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Accounting for monetary and fiscal policy effects in a simple dynamic general equilibrium model

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ABSTRACT

We construct a simple dynamic general equilibrium model to examine several important macroeconomic issues in the study. The active monetary and passive fiscal (AM/PF) policy may induce the raising of both interest rates and inflation rates. We find that there is a positive relationship between shopping time and inflation because higher inflation causes agents to reduce their money holdings so as to take more time for shopping. In addition, shopping time and output move in opposite ways due to the fact that higher shopping time results in lower working hours, so as to decrease production. Finally, this model fails to capture *liquidity effect*, but rather identify *price puzzle* through an expansion of monetary policy shock.

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1. Introduction

In this study we examine the quantitative properties of a government which affect the implementation of economic policies (monetary and fiscal policy) in a business cycle model. Discussions of government policy effects are prevalent in the recent literature. The purpose of this paper is to understand policy effects within a theoretical framework with sticky price and shopping time assumptions. More specifically, we incorporate the shopping time assumption within the basic framework of the so-called real business cycle (RBC) model, and also embed Calvo's (1983) concept of sticky price and monopolistic competition for investigating the macroeconomic policy effects.[1] In the dynamic general equilibrium model, firms can choose prices under the assumption of monopolistic competition. Based on the assumption of Calvo (1983), we assume that each firm has a constant probability of adjusting its price in each period.

In order to obtain a more generalized analysis, we cannot neglect the effect of shopping time within the dynamic framework. U.S. empirical data shows that the average time spent on shopping was about 46.2 minutes a day (Bureau of Labor Statistics (BLS) of the United States, 2008).[2] We set out a theoretical model and use it to analyze the effects of both types of policies: monetary policy and fiscal policy.[3] In order to capture low interest rate

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environments for most developed economies since 2008, monetary policy in this model focuses only on the supply shocks resulting from the quantity of money instead of from the Federal Funds rate. Policy-makers may also levy non-distortionary lump-sum taxes for financing government debt (see also, Chung, Davig, and Leeper 2007).

A feature of conventional neoclassical growth modes is based on the assumption that agents can increase utility either by making consumption or by taking leisure. In contrast with the neoclassical growth models, Sidrauski (1967) assumes that agents may also yield utility from money holding, so agents can hold money for its rising utility, commonly known as the money-in-the-utility (MIU) function. Furthermore, Croushore (1993) argues that the shopping time assumption is equivalent to the MIU model. In other words, the shopping time model is usually used to serve as a prologue to the MIU framework for the effects that money yields in terms of direct utility. Such an approach is common in recent literature with regard to shopping time (see, for example, Gavin, Kydland, and Pakko, 2007). This further strengthens our motive to incorporate shopping time into our model. According to Croushore (1993), we adopt shopping time to switch the consumer's utility function to the MIU function. In general, shopping time is affected by an agent's consumption and real money holdings. Intuitively, monetary policy shocks may affect shopping time through the agents' money holding behavior and thereby change the their allocation of time endowment, such that labor hours and leisure changes as well (see also Gavin, Keen, and Kydland, 2015). Moreover, fiscal policy also affects shopping time due to higher lump-sum taxes, which result in lower consumption and lower real money holdings, changing the value of shopping time. In other words, the allocation of agents' time endowment changes due to monetary or fiscal policy shocks. Accordingly, the key variables of macroeconomy are related to shopping time, so we apply a shopping time model to complete the analyses in the study.

Shopping time often plays a non-trivial role in the monetary economics literature. In the pioneering work of Saving (1971) it is assumed that barter transactions take time, and time is both limited and valuable for consumers. The value of the transaction (or shopping) time depends on how many goods are traded. Goodfriend and McCallum (1987), for example, point out that shopping time depends positively on consumption and negatively on real money holdings. Theoretically, shopping time is related to inflation. Higher inflation will cause agents to reduce real money holdings, so agents require more time for shopping. There is therefore a positive relationship between inflation and shopping time (see Gavin et al., 2007). An interesting corollary of shopping time is internet purchasing behavior. Internet purchasing reduces shopping time and demand for money but it also requires the greater use of credit cards (see, for instance, Wickens, 2008).[4]

In order to realize the whole picture of the economy, we employ a simple general equilibrium model to capture economic policies' effects. In the dynamic general equilibrium model, the results of this work fail to capture *liquidity effect*, but rather identify *price puzzle* resulting from an expansion of monetary policy shock.[5] An expansionary monetary policy generates higher nominal interest rates because of higher expected inflation. In other words, the positive relationship between money supply and nominal interest rate implies that this model fails to capture liquidity effect. The price puzzle we find in this study is due to the homogeneity of direction between inflation rate and nominal interest rate. Chen (2008) constructs a flexible-price monetary model to discuss liquidity effect by reference to the shopping time factor. However, in this study, the monetary growth rule fails to capture liquidity effect. Our finding is consistent with the deduction of Chen (2008).

Liquidity effect is an essential issue that is extensively discussed by macroeconomic economists. In a recently study, Christiano and Eichenbaum (1995) construct a flexible-price model to explore liquidity effect, and find decreases in nominal interest rate, accompanied by increases in employment, output and real wages in response to positive money supply shock because of cheaper money. In addition, several empirical studies evidence the existence of price puzzle in many countries, prompting many economists to explain why the phenomenon exists. Balke and Emery (1994) explore one possible explanation of price puzzle; namely, that the central bank increases the nominal interest rate in response to higher future inflation. In particular, Chung et al. (2007) and Davig and Leeper (2011) construct a regime-switching model to examine policy interactions. In their study, policies fall into two categories: active policy and passive policy. Within each of these categories are two regimes: active monetary and passive fiscal policy (AM/PF) and passive monetary and active fiscal policy (PM/AF) (see also, Davig and Leeper, 2011). The price puzzle is generated due to households' belief that there is a chance policy will shift from AM/PF to PM/AF.

In what follows, Section 2 describes the specifications of the basic model. The computational results and policy effects are set out in Section 3. Finally, Section 4 contains the concluding remarks.

2. The model

This section incorporates both monopolistic competition and sticky price assumptions (see also Calvo, 1983; Chen and Chang, 2015). In the dynamic model, there are many identical agents with infinite life spans. These agents make money by supplying labor and capital. Agents are required to make choices between consumption and real money holding in order to maximize utility. Labor and capital are employed by firms for the purpose of maximizing firm profits. In this monopolistic competition market, firms can control pricing for products. We assume staggered price following the Calvo-type price setting model: each firm has a constant probability of adjusting its price during each period.

2.1. The households

The representative household utility form is determined according to (see Chang, Chang, and Shieh, 2014; Chen and Chang, 2015):

$$u(c_t, l_t) = \frac{\left(c_t^{\chi} l_t^{1-\chi}\right)^{1-\eta}}{1-\eta}, \tag{1}$$

with $0 < \chi < 1$, $\eta > 0$, but $\eta \neq 1$. c_t is consumption per capita at time t, l_t is the fraction of time to take leisure, and χ is the power of consumption. The budget constraint of the representative household is:

$$c_t + k_t + m_t + b_t \leq \\ w_t n_t + r_t k_{t-1} + \Pi_t + (1-\delta)k_{t-1} - \tau_t + \frac{1+i_{t-1}}{1+\pi_t} b_{t-1} + \frac{1}{1+\pi_t} m_{t-1}, \tag{2}$$

where k_t is the stock of capital, b_t indicates bond holding, Π_t means firm's profit, δ is the rate of depreciation of capital, i_t denotes nominal interest rate, and π_t represents the inflation rate (see also, Davig and Foerster, 2015).

Here the assumption of x_t denotes the investment per capita at period t, and the aggregate resource constraint of the economy is expressed in per capita terms as:

$$k_t = (1-\delta)k_{t-1} + x_t.$$

The representative agent has one unit of time. We assume a household spends time to go shopping for consumption goods. Under this assumption, one unit of time can be divided into three parts: labor time, leisure time and shopping time, so the time constraint (normalized to 1) is:

$$1 = n_t + l_t + s_t,$$

where s_t denotes the shopping time, and n_t is the fraction of time spent on employment. We incorporate the shopping time model that was structured by Gavin et al. (2007) and Gavin et al. (2015), in which the shopping time is a function of consumption and real money balance, and s_t can be expressed as:

$$s_t = S(c_t, m_t) = \epsilon \left(\frac{c_t}{m_t} \right)^{\varsigma}, \tag{3}$$

with $S, S_c, S_{cc}, S_{mm} \geq 0, S_m, S_{cm} \leq 0$, and $\epsilon, \varsigma > 0$. Similar to the timing of cash-in-advance model, s_t depends on pre-transfer money, a specific timing assumption. Figure 1 shows the changes of shopping time in relation to both consumption and real money holdings. More consumption implies agents spend more time on shopping. On the other hand, the greater the amount of money which agents hold for transactions, the greater their savings in terms of time that agents spend on shopping. Furthermore, Gavin et al. (2015) show the positive relationship between inflation and shopping time. They argue that an increase in inflation induces agents to economize on real money holdings, leading to higher shopping time. The model also predicts a negative relationship between output and shopping time, because higher shopping time results in lower production.

2.2. *The firms*

The final goods are given as:

$$y_t = \left[\int_0^1 y_{i,t}^{\frac{\zeta-1}{\zeta}} di \right]^{\frac{\zeta}{\zeta-1}},$$

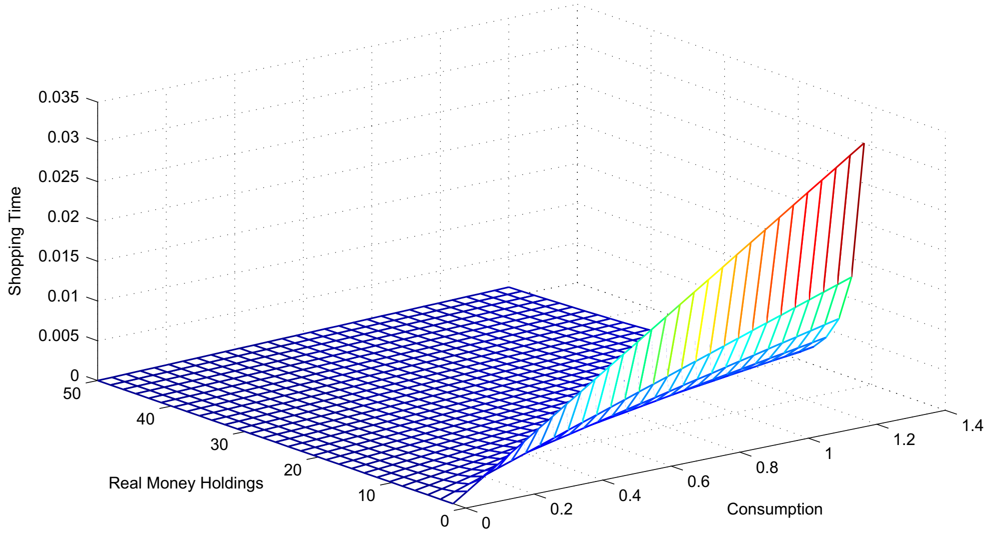

Figure 1. Relationship between shopping time, consumption and real money holdings. Source: Authors.

where $\zeta > 1$ is the elasticity of substitution among the intermediate goods $y_{i,t}$. Now we let $p_{i,t}$ denote the price of intermediate good i, so we can get the demand for intermediate goods:

$$y_{i,t} = \left[\frac{p_{i,t}}{p_t}\right]^{-\zeta} y_t,$$

where $p_t = \left[\int_0^1 p_{i,t}^{1-\zeta}\, di\right]^{\frac{1}{1-\zeta}}$.

Here we set the production function as a Cobb-Douglas form. The firms hire capital and labor to produce intermediate goods. To fit with the conventional real business cycle model, there is a stochastic disturbance to total factor productivity (TFP). So, the production function for intermediate good i is given by:

$$y_{i,t} = e^{z_t} k_{i,t-1}^{\alpha} n_{i,t}^{1-\alpha},$$

$0 < \alpha < 1$ and,

$$z_t = \rho_z z_{t-1} + e_t.$$

Now we follow Calvo (1983) and Wang and Wen (2006), allowing for sticky price. Calvo assumes that each firm has a constant probability $1-\omega$ of adjusting its price in each period. In other words, the lower the value of ω, the more flexible the price. The price when firms do not adjust their product price follows the last period's price level, p_{t-1} (see also, Davig and Leeper, 2011). Once the firm can adjust its price, it will choose the optimal price, p_t^*.

Then, the intertemporal profit maximization problem is:

$$E_t \sum_{s=0}^{\infty} (\beta\omega)^s \Delta_{t,t+s} \left[\frac{p_t^*}{p_{t+s}} - \Upsilon_{t+s} \right] \left[\frac{p_t^*}{p_{t+s}} \right]^{-\zeta} y_{t+s},$$

where $\Delta_{t,t+s} = [c_t/c_{t+s}]$ and $\Upsilon_t = \frac{1}{e^{z_t}} \left(\frac{r_t}{\alpha}\right)^{\alpha} \left(\frac{w_t}{1-\alpha}\right)^{1-\alpha}$. Υ is the real marginal cost, which is also the Lagrange multiplier. So, the first order condition for the optimal price p_t^* can be rewritten as:

$$p_t^* = \frac{\zeta \sum_{s=0}^{\infty} (\beta\omega)^s E_t \Delta_{t+s} p_{t+S}^{\zeta} y_{t+s} \Upsilon_{t+s}}{(\zeta - 1) \sum_{s=0}^{\infty} (\beta\omega)^s E_t \Delta_{t+s} p_{t+S}^{\zeta-1} y_{t+s}}, \tag{4}$$

and the final goods price index is:

$$p_t = [\omega p_{t-1}^{1-\zeta} + (1-\omega) p_t^{*1-\zeta}]^{1/(1-\zeta)}. \tag{5}$$

2.3. *The policy rules*

In our model the government has two ways of intervening in the economy: fiscal policy and monetary policy. Following Walsh (2010), our monetary policy follows the rule:

$$m_t = \left(\frac{1+\theta_t}{1+\pi_t^{\iota}} \right) m_{t-1} - b_t, \tag{6}$$

where θ_t is the growth rate of money (see Chen and Chang, 2015). We define $u_t = \theta_t - \bar{\theta}$ as the deviation of monetary growth:

$$u_t = \varrho u_{t-1} + \phi z_{t-1} + \varphi_t,$$

where φ_t is an uncorrelated mean zero innovation as:

$$\varphi_t = \rho_m \varphi_{t-1} + \varepsilon_t.$$

The monetary rule implies the major policy instrument of the central bank is the quantity of money, rather than the nominal interest rate. Rather than interest rule, the money growth rule is used to observe the possible liquidity effect and price puzzle.

The fiscal policy rule, following Bohn (1998), Chung et al. (2007) and Shiamptanis (2015), is specified as:

$$\tau_t = \gamma_0 + \gamma_1 b_{t-1} + \psi_t,$$
$$\psi_t = \rho\, \psi_{t-1} + \mu_t,$$

where τ_t is lump-sum taxes, ψ_t is disturbance in taxes, and μ_t is an uncorrelated mean zero innovation (see, Danciulsecu, 2014). The coefficient of the government debt γ_1 is positive. The fiscal rule implies lump-sum taxes are imposed in response to the government debt rather than total government liabilities (i.e., the sum of debt and money supply).[6] This equation implies τ_t can be affected by the open-market operation. The government budget constraint is expressed as:

$$b_t + m_t + \tau_t = g_t + \frac{1+i_{t-1}}{1+\pi_t} b_{t-1} + \frac{1}{1+\pi_t} m_{t-1},$$

where g_t denotes government expenditures.

2.4. The first order conditions

Now we can construct the value function, defined as the maximum present value of utility which agents can achieve. The value function is obtained:

$$V(a_t, k_{t-1}) = \max\{u(c_t, l_t) + \beta E_t V(a_{t+1}, k_t)\}, \tag{7}$$

subject to:

$$w_t n_t + r_t k_{t-1} + \Pi_t + (1-\delta)k_{t-1} + a_t \geq c_t + k_t + b_t + m_t, \tag{8}$$

$$a_{t+1} = \frac{1+i_t}{1+\pi_{t+1}} b_t + \frac{1}{1+\pi_{t+1}} m_t - \tau_{t+1}. \tag{9}$$

The first order conditions with respect to c_t, b_t, m_t, and n_t are:

$$u_c(c_t, l_t) - \beta E_t V_k(a_{t+1}, k_t) = 0, \tag{10}$$

$$\beta E_t\left(\frac{1+i_t}{1+\pi_{t+1}}\right) V_a(a_{t+1}, k_t) - \beta E_t V_k(a_{t+1}, k_t) = 0, \tag{11}$$

$$u_m(c_t, l_t) + \beta E_t\left[\frac{V_a(a_{t+1}, k_t)}{1+\pi_{t+1}}\right] - \beta E_t V_k(a_{t+1}, k_t) = 0, \tag{12}$$

$$-u_l(c_t, l_t) + \beta E_t V_k(a_{t+1}, k_t) w_t = 0. \tag{13}$$

Through mathematical calculations, we can get the following equations:

$$u_c(c_t, l_t) = u_m(c_t, l_t) + \beta E_t\left[\frac{u_c(c_{t+1}, l_{t+1})}{1+\pi_{t+1}}\right], \tag{14}$$

$$u_l(c_t, l_t) = u_c(c_t, l_t) f_n(k_{t-1}, n_t, z_t), \tag{15}$$

$$u_c(c_t, l_t) = \beta E_t R_t u_c(c_{t+1}, l_{t+1}), \tag{16}$$

where,

$$R_t = 1 - \delta + f_k(k_t, n_{t+1}, z_{t+1}).$$

According to the above equations, (12)–(14) can be expressed as explicit functions as follows:

$$\frac{u_m}{u_c} = \frac{(1-\chi)c_t^{\chi} l_t^{-\chi} \frac{s_t}{m_t}}{\chi c_t^{\chi-1} l_t^{1-\chi} - (1-\chi)c_t^{\chi} l_t^{-\chi} \frac{\epsilon}{m_t}} = \frac{i_t}{1+i_t}, \tag{17}$$

$$\frac{u_l}{u_c} = \frac{(1-\chi)c_t^{\chi} l_t^{-\chi}}{\chi c_t^{\chi-1} l_t^{1-\chi} - (1-\chi)c_t^{\chi} l_t^{-\chi}\frac{\epsilon}{m_t}} = (1-\alpha)\frac{y_t}{n_t}, \tag{18}$$

$$\begin{aligned} &(c_t^{\chi} l_t^{1-\chi})^{-\eta}[\chi(\frac{c_t}{l_t})^{\chi-1} - (1-\chi)(\frac{c_t}{l_t})^{\chi}\frac{\epsilon}{m_t}] \\ &= \beta R_t E_t(c_{t+1}^{\chi} l_{t+1}^{1-\chi})^{-\eta}\left[\chi\left(\frac{c_{t+1}}{l_{t+1}}\right)^{\chi-1} - (1-\chi)\left(\frac{c_{t+1}}{l_{t+1}}\right)^{\chi}\frac{\epsilon}{m_{t+1}}\right], \end{aligned} \tag{19}$$

$$R_t = \alpha\frac{E_t y_{t+1}}{k_t} + 1 - \delta. \tag{20}$$

2.5. The steady-states

By (17), $\bar{R} = \beta^{-1}$, so (18) can be rewritten as (see also Chang et al., 2014):

$$\frac{\bar{y}}{\bar{k}} = \frac{1}{\alpha}\left(\frac{1}{\beta} - 1 + \delta\right).$$

From the production function, we get the steady-state labor-capital ratio as:

$$\frac{\bar{n}}{\bar{k}} = \left(\frac{\bar{y}}{\bar{k}}\right)^{\frac{1}{1-\alpha}} = \left[\frac{1}{\alpha}(\frac{1}{\beta} - 1 + \delta)\right]^{\frac{1}{1-\alpha}}.$$

From the aggregate resource constraint, we know:

$$\frac{\bar{c}}{\bar{k}} = \left(\frac{\bar{y}}{\bar{k}}\right) - \delta = \frac{1}{\alpha}\left(\frac{1-\beta}{\beta}\right) + \left(\frac{1-\alpha}{\alpha}\right)\delta.$$

Since $(1+\bar{i}) = \bar{R}(1+\bar{\pi})$, and assume $1+\bar{\pi} = \Theta$, we get:

$$\frac{\bar{i}}{1+\bar{i}} = \frac{\Theta - \beta}{\Theta}.$$

Now we can get the equation for $\bar{c}$:

$$\bar{c} = \left(\frac{\bar{c}}{\bar{k}}\right)\left(\frac{\bar{k}}{\bar{n}}\right)\bar{n},$$

and the time constraint is:

$$1 = \bar{n} + \bar{l} + \bar{s}.$$

So, (15) can be rewritten as:

$$\frac{(1-\chi)(\frac{\bar{c}}{\bar{l}})^{\chi}\frac{\bar{s}}{\bar{m}}}{\chi(\frac{\bar{c}}{\bar{l}})^{\chi-1} - (1-\chi)\left(\frac{\bar{c}}{\bar{l}}\right)^{\chi}\frac{\bar{s}}{\bar{c}}} = \frac{\bar{i}}{1+\bar{i}}. \tag{21}$$

Using (19) we can obtain $\bar{m}$, and the steady-state value of shopping time can be obtained from the U.S. empirical data, thus we get the parameter value of the coefficient of shopping time, ϵ.

2.6. The linear approximations

For solving the dynamic system around the steady-state, we use the first-order Taylor expansion for linear approximations (see Chang et al., 2014). Percentage deviations of variables, for instance, q will be denoted by $\hat{q}$, where $\hat{q}_t = (q_t - \bar{q})/\bar{q}$. The real money balances can be approximated as:

$$\hat{m}_t = \hat{m}_{t-1} - \iota\hat{\pi}_t + \frac{\bar{b}}{\bar{m}}\hat{b}_t + u_t.$$

The resource constraint can be obtained as:

$$\hat{k}_t = (1-\delta)\hat{k}_{t-1} + \frac{\bar{y}}{\bar{k}}\hat{y}_t - \frac{\bar{c}}{\bar{k}}\hat{c}_t - \frac{\bar{g}}{\bar{k}}\hat{g}_t.$$

To linearize around the steady-state, the production function can be written as:

$$\hat{y}_t = \alpha\hat{k}_{t-1} + (1-\alpha)\hat{n}_t + z_t.$$

To simplify the analyses, we need to introduce a new variable λ_t.[7] λ_t equals to the marginal utility of consumption. So, we can obtain the approximation of λ_t:

$$\hat{\lambda}_t = \frac{A}{D}\hat{c}_t + \frac{B}{D}\hat{l}_t + \frac{C}{D}\hat{m}_t,$$

where $A = \left[(-\eta)\chi^2\left(\frac{\bar{c}}{\bar{l}}\right)^{\chi-1} + \chi(\chi-1)(\frac{\bar{c}}{\bar{l}})^{\chi-1}\right] - [(-\eta)\chi(1-\chi)$ $\left(\frac{\bar{c}}{\bar{l}}\right)^{\chi}\left(\frac{\epsilon}{\bar{m}}\right) + \chi(1-\chi)\left(\frac{\bar{c}}{\bar{l}}\right)^{\chi}\left(\frac{\epsilon}{\bar{m}}\right)\Big]$, $B = [(-\eta)\chi(1-\chi)(\frac{\bar{c}}{\bar{l}})^{\chi-1} + \chi(1-\chi)(\frac{\bar{c}}{\bar{l}})^{\chi-1}] - [(-\eta)(1-\chi)^2(\frac{\bar{c}}{\bar{l}})^{\chi}(\frac{\epsilon}{\bar{m}}) - \chi(1-\chi)(\frac{\bar{c}}{\bar{l}})^{\chi}(\frac{\epsilon}{\bar{m}})]$, $C = (1-\chi)(\frac{\bar{c}}{\bar{l}})^{\chi}(\frac{\epsilon}{\bar{m}})$, and $D = [\chi(\frac{\bar{c}}{\bar{l}})^{\chi-1} - (1-\chi)(\frac{\bar{c}}{\bar{l}})^{\chi}\frac{\epsilon}{\bar{m}}]$. Then equation (16) can be approximated as:

$$\hat{l}_t = -\frac{1}{\chi}\hat{y}_t + \frac{1}{\chi}\hat{n}_t - \frac{1}{\chi}\hat{\lambda}_t + \hat{c}_t.$$

By equations (3) and (4), the log-linearized optimal price and the price index are:

$$\hat{p}_t = (1-\omega)\hat{p}_t^* + \omega\hat{p}_{t-1},$$

where $\hat{p}_t^* = (1-\beta\omega)\sum_{s=0}^{\infty}(\beta\omega)^s E_t(\hat{\Upsilon}_{t+s} + \hat{p}_{t+s})$. Taken together, these equations imply the Phillips curve can be written as:

$$\hat{\pi}_t = \beta E_t\hat{\pi}_{t+1} + \frac{(1-\omega)(1-\omega\beta)}{\omega}\hat{\Upsilon}_t.$$

Equation (18) can be rewritten as:

$$\hat{r}_{\mathrm{t}} = \alpha(\frac{\bar{y}}{\bar{k}})(E_{\mathrm{t}}\hat{y}_{\mathrm{t}+1} - \hat{k}_{\mathrm{t}}).$$

The Fisher equation can also be approximated as:

$$E_{\mathrm{t}}\hat{\pi}_{\mathrm{t}+1} = \hat{i}_{\mathrm{t}} - \hat{r}_{\mathrm{t}}.$$

And the Euler condition is obtained:

$$E_{\mathrm{t}}\hat{\lambda}_{\mathrm{t}+1} = \hat{\lambda}_{\mathrm{t}} - \hat{r}_{\mathrm{t}}.$$

3. Computational results

Benchmark Specifications. In order to solve the theoretical model, we must set the parameter values. To begin with, we assume that all shocks (technology, monetary policy and fiscal policy) in the model are independent. We set δ as 0.019 following the setup of Cooley and Hansen (1995). Further, the annual growth rate of money is 5%, which implies $\Theta = 1.0125$. For the elasticity of consumption in utility, the value of χ is set as 0.65. For the coefficient of fiscal policy we follow Chung et al. (2007), so γ_1 is 0.275 in the AM/PF regime.[8] This implies the fiscal policy is restricted by the debts of the government. Following Ellison and Scott (2000), we set ω as 0.5, and in this setting, half of all firms do not change the price of their products in period t. Furthermore, we let the power of shopping time, ς be 1. The shopping time coefficient is set in terms of the BLS. BLS data show the average time people spent on shopping was 3.2% per day (in 2008). Table 1 summarizes all of the benchmark parameter choices. In general, our benchmark parameters are based on the U.S. data and RBC literature.

For solving the dynamic general equilibrium model, we use the method introduced by Uhlig (1999) to solve nonlinear dynamic stochastic models easily. Table 2 presents the U.S.

Table 1. Parameters for the benchmark case.

Symbol	Value	Description
α	0.36	Capital share
χ	0.65	Elasticity of consumption in utility
δ	0.019	Depreciation rate for capital
β	0.989	Discount factor
γ_1	0.275	Reaction to bond of fiscal authority
ι	1	Reaction to inflation of monetary authority
η	2	Relative risk aversion
ω	0.5	Ratio of firms do not change their price
ρ_z	0.95	Persistence in the technology shock
ρ_m	0.9	Persistence in the monetary policy shock
ρ_ψ	0.95	Persistence in the fiscal policy shock
σ_z	0.7	Volatility of the technology shock
σ_m	0.95	Volatility of the monetary policy shock
σ_ψ	0.9	Volatility of the fiscal policy shock
ς	1	Power of shopping time
ϵ	0.05	Shopping time parameter

Source: Authors.

Table 2. Empirical U.S. data statistics and benchmark specifications.

	Empirical U.S. Data (1990Q1-2009Q4)			Benchmark Case		
	σ_j	σ_j/σ_y	$corr(j, y)$	σ_j	σ_j/σ_y	$corr(j, y)$
y	1.12	1.00	1.00	1.23	1.00	1.00
c	0.96	0.86	0.97	0.30	0.24	0.95
n	0.34	0.31	0.59	0.53	0.43	0.94
x	5.94	5.29	0.94	8.47	6.89	1.00
i	0.63	0.56	0.44	0.46	0.38	0.37
π	0.73	0.60	0.04	0.57	0.47	0.41
s	–	–	–	0.26	0.21	−0.12

Notes: This table represents the computational results based on our parameters for the benchmark case (see Table 1). These statistics have been filtered using the method of Hodrick–Prescott (1980). The empirical U.S. data is obtained from the Federal Reserve Bank of St. Louis. For the technology shock, $\rho_z = 0.95$ and $\sigma_z = 0.7$; for the monetary policy shock, $\rho_m = 0.95$ and $\sigma_m = 0.9$; for the fiscal policy shock, $\rho\ = 0.95$ and $\sigma\ = 0.9$.
Source: Authors.

data and the computational results of this model. The empirical U.S. data are obtained from the Federal Reserve Bank of St. Louis. Table 2 reports standard deviations, standard deviations relative to output, and correlations with output for major macroeconomic variables in this model. The left panel shows the U.S. data (1990Q1-2009Q4), and the right panel reports our benchmark case. Generally speaking, in Table 2, the computational results of the economy fit well with the U.S. data. We successfully capture the volatility of output. Most of the volatilities of other variables are also similar to the empirical data. Unfortunately, the model cannot predict the volatility of consumption well. It also does a poor job in the predicting the correlations between output and inflation. The cyclical behavior of most other key factors is also captured. For example, from Table 2, we can categorize output, consumption, labor hours, investment, nominal interest rate and inflation as procyclical variables. We also conclude there is a negative relationship between shopping time and output, as mentioned in Section 2, from our benchmark case. That is to say, shopping time is a countercyclical variable in our benchmark case.

The dynamic paths which technology, monetary policy, and fiscal policy shocks take toward macro variables are reported in Figures 2–4. In Figure 2, a positive technology shock means the technological progress of production in an economy. Other things being equal, with technological progress, the same factor inputs will produce more output, or lower factor inputs will result in the same level of production. Capital stock increases follow rising investment in the wake of technological progress. Capital stock accumulates smoothly, and goes back to a steady-state slowly. The peak effect of capital accumulation is an increase of approximately 80% after about 10 quarters. Labor supply increases at a rate of about one-half that of capital stock, and then decreases sharply, after 3 quarters it falls below steady-state value then slowly converges on 0. Finally, output and consumption will increase and then shopping time goes upward. Similar to the conventional RBC results, investment and output are more volatile than consumption.

Figure 3 describes the dynamic process following an expansionary monetary policy. Agents reduce the amount of their real money holdings because they worry about the cost of inflation. Decreasing labor hours follow in the wake of increased shopping time, since there are lesser amounts of money holdings available for the transaction motive. Thus, output level moves downward, and at the same time, inflation moves upward. The nominal interest rate increases because of higher expected inflation. The liquidity effect

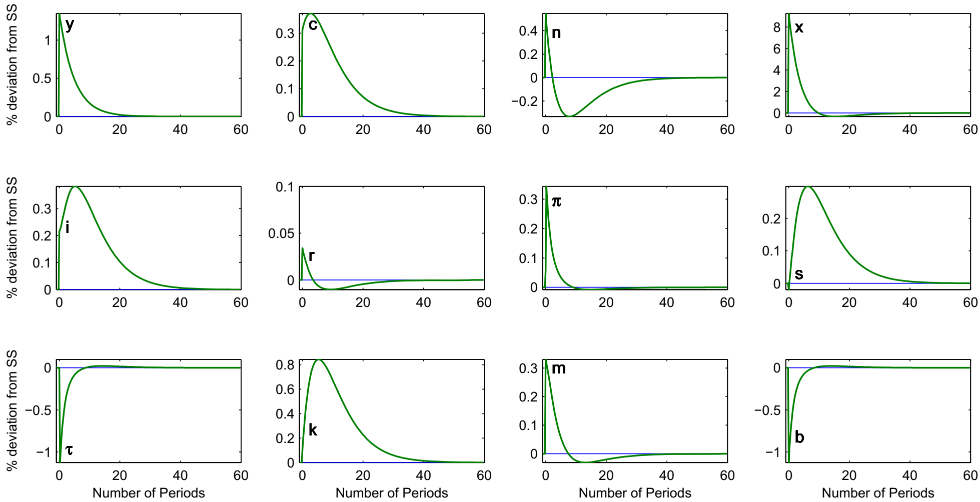

Figure 2. Impulse-responses to a positive technology shock (technology progress). Source: Authors.

is not captured in this model. The computational results are similar to Chen (2008), supporting the idea that models with money growth rules fail to capture liquidity effect. In the general equilibrium model, the main result shows that an expansionary monetary policy generates higher nominal interest rates because of higher expected inflation. In other words, the positive relationship between money supply and nominal interest rate implies that there is no liquidity effect. The price puzzle is due to the positive relationship between inflation and nominal interest rate. Of interest, inflation and shopping time moving in the same direction supports the conclusion of Gavin et al. (2015). Gavin, Kydland and Pakko find that an increase in inflation induces agents to economize on real money holdings, leading to an increase in shopping time. Finally, the dynamic path of positive fiscal shock, which increases growth of lump-sum taxes, on macro variables are reported in Figure 4. The increasing of non-distortionary tax leads to the lowering of households' real money holdings, and therefore consumption. This raises shopping times due to decreases in real money holdings, so labor hours and output decrease in response to the positive fiscal shock (increasing tax).

Obviously, the responses of technology shock on variables are more persistent and volatile than those resulting from monetary policy and fiscal policy shocks. This implies that technology shock might be the most important source of economic fluctuations (see Plosser, 1989). It's well known that most economic booms/recessions are seen as resulting from positive/negative technology shocks, in the conventional RBC school. Our computational results also support the classical theories on fiscal policy shock. The classical economists do not expect the lump-sum changes in tax-generating to have major effects on the macroeconomy, because agents are forward-looking. In the model, the effect of fiscal policy shock on variables is less persistent and less volatile than those effects caused by other shocks. Furthermore, there is the trade-off between shopping time and labor hours. The marginal propensity to consume is between 0 to 1, and the average propensity to consume decreases following a rise in income. In our results, the higher income results from more labor hour input, implying more consumption and more real money holdings.

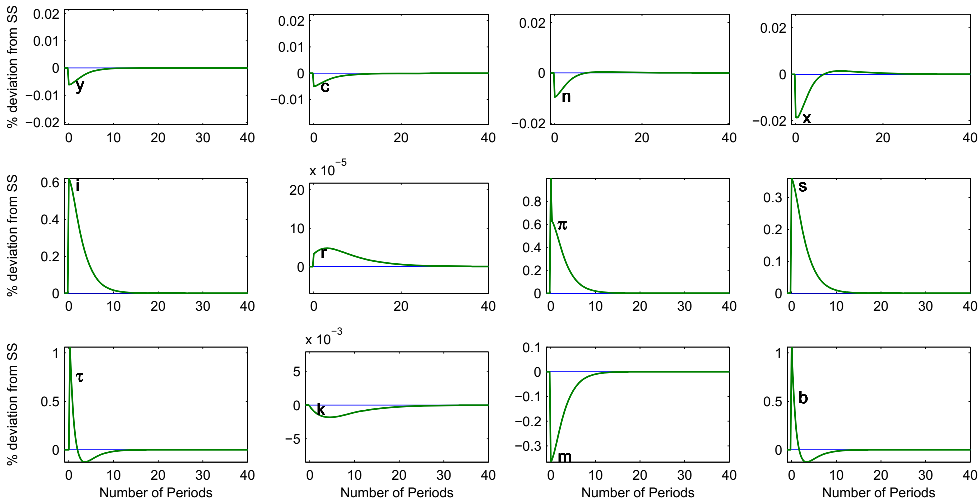

Figure 3. Impulse-responses to a positive monetary policy shock (increasing money supply). Source: Authors.

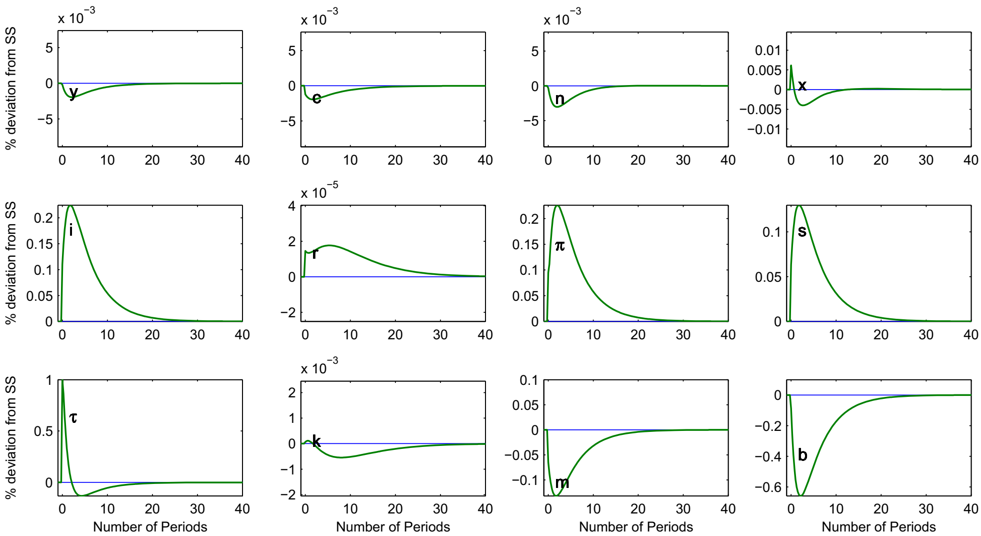

Figure 4. Impulse-responses to a positive fiscal policy shock (increasing tax). Source: Authors.

Thus, shopping time will decrease following more labor hours because of a lower average propensity to consume.

Sensitivity Analyses. The computational results of sensitivity analyses are reported in Table 3. PM denotes that the monetary authority ignores inflation when it decides to implement an expansionary monetary policy. AF means the fiscal authority implements fiscal policy (levying a lump-sum tax) consistently, and fiscal policy does not depend on the government debt. Under AM, shopping time is less positively related to production. By contrast, shopping time is strongly positively related to production under PM. Furthermore, price puzzle becomes more serious under PM. If a monetary authority implements PM, i.e. ignores inflation, the monetary expansion generates more volatile inflation and

Table 3. Sensitivity analyses of alternative policy regimes.

	PM/AF			AM/AF			PM/PF		
	σ_j	σ_j/σ_y	$corr(j,y)$	σ_j	σ_j/σ_y	$corr(j,y)$	σ_j	σ_j/σ_y	$corr(j,y)$
y	1.23	1.00	1.00	1.23	1.00	1.00	1.23	1.00	1.00
c	0.29	0.24	0.95	0.29	0.24	0.95	0.29	0.23	0.95
n	0.53	0.43	0.94	0.53	0.43	0.94	0.53	0.43	0.94
x	8.49	6.92	1.00	8.49	6.90	1.00	8.50	6.93	1.00
i	1.43	1.16	0.60	0.53	0.43	0.46	1.92	1.57	0.46
π	409.20	333.47	0.04	0.61	0.50	0.41	409.37	333.42	0.05
s	0.77	0.62	0.48	0.30	0.24	0.03	1.07	0.87	0.36

Notes: The table shows each variable's standard deviation, all standard deviations relative to standard deviation of y and correlation to y under alternative policy regimes. AM denotes active monetary policy; PM is passive monetary policy; AF active fiscal policy; PF passive fiscal policy.
Source: Authors.

Table 4. Sensitivity analyses of power of shopping time.

	$\varsigma = 0.25$			$\varsigma = 0.5$			$\varsigma = 2$			$\varsigma = 4$		
	σ_j	σ_j/σ_y	$corr(j,y)$	σ_j	σ_j/σ_y	$corr(j,y)$	σ_j	σ_j/σ_y	$corr(j,y)$	σ_j	σ_j/σ_y	$corr(j,y)$
y	1.23	1.00	1.00	1.23	1.00	1.00	1.23	1.00	1.00	1.24	1.00	1.00
c	0.30	0.24	0.96	0.30	0.24	0.95	0.29	0.24	0.95	0.29	0.23	0.95
n	0.52	0.42	0.94	0.53	0.43	0.94	0.54	0.44	0.94	0.55	0.44	0.95
x	8.42	6.85	1.00	8.44	6.86	1.00	8.50	6.91	1.00	8.61	6.94	1.00
i	0.36	0.29	0.40	0.40	0.33	0.38	0.54	0.44	0.35	0.58	0.47	0.33
π	0.51	0.41	0.43	0.53	0.43	0.42	0.63	0.51	0.39	0.66	0.53	0.38
s	0.11	0.09	−0.03	0.19	0.15	−0.05	0.26	0.21	−0.37	0.24	0.19	−0.81

Notes: The table shows each variable's standard deviation, all standard deviations relative to standard deviation of y and correlation to y under different ς. $\epsilon = 0.036$ when $\varsigma = 0.25$; $\epsilon = 0.04$ when $\varsigma = 0.5$; $\epsilon = 0.08$ when $\varsigma = 2$; $\epsilon = 0.17$ when $\varsigma = 4$.
Source: Authors.

nominal interest rates than these under AM. The policy regimes in the model can not be changed endogenously, so some computational results are drastic.

The sensitivity analyses of the power of shopping time are reported in Table 4. Based on the steady-state of shopping time obtained from BLS, the value of ϵ should be adjusted in accordance with power of shopping time. The higher the power of shopping time, the greater the value of ϵ. In substance, the higher the power of shopping time, the more volatile shopping time is. Labor hours, output level, investment, and nominal interest rate are also more volatile following higher power of shopping time. Furthermore, when the power of shopping time increases, the correlation coefficient between inflation and production decreases.

In Figure 5, we examine the volatilities of two key variables: output and inflation, in response to the different degrees of price stickiness and the power of shopping time. In our benchmark case, we set $\omega = 0.5$ and $\varsigma = 1$. Denoting ω as 0 implies prices are fully flexible. In brief, both output and inflation are more volatile when ω remains low, no matter what the size of the power of shopping time. According to Calvo (1983), flexible price (i.e., ω is low) implies that firms may reset their prices as the optimal prices in almost every quarter. Thus, the economic intuition is that inflation will be more volatile than under rigid prices. The present findings are consistent with the existing studies. Besides, the volatility of output depends on price stickiness, and shopping time shows similar behavior in response to inflation. By increasing the power of shopping time, the volatility of output will increase,

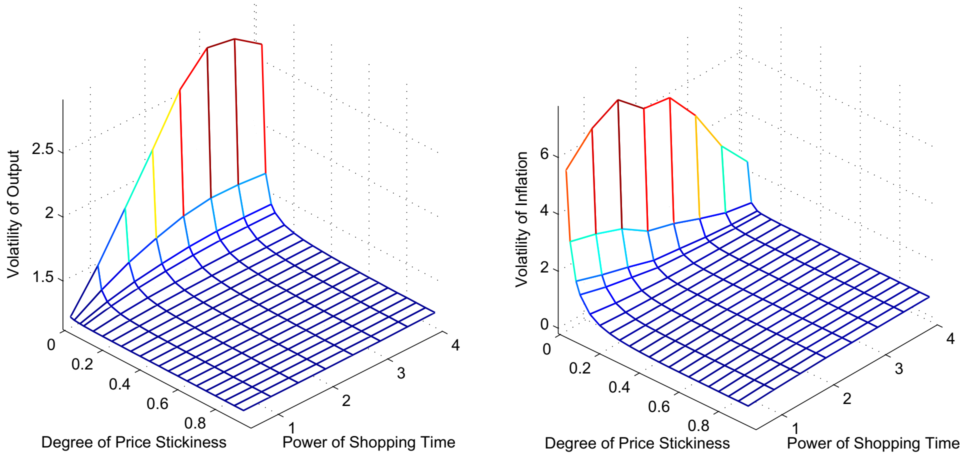

Figure 5. Degree of price stickiness, power of shopping time, and volatility of output and inflation. Source: Authors.

but the power of shopping time does not perform as sensitively as price stickiness changes. Though higher power of shopping time stabilizes inflation, it causes output to be more volatile. To summarize these analyses, $\omega = 0.5$ and $\varsigma = 1$ should be suitable for our benchmark case. Finally, Figure 5 also shows that price puzzle is retarded as the power of shopping time increasing.

4. Concluding remarks

This work builds on a simple dynamic general equilibrium model with shopping time and Calvo-type sticky price assumptions to understand a number of major macroeconomic effects and issues, using the conventional RBC approach. When the Fed implements an expansionary monetary policy, real money holdings go down, because agents worry about inflation. This causes shopping time to increase, and labor hours to decrease. Furthermore, output goes down and inflation rises. The nominal interest rate goes up because of expected inflation. This computational result is similar to the findings of Chen (2008). In other words, this means the model fails to capture liquidity effect. Our findings also support the argument that the monetary growth rule might fail to capture liquidity effect. In addition, we also find that there is a positive relationship between shopping time and inflation after an expansionary money supply. That is to say, higher inflation will lead agents to reduce their real money holdings, so as to require more time for shopping (see Gavin et al., 2015).

In addition, we find that a positive technology shock will make macroeconomic variables more volatile and persistent. Our results are consistent with the findings of the traditional RBC school which holds that technology shock is the major source of economic fluctuations. A positive fiscal shock (i.e., increasing tax) lowers real money holdings and consumption, thus increasing shopping time, which in turn causes lower labor hours and output levels. However, the effects of fiscal policy are less significant than those resulting from technology shock and monetary policy shock, because households are forward-looking. Shopping time is therefore a countercyclical variable. In other words, a negative relationship exists between shopping time and output level. Finally, we also find that a government should implement AM/PF for a stable economy.

Notes

1. Obviously, shopping time is the time an agent spends to buy consumption goods. Generally speaking, the greater the amount of money holdings for facilitating transactions means that a household can save more time and spend it on shopping.
2. Shopping time can be broken down between consumption goods purchases (49.4%), professional and personal care services (10.4%), household services (1.3%), government services (1.2%), and travel related to purchasing goods and services (37.7%). Of most interest, the average time men spent on shopping was 36.0 minutes, while women spent 55.2 minutes a day on average. See the shopping time data from the website of BLS (http://www.bls.gov/tus/data.htm).
3. One can also refer the discussions in Ćorić, Šimović, and Deskar-Škrbić (2015) for an empirical mixed monetary and fiscal policy case.
4. Recently, internet is so more and more developed that shopping behavior is changed also, many evidences show that in recent years people have been used to shopping online.
5. Liquidity effect means that a positive monetary shock lowers nominal interest rates, because an increase in money supply reduces the price of money, and the lower price of money means lower nominal interest rates, as found by Gibson (1970). Price puzzle refers to the positive relationship between interest rates and inflation.
6. In fact, there are many alternative fiscal policy approaches in the literature, such as Brătian et al. (2016). However, we adopt a very simple fiscal policy rule to figure out the issue in the study.
7. $\lambda_t = (c_t^{\chi} l_t^{1-\chi})^{-\eta}[\chi(\frac{c_t}{l_t})^{\chi-1} - (1-\chi)(\frac{c_t}{l_t})^{\chi}\frac{\epsilon}{m_t}]$ denotes the marginal utility of consumption is derived from equation (1).
8. In Chung et al. (2007), the two regimes, AM/PF (regime 1) and PM/AF (regime 2), follow a two-stage Markov chain process, and the transition matrix is:

$$\Pi = \begin{bmatrix} p_{11} & 1-p_{11} \\ 1-p_{22} & p_{22} \end{bmatrix},$$

$P[S_t = j|S_{t-1} = i] = p_{ij}$, where $i, j = 1, 2$ and $p_{12} = 1-p_{11}$ and $p_{21} = 1-p_{22}$. Chung, Davig, and Leeper make the transition probability between regimes be equal, with $p_{11} = p_{22} = 0.85$, and the average regime duration being 6.67 years. They set γ_1 as 0.275 in PF and γ_1 as 0 in AF. Actually, tax policy is affected by the government's debts in many countries, so we set PF as the benchmark case.

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No potential conflict of interest was reported by the authors.

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