNS
n	Average weekly hours (total private)	BLS: data code EEU00500005
w	Nominal wage rate (compensation per hour: nonfarm business)	BLS: data code PRS85006103 (1992 = 100)
P	GDP deflator	BEA: NIPA Table 7-1
y/n	Labor productivity	y/n
P_g	Gonvernment expenditure deflator	BEA: NIPA Table 7-1
τ	Tax rate	In Table 1
R	Nominal interest rate (treasury bill rate: 3 months)	Fed in St. Louis: FRED database Data code: TB3MS

3.2. Parameter settings

The parameters in the model include the discount factor (β), depreciation rate (δ), elasticity of real balances in the utility function ($1-\varphi_1$), labor share (α_2), public capital share (α_3), coefficient of risk aversion (σ), and growth rate (γ). Besides, I assume the random processes of exogenous shocks are ARMA(1,0), and the parameters of first order autoregression of technology, government investment, government spending, money supply and tax rate are ρ_A, ρ_{k_g}, ρ_g, ρ_Ω, ρ_τ.

The sources I use for reference to set above parameters include King et al. (1988a) and King and Plosser (1994). The setting of Φ makes the steady state value of n equal to 0.2. ρ_{k_g}, ρ_g, ρ_Ω, ρ_τ are computed by the following regressions (the t-statistic is under the coefficient, and $*$ indicates rejecting the null hypothesis that the coefficient equals zero under 5% significant level. $\sigma_{\varepsilon i}$ is the standard error of the disturbance term for variable i):

$$\ln I_{gt} = \underset{(0.33)}{0.0007} + \underset{(16.39)^*}{0.7297} \ln I_{gt-1}, \quad \sigma_{\varepsilon Ig} = 0.0289$$

$$\ln g_t = \underset{(0.01)}{0.00016} + \underset{(23.18)^*}{0.8480} \ln g_{t-1}, \quad \sigma_{\varepsilon g} = 0.0165$$

$$\Delta \ln M_t^s = \underset{(8.79)^*}{0.0109} + \underset{(3.23)^*}{0.2149} \Delta \ln M_{t-1}^s, \quad \sigma_{\varepsilon M} = 0.0122$$

$$\ln \tau_t = \underset{(0.09)}{0.00003} + \underset{(9.33)^*}{0.5853} \ln \tau_{t-1}, \quad \sigma_{\varepsilon\tau} = 0.0044$$

Here, I set $\sigma = 1.6428$ which comes from Finn, Hoffman, and Schlagenhauf (1990). All the other parameters are summarized in Table 2.

Table 2
Parameters setting

Parameter	Explanation	Value	Sources
β	Discount factor	0.988	King et al. (1988a)
δ	Depreciation rate	0.025	King et al. (1988a)
α_3	Share of government capital	0.040188	Government investment/GDP
α_2	Labor share	0.58	King et al. (1988a)
σ	Coefficient of risk aversion	1.6428	Finn et al. (1990)
$\gamma - 1$	Growth rate	0.004	King et al. (1988a)
ρ_A; $\sigma_{\varepsilon A}$	Coefficient and variance of AR(1) technology shock	0.95; 0.0075	King and Plosser (1994)
Φ	Parameter in utility function	4.5978	Make the steady state value of labor supply equals 0.2
η	Parameter in utility function	1.00	
$1 - \varphi_1$	Elasticity of real balance in the utility function	0.02	Finn et al. (1990)

Table 3
Simulated and US data

$x(t)$	Simulated data			US data 1959:1–2000:4		
	σ_x/σ_y	ρ_{xy}	ρ_x	σ_x/σ_y	ρ_{xy}	ρ_x
GDP (Y)	1.00	1.00	0.89	1.00	1.00	0.86
Consumption (C)	0.83	0.68	0.95	0.81	0.87	0.87
Investment (I)	5.00	0.76	0.75	4.45	0.90	0.79
Hours worked (n)	0.56	0.23	0.93	0.43	0.40	0.20
Productivity (y/n)	1.03	0.83	0.95	0.92	0.90	0.69
Inflation rate (π)	0.48	0.18	0.86	0.18	0.15	0.51
Nominal interest rate (R)	0.48	0.22	0.85	0.77	0.34	0.80
Real balance (m)	0.89	0.59	0.93	1.15	0.46	0.82
Corr(n, (y/n))	$\rho_{n(y/n)} = -0.2716$			$\rho_{n(y/n)} = -0.0218$		

3.3. Results

I report the simulated results in Table 3. There are two questions related to the simulation results: (1) whether this model's simulated data successfully mimics the real economy, and (2) compared with basic RBC model, whether this extended model makes any improvement in explaining the cyclical behaviors. The answer to the former question can evaluate the fit of model, and the latter can let us think about whether it is necessary to extend the basic model. If the model with purely technological shock does better than the extended one, it seems nonsensical to further complicate model. First of all, we inspect the fit of model.

From Table 3, it can be observed that this model can mostly mimic the phenomena of real economy: (1) consumption, hours worked, inflation rate and nominal interest rate are less volatile than output but investment is variable; (2) this model is consistent with the pro-cyclical behaviors of all variables; (3) this model somewhat represents the same high persistence characteristics of the observed cycles; (4) the correlation between hours worked and productivity in this model is quite small. Compared with Christiano and Eichenbaum (1992) or Hansen and Wright (1994),[3] this model has a great improvement over theirs. The reason is quite intuitive: money supply increase in this model will induce anticipated inflation effect, which makes consumption increase. According to the optimal condition of consumption-leisure choice, labor supply curve will shift up, which generates negative relationship between hours and productivity.

Roughly speaking, this model does a reasonably good job of capturing the dynamic interactions of money and real variables. This would make us more confident in the policy analysis if the model fits better.

[3] In Christiano and Eichenbaum (1992), they get $\rho_{n(y/n)} = 0.515$; in Hansen and Wright (1994), they lower the correlation to 0.49.

Table 4
Alternative models

$x(t)$	Basic with government spending			Basic with money			Basic model		
	σ_x/σ_y	ρ_{xy}	ρ_1	σ_x/σ_y	ρ_{xy}	ρ_1	σ_x/σ_y	ρ_{xy}	ρ_1
GDP	1.00	1.00	0.93	1.00	1.00	0.94	1.00	1.00	0.93
Consumption	0.61	0.57	0.95	0.52	0.84	0.99	0.31	0.99	0.95
Investment	3.26	0.91	0.93	2.51	0.95	0.52	2.82	0.99	0.93
Hours worked	0.39	0.69	0.94	0.41	0.52	0.89	0.40	0.99	0.91
Productivity	0.71	0.90	0.94	0.86	0.89	0.62	0.60	0.99	0.94
Corr$(n, (y/n))$	$\rho_{n(y/n)} = 0.6024$			$\rho_{n(y/n)} = 0.1537$			$\rho_{n(y/n)} = 0.9855$		

Next, I reconstruct three new models to answer the second question: Does this extended model perform better than the basic one? One is a basic model with government spending; one is a basic model with money and the other is basic RBC model only. By the same simulation procedure, I put the results in Table 4. It is clear that if we consider government spending, the correlation coefficient of hours worked and productivity $\rho_{n(y/n)}$ has improvement from 0.9855 to 0.6024. This result is not too surprising and it is consistent with Christiano and Eichenbaum (1992), Hansen and Wright (1994), and Braun (1994). Since we have included government spending and taxes in the model, they will affect the labor supply and enlarge the fluctuation of labor market. Furthermore, if we include money only in the model, $\rho_{n(y/n)}$ falls from 0.9855 to 0.1537. This is due to that the labor supply behaviors affected by expected inflation via utility function make the labor market more fluctuating. Finally, when we consider both government spending and money in the model, $\rho_{n(y/n)}$ improves greatly, falling to −0.2716. So far we have seen that introducing money and the government improves the model's explanation of the real economy. This may imply that monetary policy and fiscal policy play important roles in determining the macroeconomic fluctuations.

4. Welfare cost of business cycles and stabilization policy

In this section, I will investigate the welfare cost of different stabilization policies by policy experiments. It may be interesting to think about following questions: (1) how do different stabilization policies work? What are their impacts on the economy in terms of welfare cost? (2) Which policy is superior than any other policy? (3) Is it possible to find out an optimal stabilization policy? In addition, stabilization policy is frequently adopted in practice because policy makers are subject to political pressures. Therefore, it may be important to know the welfare effects of different policies and how they affect the economy.

Before I investigate the stabilization policy, I first discuss how to measure the welfare cost of business cycle.

4.1. Welfare cost estimates

On measuring the welfare cost of business cycles, I compare the expected utility of representative agent in the consumption fluctuating economy with expected utility in the steady state. Specifically, I compute how much consumption in the steady state need to be reduced to make the agent feel indifferent between the steady state and the fluctuating economy. To be more precise, welfare cost (χ) is calculated by making following function hold:

$$E_0\left\{\left[\sum_{t=0}^{100}\beta^{*t}u((1-\chi)\bar{c},\bar{l},\bar{m})\right]-\sum_{t=0}^{100}\beta^{*t}u(c_t,\bar{l},\bar{m})\right\}=0, \tag{20}$$

where $\bar{c}$, $\bar{l}$, and $\bar{m}$ are steady state values.

4.2. Stabilization policy

Consider the following stabilization policies:

$$\ln I_{gt}=\rho_{k_g}\ln I_{gt-1}-\gamma_{k_g}\ln A_{t-1}, \tag{21}$$

$$\ln g_t=\rho_g\ln g_{t-1}-\gamma_g\ln A_{t-1}, \tag{22}$$

$$\ln\tau_t=\rho_\tau\ln\tau_{t-1}+\gamma_\tau\ln A_{t-1}, \tag{23}$$

$$\Delta\ln M_t^s=\rho_\Omega\,\Delta\ln M_{t-1}^s-\gamma_\Omega\ln A_{t-1}, \tag{24}$$

where $\gamma_i, i=k_g, g, \tau, \Omega$ are feedback rule coefficients. The results are depicted in Fig. 1. It is clear that as feedback rule coefficients of tax rate and monetary policy increase, welfare costs decrease monotonically. The feedback coefficient of government investment, however, raise welfare cost. Moreover, it is interesting to notice that there may exist a kind of "Laffer curve" patterns for the feedback coefficient of government consumption. This may imply that we can possibly find an optimal feedback coefficient which minimizes the welfare cost of business cycles when government consumption is chosen as an instrument to stabilize the fluctuations.

In order to compare the three policies which can reduce the welfare cost, I put the welfare cost against the feedback coefficients of government consumption, tax rate and monetary policy in Fig. 2. It may also suggest that monetary policy is a better stabilization policy than other policies. Finally, an interesting topic, tax smoothing hypothesis, can be examined in this model. An argument given by Barro (1979) suggests that, acting as a social planner in a neoclassical competitive economy, the government should choose the smooth taxes when it needs to finance an irregular flow of public expenditures. This is so-called "tax smoothing hypothesis." Simply increasing the variability of tax rate from 0 to 30% ($\sigma_{\varepsilon\tau}$ = 0–30%), I calculate the welfare cost in Table 5. It is clear that the tax smoothing property holds in this model since that more volatile the tax rate, the higher the welfare cost.

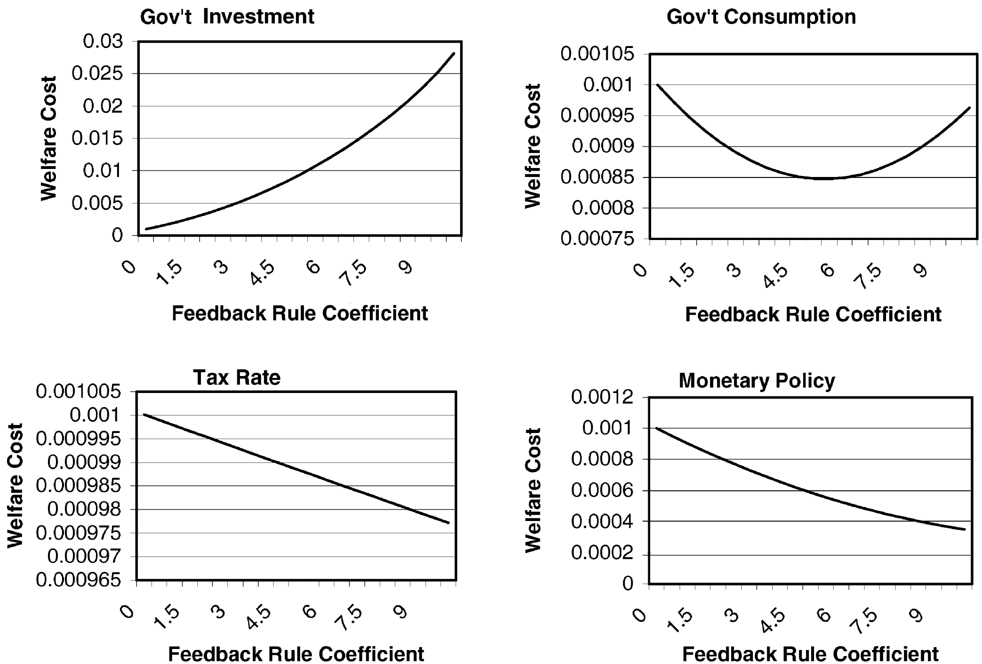

Fig. 1. Feedback rules.

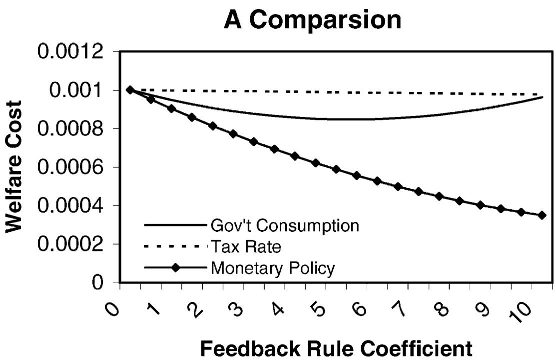

Fig. 2. Different stabilization policies.

Table 5
Welfare cost under different values of $\sigma_{\varepsilon T}$

$\sigma_{\varepsilon T}$ (%)	Standar deviation (%)				
	Output	Consumption	Investment	Labor	Welfare cost (%)
0	2.26	1.90	8.76	1.10	0.1000
5	2.37	1.92	9.27	1.58	0.1041
10	2.66	1.96	10.54	2.50	0.1089
15	3.06	2.01	12.34	3.54	0.1142
20	3.53	2.08	14.47	4.61	0.1198
25	4.06	2.16	16.80	5.70	0.1258
30	4.63	2.25	19.26	6.80	0.1323

5. Conclusion

This paper introduces money and government spending to the basic real business cycle model. The results show that the extended model can mimic post-war US business cycles well and that my model has a lower correlation coefficient of hours worked and productivity than does the RBC model in Christiano and Eichenbaum (1992) or Hansen and Wright (1994). Moreover, my model successfully captures the pro-cyclical behavior of output and other important macroeconomic series. Three alternative models, basic RBC model, basic model with public sector, basic model with money only, are discussed and compared. According to the traditional method comparing model's moments, the extended model shows its ability to fit data better. This may suggest that I have constructed a reasonable good model to explain the dynamic interactions of money and real variables. This success gives the extended model much credence for the measure of welfare cost of business cycles and policy experiments. In addition, from the results of this model, it may be concluded that monetary policy and fiscal policy do indeed play important roles in determining US business cycle fluctuations.

Finally, according to the experiments of different stabilization policies, it can be found that (1) monetary policy induces lower welfare cost and may be a better stabilization policy than other policies, (2) there may exist a kind of "Laffer curve" patterns for the feedback coefficient of government consumption, (3) stable tax rate process induces lower welfare cost than variable tax rate. Tax smoothing property holds in this extended model.

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