

# On the efficiency of monetary and fiscal policy in open economies

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## Abstract

This paper investigates the efficiency of monetary and fiscal policy in a two-country general equilibrium model with monopolistic competition and wage stickiness. When monopoly distortions are completely eliminated, we find that stochastic government spending can affect the efficiency of the global monetary policy that replicates the real allocation under flexible wages. When the stochastic government spending is present, we find that the monopoly distortions can also affect the efficiency of the global monetary policy that replicates the real allocation under flexible wages. The combination of proportional subsidy policies used to completely eliminate monopoly distortions and the monetary policy replicating the real allocation under flexible wages can be improved after we introduce the stochastic government spending. Fiscal policy is found to be unable to replicate the real allocation under flexible wages.

### *Keywords:*

New open-economy macroeconomics, Efficiency of global monetary policy, Stochastic government spending, Monopoly distortions

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## 1. Introduction

Much recent research has focused on the choice of optimal monetary policy in open economies with imperfect competition and price stickiness.<sup>1</sup> One of conclusions of the research is that the optimal global monetary policy involves replicating the real allocation under flexible prices, see Obstfeld and Rogoff (hereafter referred to as OR, 2000, 2002), Devereux and Engel (hereafter referred to as DE, 2003) for the case of PCP<sup>2</sup>, Benigno and Benigno (hereafter BB, 2003) under some restrictive conditions, among many others. Equivalently, the conclusion means that the monetary policy replicating the real allocation under flexible prices is efficient. The point is easy to understand, *inter alia*, flexible prices can induce an efficient allocation of resources across different uses and times.

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<sup>1</sup>A nonexhaustive list includes Obstfeld and Rogoff (1995, 2000, 2001, 2002), Clarida, Gali and Gertler (2002), Devereux and Engel (2003), Benigno, G and Benigno, P (2003), Benigno, P (2004), Corsetti and Pesenti (2005), Gali, and Monacelli (2005), Corsetti, Dedola and Leduc (2011), Engel (2011), among many others.

<sup>2</sup>PCP is the abbreviation of producer currency pricing. By comparison, another specification is local currency pricing or LCP

We revisit this problem and verify whether the monetary policy replicating the real allocation under flexible prices is efficient or not when we introduce stochastic government spending shocks in OR (2000) for a more realistic purpose. Though the practice is similar to that adopted in the recent literature on the interactions between monetary and fiscal policy in open economies<sup>3</sup>, the fiscal role played by the government in our analysis is different. We just assume that the government spending is exogenously given shock not as a stabilization tool when we analyze the efficiency of the monetary policy that replicates the real allocation under flexible wages<sup>4</sup>.

We find that the conclusion found in OR (2000, 2002) and DE (2003) for the case of PCP can't be generalized without restriction after stochastic government spending is introduced, even for a special case in which the government uses the monetary policy to replicate the real allocation under flexible wages and constant government spending shares. Under the condition  $\log(1 - g_c) < E \log(1 - g)$  and  $\log(1 - g_c^*) < E \log(1 - g^*)$ ,<sup>5</sup> the global monetary policy can be Pareto improved when some requirements are satisfied. The reason behind the possible improvement is that the adverse influence of stochastic government spending shares on individual's utility under sticky wages is less than that of constant government spending shares on individual's utility under flexible wages. When the requirements are not satisfied, however, the global monetary policy is efficient. Under the condition  $\log(1 - g_c) \geq E \log(1 - g)$  and  $\log(1 - g_c^*) \geq E \log(1 - g^*)$ , the conclusion found in OR (2000, 2002) and DE (2003) for the case of PCP can be generalized without restriction in our setting.

The introduction of stochastic government spending can change the conclusion that obtained in OR (2000, 2002) and DE (2003) for the case of PCP. An implied result in OR (2000, 2002) is that the global monetary policy that replicates the real allocation under flexible wages when monopoly distortions are completely eliminated by government's proportional subsidy policies is efficient. However, after we introduce the stochastic government spending, the result can be overturned under some conditions. The key is that the monopoly distortions both in labor and output markets will decrease the disutility from labor when the wages are sticky, and the presence of stochastic government spending causes the benefit of a lower disutility from labor to outweigh adverse effect of monopoly distortions on expected utility from consumption. The complete elimination of monopoly distortions in labor and output markets will remove the potentially large gains when the government spending is present. Consequently, it leaves the room for exogenous monetary policy to Pareto improve one that replicates the real allocation under flexible wages and stochastic government spending shares when monopoly distortions are completely eliminated. Otherwise, the global monetary policy that replicates the real allocation under flexible wages and stochastic government spending shares but without monopoly distortions is efficient.

After we introduce the stochastic government spending, the monopoly distortions turn to be important for the efficiency of the global monetary policy that replicates the real allocation under flexible wages. As emphasized in the last paragraph, one of our conclusions is that the global monetary policy that replicates the real allocation under flexible wages and stochastic government spending shares when monopoly distortions are completely eliminated by government's proportional subsidy policies can be Pareto improved under some conditions. By comparison, the global

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<sup>3</sup>A partial list includes Lombardo and Sutherland (2004), Beetsma and Jensen (2005), Kirsanova et al. (2007), Gali and Monacelli (2008), Ferrero (2009), among many others.

<sup>4</sup>OR (2000) assumes sticky nominal wages but perfect flexible output prices and believes that it is more closer to the reality.

<sup>5</sup>Here  $g$  denotes Home stochastic government spending share and  $g_c$  Home constant government spending share. In addition,  $g^*$  and  $g_c^*$  are their Foreign counterparts respectively (Foreign variables are denoted by asterisks).

monetary policy that replicates the real allocation under flexible wages and stochastic government spending shares when the government leaves the monopoly distortions to be intact is efficient.

In OR (2000, 2002), the monetary policy that replicates the real allocation under flexible wages when monopoly distortions are completely eliminated can bring the individual the highest expected utility. After introducing the stochastic government spending, we depart from the conclusion and show that the expected utility provided by global monetary policy that replicates the real allocation under flexible wages and stochastic government spending shares when monopoly distortions are completely eliminated is lower than that provided by the same global monetary policy accompanied by specially-chosen subsidy policies. However, the global monetary policy accompanied by the specially-chosen subsidy policies can also be Pareto improved by exogenous monetary policy when some conditions are satisfied. Otherwise, it is efficient.

One potential merit of our introducing stochastic government spending is that we can analyze the endogenous global fiscal policy. We assume that the government can endogenously choose the fiscal policy as a stabilization tool after observing the productivity shocks and monetary shocks. Our treatment to the endogenous fiscal policy is similar to that appearing in recent literature on the interactions between monetary and fiscal policy in open economies, but our treatment to the monetary policy (as exogenously given shock) is different. However, similar to what obtained in Lombardo and Sutherland (2004), the endogenous fiscal policy can't replicate the real allocation under flexible wages.

The paper is organized as follows: Section 2 through 4 generalize the new open-economy macroeconomics model of OR (2000) by introducing the stochastic government spending; Section 5 analyzes the efficiency of endogenous global monetary policy that replicates the real allocation under flexible wages; Section 6 analyzes the endogenous fiscal policy; Finally, Section 7 concludes the paper.

## 2. The Model

We extend the model developed by OR (2000) by introducing stochastic government spending. The setup and the notation are similar to that of OR (2000). The world consists of two countries with equal size, Home and Foreign. Production of differentiated goods requires a continuum of differentiated labor inputs indexed by  $[0, 1]$ . Domestic tradable goods are represented by the interval  $[0, 1]$ , while Foreign's tradables are represented by  $[1, 2]$ . In addition, each country produces a continuum of differentiated nontraded goods represented by  $[0, 1]$ . Workers provide differentiated labor services to firms as monopolistic suppliers that are represented by the interval  $[0, 1]$ . And as in OR (2000) and other recent research, we focus on a single period which is justified by the equality of Home and Foreign per capita consumption of tradables and perfect international sharing of consumption risks in tradable goods.

### 2.1. Preferences

All individuals have identical preferences and a Home individual of type  $i$  maximizes

$$U^i = \log(C^i) + \frac{\chi}{1-\varepsilon} \left(\frac{M^i}{P}\right)^{1-\varepsilon} - \frac{K}{\nu} (L^i)^\nu, \quad (1)$$

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<sup>6</sup>In line with OR (1995), government spending doesn't directly affect private utility.

where

$$L^i \equiv \int_0^1 [L_H(i, j) + L_N(i, j)] dj$$

and  $v > 1$ .<sup>7</sup> In (1),  $M$  is exogenous stochastic monetary supply,  $K$  is stochastic Home productivity shock. For convenience, we assume that stochastic Foreign productivity shock  $K^*$  has symmetric but not necessarily independent distribution. For any individual  $i$ , the overall consumption index  $C$  is given by

$$C = \frac{C_T^\gamma C_N^{1-\gamma}}{\gamma^\gamma (1-\gamma)^{1-\gamma}},$$

where  $C_T$  is consumption index of tradables and has the form

$$C_T = 2C_H^{\frac{1}{2}}C_F^{\frac{1}{2}}. \quad (2)$$

Three consumption subindexes  $C_H, C_F, C_N$  are defined respectively by

$$C_H = \left[ \int_0^1 C_T(j)^{\frac{\theta-1}{\theta}} dj \right]^{\frac{\theta}{\theta-1}}, \quad C_F = \left[ \int_1^2 C_T(j)^{\frac{\theta-1}{\theta}} dj \right]^{\frac{\theta}{\theta-1}},$$

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

where  $\theta > 1$  is the elasticity of substitution between goods and also an index of monopolistic distortion. Corresponding price indexes for  $C_H, C_F, C_N$  are respectively

$$P_H = \left[ \int_0^1 P_T(j)^{1-\theta} dj \right]^{\frac{1}{1-\theta}}, \quad P_F = \left[ \int_1^2 P_T(j)^{1-\theta} dj \right]^{\frac{1}{1-\theta}},$$

$$P_N = \left[ \int_0^1 P_N(j)^{1-\theta} dj \right]^{\frac{1}{1-\theta}}.$$

In addition, domestic price index for  $C_T$  is

$$P_T = P_H^{\frac{1}{2}}P_F^{\frac{1}{2}}, \quad (3)$$

for  $C$  is

$$P = P_T^\gamma P_N^{1-\gamma}. \quad (4)$$

Cost minimization yields the following domestic commodity demand functions

$$C_T = \gamma \left( \frac{P_T}{P} \right)^{-1} C, \quad C_N = (1-\gamma) \left( \frac{P_N}{P} \right)^{-1} C,$$

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<sup>7</sup>Here we make a slight modification to OR (2000) to leave the case  $v = 1$  out of consideration. The assumption that  $v$ , the degree of convexity of effort cost, is strictly greater than unity is also adopted in lots of literature, such as OR (1995, 2001), Harald Hau (2000), Cedric Tille (2001), Corsetti and Pesenti (2001), among others.

$$\begin{aligned}
C_H &= \frac{1}{2} \left( \frac{P_H}{P_T} \right)^{-1} C_T, & C_F &= \frac{1}{2} \left( \frac{P_F}{P_T} \right)^{-1} C_T, \\
C_T(h) &= \left[ \frac{P_T(h)}{P_H} \right]^{-\theta} C_H, & C_T(f) &= \left[ \frac{P_T(f)}{P_F} \right]^{-\theta} C_F, \\
C_N(h) &= \left[ \frac{P_N(h)}{P_N} \right]^{-\theta} C_N.
\end{aligned}$$

We assume that the government spending index takes the same form as the individual's and government purchases a same proportion  $g$  from domestic traded sector as from nontraded sector. It implies

$$G_H = \left[ \int_0^1 G_T(j)^{\frac{\theta-1}{\theta}} dj \right]^{\frac{\theta}{\theta-1}} \equiv g \int_0^1 Y_H(j) dj$$

and

$$G_N = \left[ \int_0^1 G_N(j)^{\frac{\theta-1}{\theta}} dj \right]^{\frac{\theta}{\theta-1}} \equiv g \int_0^1 Y_N(j) dj,^8$$

where  $g$  is a exogenous stochastic variable, and  $G_H$  and  $G_N$  are indexes of government spending on tradables and nontradables respectively. We also assume that the government behaves competitively in goods markets, and its commodity demand functions have the same forms as those of individual's

$$G_T(h) = \left[ \frac{P_T(h)}{P_H} \right]^{-\theta} G_H = g \left[ \frac{P_T(h)}{P_H} \right]^{-\theta} \int_0^1 Y_H(j) dj$$

and

$$G_N(h) = \left[ \frac{P_N(h)}{P_N} \right]^{-\theta} G_N = g \left[ \frac{P_N(h)}{P_N} \right]^{-\theta} \int_0^1 Y_N(j) dj.$$

The first-order condition for individual  $i$ 's nominal money balances is

$$\frac{1}{C^i} = \chi \left( \frac{M^i}{P} \right)^{-\varepsilon}, \quad (5)$$

which is standard in MIU models but assumption of one-period need to be taken into account.

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<sup>8</sup>Here  $g$  represents the size of government which appears in Barro (1990) but in a stochastic sense. In addition, in line with Beetsma and Jensen (2005), we assume complete home bias in government spending.

## 2.2. Firms

Home traded and nontraded sectors have the following production functions respectively

$$Y_H(j) = \left[ \int_0^1 L_H(i, j)^{\frac{\phi-1}{\phi}} di \right]^{\frac{\phi}{\phi-1}}$$

and

$$Y_N(j) = \left[ \int_0^1 L_N(i, j)^{\frac{\phi-1}{\phi}} di \right]^{\frac{\phi}{\phi-1}},$$

where  $Y(j)$  denotes firm  $j$ 's output and  $L(i, j)$  firm  $j$ 's demand for labor  $i$ , and  $\phi > 1$  is substitution elasticity between labors and also a (decreasing) index of imperfect competition. Foreign production functions have the identical structures except that tradables produced by Foreign are denoted by  $Y_F(j)$  ( $j \in [1, 2]$ ).

The wage index  $W$  has the following form

$$W = \left[ \int_0^1 W(i)^{1-\phi} di \right]^{\frac{1}{1-\phi}}, \quad (6)$$

where  $W(i)$  denotes the nominal wage paid to individual  $i$ . Labor demand function of firm  $j$  for labor  $i$  is

$$L(i, j) = \left[ \frac{W(i)}{W} \right]^{-\phi} Y(j). \quad (7)$$

## 2.3. Asset markets and budget constraints

All domestic profits and initial stock of the domestic currency are shared equally by Home individuals. And as explained in OR (2000), it does't exist ex ante equity trade between Home and Foreign.

Home individual  $i$  has the following budget constraint

$$M^i + PC^i + PT = M_0^i + W(i)L^i + \int_0^1 [\Pi_H(j) + \Pi_N(j)] dj, \quad (8)$$

where  $\Pi_H$  and  $\Pi_N$  are profits paid by firms and  $T$  is per capita lump-sum tax denominated by composite consumption good.

The government's budget constraint is

$$M - M_0 + PT = P_H G_H + P_N G_N.$$

## 3. Equilibrium Price and Wage Setting

Workers set nominal wages at the beginning of the period and the wages are sticky during the period.

### 3.1. Optimal wage setting

Solving the individual's optimization problem yields the following

$$W(i) = \left( \frac{\phi}{\phi - 1} \right) \frac{E \{ K (L^i)^{\nu} \}}{E \left\{ \frac{L^i}{PC^i} \right\}}. \quad (9)$$

The above equation is identical to that in OR (2000) and has the same interpretation.

### 3.2. price setting, the real exchange rate and the terms of trade

That monopolistic firms will charge a constant markup over wages and the law of one price holds implies

$$P_H = P_N = \left( \frac{\theta}{\theta - 1} \right) W = \mathcal{E} P_H^* \quad \text{and} \quad P_N^* = P_F^* = \left( \frac{\theta}{\theta - 1} \right) W^* = \frac{P_F}{\mathcal{E}}. \quad (10)$$

The real exchange rate is

$$\text{Real exchange rate} \equiv \frac{\mathcal{E} P^*}{P} = \left( \frac{\mathcal{E} W^*}{W} \right)^{1-\gamma}, \quad (11)$$

and the terms of trade is

$$\text{Terms of trade} \equiv \frac{\mathcal{E} P_F^*}{P_H} = \frac{\mathcal{E} W^*}{W}. \quad (12)$$

### 3.3. Output market clearing

The clearing of Home market for nontradables implies that  $C_N = (1 - g) Y_N$ . As for tradables, equilibrium requires that  $(1 - g) P_H Y_H = \frac{1}{2} P_T C_T + \frac{1}{2} \mathcal{E} P_T^* C_T^*$  and  $(1 - g^*) P_F Y_F = \frac{1}{2} P_T C_T + \frac{1}{2} \mathcal{E} P_T^* C_T^*$ , from which  $(1 - g) P_H Y_H = (1 - g^*) P_F Y_F$  follows. The budget constraints and market clearing for nontradables imply that  $P_T C_T = (1 - g) P_H Y_H$  and  $\mathcal{E} P_T^* C_T^* = P_T C_T = (1 - g^*) P_F Y_F$ , from which  $C_T = C_T^*$  follows. This result appears in OR (2000, 2001, 2002), Corsetti and Pesenti (2001) and Devereux and Engel (2003) when PCP holds. As emphasized in OR (2002), in general case of CRRA consumption preference,  $C_T = C_T^*$  can't guarantee efficient international sharing of consumption risks in tradable goods. But here we stick with OR (2000), the utility separability between tradables and nontradables implies perfect risk sharing in tradable goods when  $C_T = C_T^*$  holds.

As in OR (2000, 2002),  $C_T = C_T^*$  doesn't imply the equality of the overall consumption indexes  $C$  and  $C^*$ . But if measured in units of tradables, Home spending  $Z \equiv C_T + \left( \frac{P_N}{P_T} \right) C_N$  is identical to Foreign spending  $Z^*$ . The result follows from  $\frac{P_N}{P_T} = \frac{(1-\gamma)C_T}{\gamma C_N}$ ,  $Z = \frac{C_T}{\gamma}$  and  $Z^* = \frac{C_T^*}{\gamma}$ .

### 3.4. Equilibrium preset wages

Taking the same procedures as in OR (2000), We obtain the following

$$\left( \frac{W}{W^*} \right)^{\frac{\nu}{2}} = \frac{\phi}{(\phi - 1)} \frac{\theta}{(\theta - 1)} \frac{E \left\{ K (1 - g)^{-\nu} \mathcal{E}^{\frac{\nu}{2}} Z^{\nu} \right\}}{E \left\{ (1 - g)^{-1} \right\}}. \quad (13)$$

Combining Eq. (13) and it's foreign analog yields:

$$\left(\frac{W}{W^*}\right)^\nu = \frac{E\left\{K(1-g)^{-\nu}\mathcal{E}^{\frac{\nu}{2}}Z^\nu\right\}E\left\{(1-g^*)^{-1}\right\}}{E\left\{K^*(1-g^*)^{-\nu}\mathcal{E}^{-\frac{\nu}{2}}Z^\nu\right\}E\left\{(1-g)^{-1}\right\}}. \quad (14)$$

As we show in the following, Eqs. (13) and (14) will lead to a simple closed-form solution.

#### 4. A closed-form solution

In this section, we can solve the model analytically by assuming the exogenous stochastic shocks  $\{m, m^*, \kappa, \kappa^*, \log(1-g), \log(1-g^*)\}$  follow jointly normal distribution, where  $m = \log M, m^* = \log M^*, \kappa = \log K, \kappa^* = \log K^*$ . In the following, we suppose lower case letters denote natural logs and  $E\kappa = E\kappa^*$  and  $\sigma_\kappa^2 = \sigma_{\kappa^*}^2$ . As showed in Corsetti and Pesenti (2001), we solve the model under the condition that voluntary participation constraints hold. It means that the variances of the shocks are sufficiently small.

##### 4.1. Solutions for expected terms of trade and world spending

Taking logs to Eq. (14) yields

$$\begin{aligned} E\tau = Ee + w^* - w = & -\nu\sigma_{ez} - \frac{1}{2}(\sigma_{\kappa e} + \sigma_{\kappa^* e}) - (\sigma_{\kappa z} - \sigma_{\kappa^* z}) + \frac{(v-1)}{v}[E\log(1-g) - E\log(1-g^*)] \\ & + \frac{(1-\nu^2)}{2\nu}[\sigma_{\log(1-g)}^2 - \sigma_{\log(1-g^*)}^2] + [\sigma_{\kappa \log(1-g)} - \sigma_{\kappa^* \log(1-g^*)}] + \frac{v}{2}[\sigma_{e \log(1-g)} + \sigma_{e \log(1-g^*)}] \\ & + v[\sigma_{z \log(1-g)} - \sigma_{z \log(1-g^*)}] \end{aligned} \quad (15)$$

in which  $\tau$  is the log terms of trade (*TOT*). The log real exchange rate is given by  $(1-\gamma)\tau$ . Combining (the log of) Eq. (13) with Eq. (15) yields

$$\begin{aligned} Ez = & \frac{1}{v}\left\{\log\left[\frac{(\phi-1)(\theta-1)}{\phi\theta}\right] - E\kappa - \frac{1}{2}\sigma_\kappa^2\right\} - \frac{\nu}{2}\sigma_z^2 - \frac{v}{8}\sigma_e^2 - \frac{1}{2}(\sigma_{\kappa z} + \sigma_{\kappa^* z}) \\ & - \frac{1}{4}(\sigma_{\kappa e} - \sigma_{\kappa^* e}) + \frac{(v-1)}{2\nu}[E\log(1-g) + E\log(1-g^*)] + \frac{(1-\nu^2)}{4\nu}(\sigma_{\log(1-g)}^2 + \sigma_{\log(1-g^*)}^2) \\ & + \frac{1}{2}(\sigma_{\kappa \log(1-g)} + \sigma_{\kappa^* \log(1-g^*)}) + \frac{v}{4}(\sigma_{e \log(1-g)} - \sigma_{e \log(1-g^*)}) + \frac{v}{2}(\sigma_{z \log(1-g)} + \sigma_{z \log(1-g^*)}). \end{aligned} \quad (16)$$

Eqs. (15) and (16) are identical to their counterparts in OR (2000) if the government spending disappears, and have the same explanations. After we introduce the government spending, the immediately above two expressions give us some additional intuitions to explain how uncertainties affect the expected terms of trade and the expected expenditure levels measured in units of tradables.

From Eq. (15), A positive covariance between productivity shock  $\kappa$  and  $1-g$  (remaining output fraction to individuals after government buys fraction  $g$ ) encourages labor effort, because it means that the demand for Home labor is low when the disutility from labor is high. As a result, Home individuals set a relatively lower wages, and the fact that the Home produces more deteriorates the



Home's expected terms of trade  $E\tau$ . The explanations of the effects of  $\sigma_{\varepsilon \log(1-g)}$  and  $\sigma_{z \log(1-g)}$  on  $E\tau$  are similar. The increase of  $Eg$  will affect the Home's expected  $TOT$  via the term  $E \log(1-g)$ <sup>9</sup>. A higher expected government spending in all states will affect expected output by two different ways. For one thing, a higher expected government spending will increase the demand for labor and encourage the individual to set a relatively higher wage, higher wage will depress the output. For another, with wage preset ex ante, a higher expected government spending will induce the firm to produce more. The net effect of a higher expected government spending on the expected output depends on the balance of depressing effect of higher ex ante wage and direct stimulating effect of higher expected government spending.<sup>10</sup> Anyway, a higher expected government spending will crowd out expected private consumption.<sup>11</sup> A resulting lower Home output allocated for private transaction in tradables, however, doesn't mean that Home's expected  $TOT$  will improve for sure. The effect of expected government spending on Home's expected  $TOT$  depends on whether Home expected government spending exceeds that of the Foreign or not. If the answer is yes, the domestic private tradables will be scarcer as a result of a larger crowding effect, consequently, the Home's expected  $TOT$  will improve. Now we analyze the effect of the variance of the government spending share  $g$  on the Home's expected  $TOT$ . A higher volatility of government spending share will only produce the depressing effect on the expected output by higher ex ante preset wage. Consequently, the increase of the volatility of the government spending share will lower the output, thus, the tradables for private transaction and improve the Home's expected  $TOT$ .<sup>12</sup> Explanations of effects of new terms in Eq. (16) on expected spending measured in terms of tradables are also similar to those of effects they have on the expected terms of trade.

#### 4.2. Ex post spending, the ex post exchange rate and nominal wage levels

Now we solve ex post spending and ex post exchange rate to obtain absolute nominal wage levels and express the variances of the endogenous variables in terms of the exogenous shocks.

The results are identical to those in OR (2000) and have the same explanations. They are respectively

$$z = \frac{\varepsilon}{2}(m + m^*) - \frac{\varepsilon}{2}(w + w^*) - \log \chi - \varepsilon \log \left( \frac{\theta}{\theta - 1} \right), \quad (17)$$

$$e = \frac{\varepsilon(m - m^*)}{1 - \gamma + \gamma\varepsilon} - \frac{(\varepsilon - 1)(1 - \gamma)(w - w^*)}{1 - \gamma + \gamma\varepsilon}, \quad (18)$$

$$w = Em - \log \left( \frac{\theta}{\theta - 1} \right) - \frac{(Ez + \log \chi)}{\varepsilon} - \frac{(1 - \gamma) + \gamma\varepsilon}{\varepsilon} \left( \frac{E\tau}{2} \right),$$

$$w^* = Em^* - \log \left( \frac{\theta}{\theta - 1} \right) - \frac{(Ez + \log \chi)}{\varepsilon} - \frac{(1 - \gamma) + \gamma\varepsilon}{\varepsilon} \left( \frac{E\tau}{2} \right).$$

<sup>9</sup>A higher value of  $Eg$  implies a more negative value of  $E \log(1-g)$ .

<sup>10</sup>The equation  $Ey = -E \log(1-g) + \frac{1}{2}E\tau + Ez$  shows that the increase of the expected value of  $g$  will result in a higher stimulating effect, thus, a higher expected output.

<sup>11</sup>From the equation  $Ec = Ez + \frac{1-\gamma}{2}E\tau$  and the expressions for  $Ez$  and  $E\tau$ , the statement holds obviously.

<sup>12</sup>Of course, the statement holds under the condition that the volatility of domestic government spending share is larger than that of the Foreign.

It's noteworthy that the government spending doesn't affect ex post spending level  $z$ , and ex post exchange rate  $e$  directly. The government spending affects these two terms through its effects on predetermined wages which are the functions of the expected spending level  $Ez$  and expected terms of trade  $E\tau$ , by Eqs.(15) and (16), both  $Ez$  and  $E\tau$  are affected by government spending.

#### 4.3. solutions for variances

Before we solve for covariances in Eqs. (15) and (16) to express the endogenous variables in terms of exogenous parameters, we assume that both monetary policy and fiscal spending don't respond to productivity shocks and monetary policy and fiscal spending don't respond to each other. These assumptions mean that  $\sigma_{\kappa e}$ ,  $\sigma_{\kappa^* e}$ ,  $\sigma_{\kappa z}$ ,  $\sigma_{\kappa^* z}$ ,  $\sigma_{\kappa \log(1-g)}$ ,  $\sigma_{\kappa^* \log(1-g^*)}$ ,  $\sigma_{e \log(1-g)}$ ,  $\sigma_{e \log(1-g^*)}$ ,  $\sigma_{z \log(1-g)}$ ,  $\sigma_{z \log(1-g^*)}$  are all zero. The covariance terms in Eqs. (15) and (16) can be calculated as follows:

$$\sigma_e^2 = \left( \frac{\varepsilon}{1 - \gamma + \gamma\varepsilon} \right)^2 (\sigma_m^2 - 2\sigma_{mm^*} + \sigma_{m^*}^2), \quad (19)$$

$$\sigma_z^2 = \frac{\varepsilon^2}{4} (\sigma_m^2 + 2\sigma_{mm^*} + \sigma_{m^*}^2), \quad (20)$$

$$\sigma_{ze} = \left( \frac{\varepsilon^2}{1 - \gamma + \gamma\varepsilon} \right) \frac{(\sigma_m^2 - \sigma_{m^*}^2)}{2}. \quad (21)$$

Later, we will consider the endogenous monetary policies and fiscal policies.

#### 4.4. Solving explicitly for expected utilities

When analyzing the welfare implications of policy rules, we consider the limiting case as  $\chi \rightarrow 0$  which means that the derived utility from real balances is small relative to that from private consumption.

##### 4.4.1. Expected utilities under sticky wages, stochastic government spending shares and monopoly distortions

Using the same procedures suggested by OR (2000), the following results are natural

$$\begin{aligned} EU &= E \left\{ \log C - \frac{\kappa}{v} L^v \right\} \\ &= Ez + \frac{(1-\gamma)}{2} E\tau - \frac{(\varphi-1)(\theta-1)}{v\varphi\theta} \exp \left[ -E \log(1-g) + \frac{\sigma_{\log(1-g)}^2}{2} \right] \\ &= \frac{1}{v} \left\{ \log \frac{(\varphi-1)(\theta-1)}{\varphi\theta} - \frac{(\varphi-1)(\theta-1)}{\varphi\theta} \exp \left[ -E \log(1-g) + \frac{\sigma_{\log(1-g)}^2}{2} \right] - E\kappa \right\} \\ &\quad + \frac{(v-1)}{2v} [(2-\gamma)E \log(1-g) + \gamma E \log(1-g^*)] + \Omega + \Phi, \end{aligned} \quad (22)$$

where  $\Omega$  and  $\Phi$  are respectively

$$\Omega = -\frac{1}{2v}\sigma_\kappa^2 - \frac{v}{2}\sigma_z^2 - \frac{v}{8}\sigma_e^2 - \frac{(1-\gamma)v}{2}\sigma_{ez} - \frac{1}{2}[(2-\gamma)\sigma_{\kappa z} + \gamma\sigma_{\kappa^* z}] - \frac{1}{4}[(2-\gamma)\sigma_{\kappa e} - \gamma\sigma_{\kappa^* e}]$$

and

$$\begin{aligned} \Phi = & \frac{(1-v^2)}{4v} \left[ (2-\gamma) \sigma_{\log(1-g)}^2 + \gamma \sigma_{\log(1-g^*)}^2 \right] + \frac{1}{2} \left[ (2-\gamma) \sigma_{\kappa \log(1-g)} + \gamma \sigma_{\kappa^* \log(1-g^*)} \right] \\ & + \frac{v}{4} \left[ (2-\gamma) \sigma_{e \log(1-g)} - \gamma \sigma_{e \log(1-g^*)} \right] + \frac{v}{2} \left[ (2-\gamma) \sigma_{z \log(1-g)} + \gamma \sigma_{z \log(1-g^*)} \right]. \end{aligned}$$

The term  $\Omega$  is identical to that in OR (2000) which reflects the effects of monetary policies, it's effects on the expected utility of Home typical individual remain the same. However, comparing with it's counterpart in OR (2000), Eq.(22) has a new term  $\Phi$  which, together with the terms  $E \log(1-g)$ ,  $E \log(1-g^*)$  and  $\sigma_{\log(1-g)}^2$ , reflect the effects of government spending on the expected utility level. We analyze the effects of  $E \log(1-g)$  on  $EU$  to illustrate the channels through which the fiscal policy affects the expected utility level. A higher expected government spending share  $g$ , as analyzed before, will be expected to crowd out consumption, thus, result in a lower expected utility level. The effect is reflected by the term  $\frac{(v-1)}{2v} [(2-\gamma) E \log(1-g) + \gamma E \log(1-g^*)]$ . In addition, as captured by the term  $\frac{(\varphi-1)(\theta-1)}{\varphi\theta} \exp \left[ -E \log(1-g) + \frac{\sigma_{\log(1-g)}^2}{2} \right]$ , a higher expected government spending share will cause more disutility from labor.<sup>13</sup> A more volatile government spending share will induce the individual to set a higher wage, lower expected output caused by higher wage leads to a lower expected utility from consumption which captured by the term  $\frac{(1-v^2)}{4v} \left[ (2-\gamma) \sigma_{\log(1-g)}^2 + \gamma \sigma_{\log(1-g^*)}^2 \right]$ . In addition, as reflected by the term

$$\frac{(\varphi-1)(\theta-1)}{\varphi\theta} \exp \left[ -E \log(1-g) + \frac{\sigma_{\log(1-g)}^2}{2} \right],$$

a more volatile government spending share will produce more disutility from labor.<sup>14</sup> A positive covariance between  $\kappa$  and  $1-g$  will, as explained before, induce the individual to set a lower wage. Consequently, the individual will obtain more utility from consumption since the firm will produce more output. The effects of  $\sigma_{e \log(1-g)}$  and  $\sigma_{z \log(1-g)}$  on the expected utility level can be analyzed similarly.

The Foreign typical individual's expected utility is given by the following

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<sup>13</sup>From Eq. (9) and  $PC = (1-g) \frac{\theta}{\theta-1} WL$ , a higher expected government spending will raise the expected marginal utility of real wage by the crowding-out effect, therefore, increase the labor offered by the individual.

<sup>14</sup>Similar to explanation in the last footnote, a more volatile government spending share will raise the expected marginal utility of real wage from depressing effect, therefore, increase the labor offered by the individual.

$$\begin{aligned}
EU^* &= E \left\{ \log C^* - \frac{\kappa}{v} L^{*v} \right\} \\
&= Ez - \frac{(1-\gamma)}{2} E\tau - \frac{(\varphi-1)(\theta-1)}{v\varphi\theta} \exp \left[ -E \log(1-g^*) + \frac{\sigma_{\log(1-g^*)}^2}{2} \right] \\
&= \frac{1}{v} \left\{ \log \frac{(\varphi-1)(\theta-1)}{\varphi\theta} - \frac{(\varphi-1)(\theta-1)}{\varphi\theta} \exp \left[ -E \log(1-g^*) + \frac{\sigma_{\log(1-g^*)}^2}{2} \right] - E\kappa \right\} \\
&\quad + \frac{(v-1)}{2v} [\gamma E \log(1-g) + (2-\gamma) E \log(1-g^*)] + \Omega^* + \Phi^*, \tag{23}
\end{aligned}$$

where  $\Omega^*$  and  $\Phi^*$  are respectively

$$\Omega^* = -\frac{1}{2v} \sigma_{\kappa}^2 - \frac{v}{2} \sigma_z^2 - \frac{v}{8} \sigma_e^2 + \frac{(1-\gamma)v}{2} \sigma_{ez} - \frac{1}{2} [\gamma \sigma_{\kappa z} + (2-\gamma) \sigma_{\kappa^* z}] - \frac{1}{4} [\gamma \sigma_{\kappa e} - (2-\gamma) \sigma_{\kappa^* e}]$$

and

$$\begin{aligned}
\Phi^* &= \frac{(1-v^2)}{4v} \left[ \gamma \sigma_{\log(1-g)}^2 + (2-\gamma) \sigma_{\log(1-g^*)}^2 \right] + \frac{1}{2} [\gamma \sigma_{\kappa \log(1-g)} + (2-\gamma) \sigma_{\kappa^* \log(1-g^*)}] \\
&\quad + \frac{v}{4} [\gamma \sigma_{e \log(1-g)} - (2-\gamma) \sigma_{e \log(1-g^*)}] + \frac{v}{2} [\gamma \sigma_{z \log(1-g)} + (2-\gamma) \sigma_{z \log(1-g^*)}].
\end{aligned}$$

The analysis of the effects of new terms on the Foreign individual's expected utility is the same as what we conduct for the Home individual.

Notice here the way the monopoly distortion term  $\frac{(\varphi-1)(\theta-1)}{\varphi\theta}$  enters the utility function is different from that in OR (2000). The point is essential to change the main conclusion obtained in OR (2000), it will become apparent later. And as in OR (2000), the parameters  $\theta$  and  $\varphi$  do not enter the terms  $\Omega$ ,  $\Omega^*$ ,  $\Phi$  and  $\Phi^*$ .

#### 4.4.2. Expected utilities under flexible wages, constant government spending shares and monopoly distortions

In order to compare with the conclusion in OR (2000), we consider a special case in which government spending share is a constant. Let upper bars denote variables with flexible wages, constant government spending shares and monopoly distortions. The Home and Foreign outputs in this circumstance are respectively

$$\bar{Y} = \bar{L} = \left[ \frac{(\varphi-1)(\theta-1)}{\varphi\theta K(1-g_c)} \right]^{\frac{1}{v}} \tag{24}$$

and

$$\bar{Y}^* = \bar{L}^* = \left[ \frac{(\varphi-1)(\theta-1)}{\varphi\theta K^*(1-g_c^*)} \right]^{\frac{1}{v}}, \tag{25}$$

in which  $g_c$  represents constant government spending share. Taking logs to Eqs.(24) and (25) and then taking derivative to productivity shock yield  $\frac{\partial \bar{y}}{\partial \kappa} = \frac{\partial \bar{y}^*}{\partial \kappa^*} = -\frac{1}{v} < 0$ , which means that a positive

productivity shock will result in a higher output. In addition, we have  $\frac{\partial \bar{y}}{\partial g_c} = \frac{1}{v(1-g_c)} > 0$  and  $\frac{\partial \bar{y}^*}{\partial g_c^*} = \frac{1}{v(1-g_c^*)} > 0$ , which mean that a higher government spending share will lead to more output. The intuition is that a higher government spending share will crowd out the individual's consumption and increase the marginal utility of consumption, a higher marginal utility of consumption induces the individual to offer more labor. The expected utility of the Home typical individual in this circumstance is

$$E\bar{U} = \frac{1}{v} \left\{ \log \frac{(\varphi-1)(\theta-1)}{\varphi\theta} - \frac{(\varphi-1)(\theta-1)}{\varphi\theta(1-g_c)} - E\kappa \right\} + \frac{(v-1)}{2v} [(2-\gamma) \log(1-g_c) + \gamma \log(1-g_c^*)], \quad (26)$$

and it's Foreign counterpart is

$$E\bar{U}^* = \frac{1}{v} \left\{ \log \frac{(\varphi-1)(\theta-1)}{\varphi\theta} - \frac{(\varphi-1)(\theta-1)}{\varphi\theta(1-g_c^*)} - E\kappa \right\} + \frac{(v-1)}{2v} [\gamma \log(1-g_c) + (2-\gamma) \log(1-g_c^*)]. \quad (27)$$

#### 4.4.3. *Expected utilities under flexible wages, stochastic government spending shares but without monopoly distortions*

Monopoly distortions can be eliminated completely by giving individuals a proportional wage subsidy of  $\frac{1}{\varphi-1}$  and firms a proportional production subsidy of  $\frac{1}{\theta-1}$ . When monopoly distortions are eliminated completely and wages are flexible, the Home and Foreign outputs are respectively<sup>15</sup>

$$\hat{Y} = \hat{L} = \left( \frac{1}{(1-g)K} \right)^{\frac{1}{v}} \quad (28)$$

and

$$\hat{Y}^* = \hat{L}^* = \left( \frac{1}{(1-g^*)K^*} \right)^{\frac{1}{v}}. \quad (29)$$

Similarly, we have  $\frac{\partial \hat{y}}{\partial \kappa} = \frac{\partial \hat{y}^*}{\partial \kappa^*} = \frac{\partial \hat{l}}{\partial \kappa} = \frac{\partial \hat{l}^*}{\partial \kappa^*} = -\frac{1}{v} < 0$ ,  $\frac{\partial \hat{y}}{\partial g} = \frac{\partial \hat{l}}{\partial g} = \frac{1}{v(1-g)} > 0$  and  $\frac{\partial \hat{y}^*}{\partial g^*} = \frac{\partial \hat{l}^*}{\partial g^*} = \frac{1}{v(1-g^*)} > 0$ . The expressions can also be explained similarly.

The Home individual's expected utility in this circumstance is

$$E\hat{U} = \frac{1}{v} \left\{ -\exp \left[ -E \log(1-g) + \frac{\sigma_{\log(1-g)}^2}{2} \right] - E\kappa \right\} + \frac{(v-1)}{2v} [(2-\gamma) E \log(1-g) + \gamma E \log(1-g^*)], \quad (30)$$

and it's Foreign counterpart is

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<sup>15</sup>Here we let the hats denote the variables with flexible wages, stochastic government spending shares when monopoly distortions are eliminated.

$$E\hat{U}^* = \frac{1}{v} \left\{ -\exp \left[ -E \log(1-g^*) + \frac{\sigma_{\log(1-g^*)}^2}{2} \right] - E\kappa \right\} + \frac{(v-1)}{2v} [\gamma E \log(1-g) + (2-\gamma) E \log(1-g^*)]. \quad (31)$$

4.4.4. *Expected utilities under flexible wages, stochastic government spending shares and monopoly distortions*

Let tildes denote variables with flexible wages, stochastic government spending shares and monopoly distortions. It's easy to show that the Home and Foreign outputs in this circumstance are the following respectively

$$\tilde{Y} = \tilde{L} = \tilde{L}_H + \tilde{L}_N = \left[ \frac{(\theta-1)(\varphi-1)}{\theta\varphi K(1-g)} \right]^{\frac{1}{v}} \quad (32)$$

and

$$\tilde{Y}^* = \tilde{L}^* = \tilde{L}_F^* + \tilde{L}_N^* = \left[ \frac{(\theta-1)(\varphi-1)}{\theta\varphi K^*(1-g^*)} \right]^{\frac{1}{v}}. \quad (33)$$

As before, we have  $\frac{\partial \tilde{y}}{\partial \kappa} = \frac{\partial \tilde{y}^*}{\partial \kappa^*} = \frac{\partial \tilde{l}}{\partial \kappa} = \frac{\partial \tilde{l}^*}{\partial \kappa^*} = -\frac{1}{v} < 0$ ,  $\frac{\partial \tilde{y}}{\partial g} = \frac{\partial \tilde{l}}{\partial g} = \frac{1}{v(1-g)} > 0$ ,  $\frac{\partial \tilde{y}^*}{\partial g} = \frac{\partial \tilde{l}^*}{\partial g^*} = \frac{1}{v(1-g^*)} > 0$ , and the interpretations remain the same.

The Home typical individual's expected utility in this circumstance is

$$E\tilde{U} = \frac{1}{v} \left\{ \log \frac{(\varphi-1)(\theta-1)}{\varphi\theta} - \frac{(\varphi-1)(\theta-1)}{\varphi\theta} \exp \left[ -E \log(1-g) + \frac{\sigma_{\log(1-g)}^2}{2} \right] - E\kappa \right\} + \frac{(v-1)}{2v} [(2-\gamma) E \log(1-g) + \gamma E \log(1-g^*)], \quad (34)$$

and it's Foreign counterpart is

$$E\tilde{U}^* = \frac{1}{v} \left\{ \log \frac{(\varphi-1)(\theta-1)}{\varphi\theta} - \frac{(\varphi-1)(\theta-1)}{\varphi\theta} \exp \left[ -E \log(1-g^*) + \frac{\sigma_{\log(1-g^*)}^2}{2} \right] - E\kappa \right\} + \frac{(v-1)}{2v} [\gamma E \log(1-g) + (2-\gamma) E \log(1-g^*)]. \quad (35)$$

What contrasts with the conclusion in OR (2000) is that, in general,  $E\tilde{U}$  doesn't equal  $E\tilde{U}^*$ , even though the condition  $E\kappa = E\kappa^*$  is imposed. Except that in special case that the distributions of Home fiscal policy and Foreign's are identical, i.e.  $E \log(1-g) = E \log(1-g^*)$  and  $\sigma_{\log(1-g)}^2 = \sigma_{\log(1-g^*)}^2$ .

## 5. Efficiency of global monetary policy

Before presenting the formal analysis, we should emphasize that whenever we say monetary policies are efficient, it means that they are constrained-efficient, in the sense clarified in OR (2000) (i.e. maximizing an average of Home and Foreign expected utilities subject to optimal behaviors of the players in the model). In addition, when the government endogenously chooses the monetary policy to replicate the real allocation under flexible wages, we take the fiscal spending as shocks and assume that the government can observe the productivity shocks  $K, K^*$  and the fiscal spending shocks  $g$  and  $g^*$ .

In order to compare with the conclusion in OR (2000,2002), DE (2003) and BB (2003), i.e. the monetary policy that replicates the real allocation under flexible prices is efficient. We consider first the case in which that the government uses monetary policy to replicate the real allocation under flexible wages, constant government spending shares and monopoly distortions. In order to keep some degree of symmetry between Home and Foreign, we analyze the efficiency of endogenous global monetary policy in the following three cases: Case 1.  $\log(1 - g_c) = E \log(1 - g)$  and  $\log(1 - g_c^*) = E \log(1 - g^*)$ ; Case 2.  $\log(1 - g_c) > E \log(1 - g)$  and  $\log(1 - g_c^*) > E \log(1 - g^*)$ ; Case 3.  $\log(1 - g_c) < E \log(1 - g)$  and  $\log(1 - g_c^*) < E \log(1 - g^*)$ .

**Proposition 1.** *If the government keeps the monopoly distortions to be intact and chooses endogenously monetary policy after observing both the productivity shocks  $K, K^*$  and fiscal spending shocks  $g$  and  $g^*$ , Then*

(1). *The Home monetary policy to replicate the real allocation under flexible wages, constant government spending shares is*

$$m = Em + \frac{1}{2v\varepsilon} \{ \gamma(\varepsilon - 1)(\kappa^* - E\kappa^*) - (2 + \gamma(\varepsilon - 1))(\kappa - E\kappa) \} \\ + \frac{1}{2\varepsilon} \{ (2 - \gamma(1 - \varepsilon))(\log(1 - g) - E \log(1 - g)) + \gamma(1 - \varepsilon)(\log(1 - g^*) - E \log(1 - g^*)) \}, \quad (36)$$

and its Foreign counterpart is

$$m^* = Em^* + \frac{1}{2v\varepsilon} \{ \gamma(\varepsilon - 1)(\kappa - E\kappa) - (2 + \gamma(\varepsilon - 1))(\kappa^* - E\kappa^*) \} \\ + \frac{1}{2\varepsilon} \{ \gamma(1 - \varepsilon)(\log(1 - g) - E \log(1 - g)) + (2 - \gamma(1 - \varepsilon))(\log(1 - g^*) - E \log(1 - g^*)) \}. \quad (37)$$

(2). *The global monetary policy given by Eqs. (36) and (37) is efficient when  $\log(1 - g_c) \geq E \log(1 - g)$  and  $\log(1 - g_c^*) \geq E \log(1 - g^*)$ .*

(3). *The global monetary policy given by Eqs. (36) and (37) can be Pareto improved when  $\log(1 - g_c) < E \log(1 - g)$  and  $\log(1 - g_c^*) < E \log(1 - g^*)$ , if*

$$\frac{1}{v} \frac{(\varphi - 1)(\theta - 1)}{\varphi\theta} \left[ \frac{1}{1 - g_c} - \exp \left[ -E \log(1 - g) + \frac{\sigma_{\log(1-g)}^2}{2} \right] \right] - \frac{(1 - \gamma)v}{2} \left( \frac{\varepsilon^2}{1 - \gamma + \gamma\varepsilon} \right) \frac{(\sigma_m^2 - \sigma_{m^*}^2)}{2} \\ - \frac{(v - 1)}{2v} \{ (2 - \gamma)[\log(1 - g_c) - E \log(1 - g)] + \gamma[\log(1 - g_c^*) - E \log(1 - g^*)] \} \\ > \Theta - \frac{(1 - v^2)}{4v} \left[ (2 - \gamma)\sigma_{\log(1-g)}^2 + \gamma\sigma_{\log(1-g^*)}^2 \right] \quad (38)$$

and

$$\begin{aligned}
& \frac{1}{v} \frac{(\varphi-1)(\theta-1)}{\varphi\theta} \left[ \frac{1}{1-g_c^*} - \exp \left[ -E \log(1-g^*) + \frac{\sigma_{\log(1-g^*)}^2}{2} \right] \right] + \frac{(1-\gamma)v}{2} \left( \frac{\varepsilon^2}{1-\gamma+\gamma\varepsilon} \right) \frac{(\sigma_m^2 - \sigma_{m^*}^2)}{2} \\
& - \frac{(v-1)}{2v} \{ \gamma [\log(1-g_c) - E \log(1-g)] + (2-\gamma) [\log(1-g_c^*) - E \log(1-g^*)] \} \\
& \geq \Theta - \frac{(1-v^2)}{4v} \left[ \gamma \sigma_{\log(1-g)}^2 + (2-\gamma) \sigma_{\log(1-g^*)}^2 \right] \tag{39}
\end{aligned}$$

hold simultaneously, in which

$\Theta = \frac{1}{2v} \sigma_\kappa^2 + \frac{v\varepsilon^2}{8} (\sigma_m^2 + 2\sigma_{mm^*} + \sigma_{m^*}^2) + \frac{v}{8} \left( \frac{\varepsilon}{1-\gamma+\gamma\varepsilon} \right)^2 (\sigma_m^2 - 2\sigma_{mm^*} + \sigma_{m^*}^2) > 0$ . Or inequality (38) with sign  $\geq$  replacing sign  $>$  and inequality (39) with sign  $>$  replacing sign  $\geq$  hold simultaneously. Otherwise, the global monetary policy given by Eqs. (36) and (37) is efficient.

**Proof.** (1). To obtain Eqs. (36) and (37), we take logs to Eqs. (24) and (25) and get  $\bar{y} = \frac{1}{v} \left\{ \log \frac{(\varphi-1)(\theta-1)}{\varphi\theta} - \kappa - \log(1-g_c) \right\}$  and  $\bar{y}^* = \frac{1}{v} \left\{ \log \frac{(\varphi-1)(\theta-1)}{\varphi\theta} - \kappa^* - \log(1-g_c^*) \right\}$ . In addition, log outputs under sticky wages, stochastic government spending shares and monopoly distortions are  $y = z - \frac{1}{2}(w - e - w^*) - \log(1-g)$  and  $y^* = z + \frac{1}{2}(w - e - w^*) - \log(1-g^*)$  respectively. Then Eqs. (36) and (37) can be obtained after we equate  $\bar{y}$  to  $y$  and  $\bar{y}^*$  to  $y^*$ , and express  $z$  and  $e$  in terms of  $m$  and  $m^*$ .

(2). Suppose that there exists other global monetary policy such that both  $EU > E\bar{U}$  and  $EU^* \geq E\bar{U}^*$  hold or both  $EU \geq E\bar{U}$  and  $EU^* > E\bar{U}^*$  hold. From the Eqs. (19), (20), (21), (22), (23), (26) and (27), that both  $EU > E\bar{U}$  and  $EU^* \geq E\bar{U}^*$  hold means

$$\begin{aligned}
& \frac{1}{v} \frac{(\varphi-1)(\theta-1)}{\varphi\theta} \left\{ \frac{1}{1-g_c} - \exp \left[ -E \log(1-g) + \frac{\sigma_{\log(1-g)}^2}{2} \right] \right\} - \frac{(1-\gamma)v}{2} \left( \frac{\varepsilon^2}{1-\gamma+\gamma\varepsilon} \right) \frac{(\sigma_m^2 - \sigma_{m^*}^2)}{2} \\
& > - \frac{(v-1)}{2v} \{ (2-\gamma) [E \log(1-g) - \log(1-g_c)] + \gamma [E \log(1-g^*) - \log(1-g_c^*)] \} + \Theta \\
& - \frac{(1-v^2)}{4v} \left[ (2-\gamma) \sigma_{\log(1-g)}^2 + \gamma \sigma_{\log(1-g^*)}^2 \right] \tag{40}
\end{aligned}$$

and

$$\begin{aligned}
& \frac{1}{v} \frac{(\varphi-1)(\theta-1)}{\varphi\theta} \left\{ \frac{1}{1-g_c^*} - \exp \left[ -E \log(1-g^*) + \frac{\sigma_{\log(1-g^*)}^2}{2} \right] \right\} + \frac{(1-\gamma)v}{2} \left( \frac{\varepsilon^2}{1-\gamma+\gamma\varepsilon} \right) \frac{(\sigma_m^2 - \sigma_{m^*}^2)}{2} \\
& \geq - \frac{(v-1)}{2v} \{ \gamma [E \log(1-g) - \log(1-g_c)] + (2-\gamma) [E \log(1-g^*) - \log(1-g_c^*)] \} + \Theta \\
& - \frac{(1-v^2)}{4v} \left[ \gamma \sigma_{\log(1-g)}^2 + (2-\gamma) \sigma_{\log(1-g^*)}^2 \right] \tag{41}
\end{aligned}$$

hold simultaneously. Under the conditions that  $\varphi > 1$ ,  $\theta > 1$ ,  $v > 1$ ,  $0 \leq \gamma \leq 1$ ,  $\varepsilon > 0$ ,  $E \log(1-g) < 0$ ,  $E \log(1-g^*) < 0$ ,  $\log(1-g_c) < 0$ ,  $\log(1-g_c^*) < 0$ ,  $\sigma_\kappa^2 > 0$ ,  $\sigma_z^2 > 0$ ,  $\sigma_e^2 > 0$ ,  $\sigma_{\log(1-g)}^2 > 0$ ,  $\sigma_{\log(1-g^*)}^2 > 0$ ,  $\log(1-g_c) \geq E \log(1-g)$  and  $\log(1-g_c^*) \geq E \log(1-g^*)$ , the sum



of the right-hand side of the inequality (40) is strictly greater than zero, but the first term of the left-hand side of the inequality (40) is strictly less than zero. The same is true for the inequality (41). Therefore, neither inequalities holds if  $\gamma = 1$  or  $\sigma_m^2 = \sigma_{m^*}^2$ . If  $0 \leq \gamma < 1$  and  $\sigma_m^2 > \sigma_{m^*}^2$ , the inequality (40) doesn't hold. If  $0 \leq \gamma < 1$  and  $\sigma_m^2 < \sigma_{m^*}^2$ , the inequality (41) doesn't hold. In sum, it's impossible for inequalities (40) and (41) to hold simultaneously. Similarly,  $EU \geq E\bar{U}$  and  $EU^* > E\bar{U}^*$  can't hold simultaneously. The above analysis contradicts the hypothesis that there exists other global monetary policy to Pareto improve one given by Eqs. (36) and (37).

(3) .Adding the term  $\frac{1}{v} \left\{ \log \frac{(\varphi-1)(\theta-1)}{\varphi\theta} - E\kappa \right\}$  to both sides of inequalities (38) and (39) respectively and then rearranging yield  $EU > E\bar{U}$  and  $EU^* \geq E\bar{U}^*$ . Similarly, we can obtain  $EU \geq E\bar{U}$  and  $EU^* > E\bar{U}^*$ . Either case means that there exists other global monetary policy that Pareto dominates one given by Eqs. (36) and (37). ■

When there is no fiscal spending, i.e.  $\log(1 - g_c) = E \log(1 - g) = \log(1 - g_c^*) = E \log(1 - g^*) = 0$ , the first two conclusions of Proposition 1 will degenerate into those obtained in OR (2000). In general case in which there exists government spending, Proposition 1 tells us to what extent the conclusion in OR (2000) can be generalized. The second conclusion of Proposition 1 implies that the global monetary policy given by Eqs. (36) and (37) is efficient when  $\log(1 - g_c) \geq E \log(1 - g)$  and  $\log(1 - g_c^*) \geq E \log(1 - g^*)$  are satisfied. What's the reason that the result obtained in OR (2000) hold in this case? Roughly speaking, under the conditions  $\log(1 - g_c) \geq E \log(1 - g)$  and  $\log(1 - g_c^*) \geq E \log(1 - g^*)$ , the adverse influences of stochastic  $g$  and  $g^*$  on  $EU$  are greater than those of constant  $g_c$  and  $g_c^*$  on  $E\bar{U}$ <sup>16</sup>, and the same is true for the Foreign. Though a lower variance of Home exogenous monetary policy than that of Foreign will increase  $EU$ <sup>17</sup>, opposite effect of it on  $EU^*$  makes it impossible for the effects of exogenous monetary policies to exceed those of exogenous fiscal policies in both countries simultaneously. Consequently, the global monetary policy given by (36) and (37) is efficient.

However, under conditions  $\log(1 - g_c) < E \log(1 - g)$  and  $\log(1 - g_c^*) < E \log(1 - g^*)$ , the adverse influences of stochastic  $g$  and  $g^*$  on  $EU$  are less than those of constant  $g_c$  and  $g_c^*$  on

<sup>16</sup>The condition  $\log(1 - g_c) \geq E \log(1 - g)$  means that  $g$  is greater than  $g_c$  with a high probability. Similarly,  $g^*$  is greater than  $g_c^*$  with a high probability. The effect of  $g_c$  on the expected disutility from labor in  $E\bar{U}$  is  $\frac{1}{1-g_c}$ , the effect of stochastic  $g$  on the expected disutility from labor in  $EU$ , however, is  $\exp \left[ -E \log(1 - g) + \frac{\sigma_{\log(1-g)}^2}{2} \right]$ . By the known condition, we have  $\frac{1}{1-g_c} < \exp \left[ -E \log(1 - g) + \frac{\sigma_{\log(1-g)}^2}{2} \right]$ . The effects of  $g_c$  and  $g_c^*$  on expected utility from consumption in  $E\bar{U}$  is  $\frac{(v-1)}{2v} [(2-\gamma) \log(1 - g_c) + \gamma \log(1 - g_c^*)]$ , the effects of stochastic  $g$  and  $g^*$  on the expected utility from consumption in  $EU$ , however, is  $\frac{(v-1)}{2v} [(2-\gamma) E \log(1 - g) + \gamma E \log(1 - g^*)] + \frac{(1-v^2)}{4v} [(2-\gamma) \sigma_{\log(1-g)}^2 + \gamma \sigma_{\log(1-g^*)}^2]$ . By the known conditions, we have

$$\begin{aligned} & \frac{(v-1)}{2v} [(2-\gamma) E \log(1 - g) + \gamma E \log(1 - g^*)] + \frac{(1-v^2)}{4v} [(2-\gamma) \sigma_{\log(1-g)}^2 + \gamma \sigma_{\log(1-g^*)}^2] \\ & < \frac{(v-1)}{2v} [(2-\gamma) \log(1 - g_c) + \gamma \log(1 - g_c^*)]. \end{aligned}$$

Therefore, the adverse effects of stochastic  $g$  and  $g^*$  on  $EU$  are greater than those of constant  $g_c$  and  $g_c^*$  on  $E\bar{U}$ .

<sup>17</sup>A lower variance of Home exogenous monetary policy than that of Foreign implies negative covariance between  $z$  and  $e$ , the negative covariance will deteriorate expected  $TOT$ , as a result, nontradables are cheaper. Given total spending  $z$  measured in tradables, higher real consumption resulting from cheaper nontradables will bring higher expected utility.

$E\bar{U}$ , and the same is true for the Foreign. It's the point that makes it possible for exogenous monetary policies to Pareto improve endogenous monetary policies given in Eqs. (36) and (37). What conditions should Pareto-improving exogenous monetary policies satisfy? Eqs. (38) and (39) are more likely to be satisfied when the followings take place: Both exogenous monetary and fiscal policies are less volatile; the productivity shocks are less volatile; the variances of both Home and Foreign exogenous monetary policies are not only small but also close in values; the government spending shares are expected to be small and the covariance between the Home and Foreign exogenous monetary policies is small. Considering the voluntary participation constraints imposed in our model, these conditions are relevant. When the government spending shares are less volatile, the disutility from labor will be lower and the utility from consumption will be higher in calculating  $EU$  and  $EU^*$ . Less volatility of the monetary policies will increase  $EU$  and  $EU^*$ , because they will lead to a higher expected output measured in tradables  $z$ . Less volatility of the monetary policies also imply that the effect of the monetary policies on expected  $TOT$  is small.<sup>18</sup> Pareto-improving exogenous monetary policies will insure that the possible adverse effect of the monetary policies on  $TOT$ <sup>19</sup> is too small to dominate the beneficial effects of the fiscal and monetary policies on  $EU$  and  $EU^*$ .

A further investigation into OR (2000) reveals that the combination of subsidy policies and monetary policy that replicates the real allocation under flexible wages can replicate the real allocation under flexible wages but without monopoly distortions.<sup>20</sup> The resulting allocation will provide the individual higher expected utility than that provided by using only monetary policy that replicates the real allocation under flexible wages. In addition, the global monetary policy in this circumstance is efficient. Do the same conclusions hold after we introduce stochastic government spending?

**Proposition 2.** *Both Home and Foreign governments can replicate the real allocation under flexible wages, stochastic government spending shares but without monopoly distortions by giving a proportional wage subsidy of  $\frac{1}{\varphi-1}$  and production subsidy of  $\frac{1}{\theta-1}$  to eliminate monopoly distortions and choosing endogenously monetary policy to replicate the real allocation under flexible wages and stochastic government spending shares after observing both productivity shocks  $K, K^*$  and fiscal spending shocks  $g$  and  $g^*$ .*

(1). *The Home monetary policy to replicate the real allocation under flexible wages, stochastic government spending shares is*

$$m = Em + \frac{1}{2v\varepsilon} \{ \gamma(\varepsilon - 1)(\kappa^* - E\kappa^*) - (2 + \gamma(\varepsilon - 1))(\kappa - E\kappa) \} + \frac{1}{2\varepsilon} \left( 1 - \frac{1}{v} \right) \{ (2 - \gamma(1 - \varepsilon))(\log(1 - g) - E\log(1 - g)) + \gamma(1 - \varepsilon)(\log(1 - g^*) - E\log(1 - g^*)) \}, \quad (42)$$

<sup>18</sup>Noticing that the effect of expected  $TOT$  on  $EU$  is opposite to that of it on  $EU^*$ .

<sup>19</sup>Whether the effect is beneficial or adverse depends on the comparison between  $\sigma_m^2$  and  $\sigma_{m^*}^2$ .

<sup>20</sup>In order to get rid of monopoly distortions, the government need to give workers a proportional wage subsidy of  $\frac{1}{\varphi-1}$  and firms a proportional production subsidy of  $\frac{1}{\theta-1}$ .

and its Foreign counterpart is

$$m^* = Em^* + \frac{1}{2v\varepsilon} \{ \gamma(\varepsilon - 1)(\kappa - E\kappa) - (2 + \gamma(\varepsilon - 1))(\kappa^* - E\kappa^*) \} + \frac{1}{2\varepsilon} \left( 1 - \frac{1}{v} \right) \{ \gamma(1 - \varepsilon)(\log(1 - g) - E\log(1 - g)) + (2 - \gamma(1 - \varepsilon))(\log(1 - g^*) - E\log(1 - g^*)) \}. \quad (43)$$

(2) In this case, the global monetary policy given by Eqs. (42) and (43) can be Pareto improved if

$$\begin{aligned} & \frac{1}{v} \exp \left[ -E\log(1 - g) + \frac{\sigma_{\log(1-g)}^2}{2} \right] \left[ 1 - \frac{(\varphi - 1)(\theta - 1)}{\varphi\theta} \right] - \frac{(1 - \gamma)v}{2} \left( \frac{\varepsilon^2}{1 - \gamma + \gamma\varepsilon} \right) \frac{(\sigma_m^2 - \sigma_{m^*}^2)}{2} \\ & > -\frac{1}{v} \log \frac{(\varphi - 1)(\theta - 1)}{\varphi\theta} + \Theta - \frac{(1 - v^2)}{4v} \left[ (2 - \gamma)\sigma_{\log(1-g)}^2 + \gamma\sigma_{\log(1-g^*)}^2 \right] \end{aligned} \quad (44)$$

and

$$\begin{aligned} & \frac{1}{v} \exp \left[ -E\log(1 - g^*) + \frac{\sigma_{\log(1-g^*)}^2}{2} \right] \left[ 1 - \frac{(\varphi - 1)(\theta - 1)}{\varphi\theta} \right] + \frac{(1 - \gamma)v}{2} \left( \frac{\varepsilon^2}{1 - \gamma + \gamma\varepsilon} \right) \frac{(\sigma_m^2 - \sigma_{m^*}^2)}{2} \\ & \geq -\frac{1}{v} \log \frac{(\varphi - 1)(\theta - 1)}{\varphi\theta} + \Theta - \frac{(1 - v^2)}{4v} \left[ \gamma\sigma_{\log(1-g)}^2 + (2 - \gamma)\sigma_{\log(1-g^*)}^2 \right] \end{aligned} \quad (45)$$

hold simultaneously. Or inequality (44) with sign  $\geq$  replacing sign  $>$  and inequality (45) with sign  $>$  replacing sign  $\geq$  hold simultaneously. Otherwise, the global monetary policy given by Eqs. (42) and (43) is efficient.

**Proof.** (1) To obtain Eqs.(42) and (43), we take logs to Eqs. (28) and (29) and get  $\hat{y} = \frac{1}{v} [-\log(1 - g) - \kappa]$  and  $\hat{y}^* = \frac{1}{v} [-\log(1 - g^*) - \kappa^*]$ . Then Eqs. (42) and (43) are obtained after we equate  $\hat{y}$  to  $y$  and  $\hat{y}^*$  to  $y^*$ , and express  $z$  and  $e$  in terms of  $m$  and  $m^*$ .

(2). Adding the term  $-\frac{1}{v}E\kappa + \frac{(v-1)}{2v} [(2 - \gamma)E\log(1 - g) + \gamma E\log(1 - g^*)]$  to both sides of inequality (44) and  $-\frac{1}{v}E\kappa + \frac{(v-1)}{2v} [\gamma E\log(1 - g) + (2 - \gamma)E\log(1 - g^*)]$  to both sides of inequality (45) and then rearranging both enlarged inequalities yield  $EU > E\hat{U}$  and  $EU^* \geq E\hat{U}^*$ . Similarly,  $EU \geq E\bar{U}$  and  $EU^* > E\bar{U}^*$  can hold simultaneously. Either case means that there exists other global monetary policy to Pareto dominate one given by Eqs. (42) and (43). Clearly, if neither case holds, then the global monetary policy given by Eqs. (42) and (43) is efficient. ■

Comparison between the conclusion implied in OR (2000) and Proposition 2 shows that the introduction of stochastic government spending can affect the efficiency of the global monetary policy that replicates the real allocation under flexible wages when monopoly distortions are completely eliminated. What Proposition 2 tells us seems difficult to understand at the first sight. After all, with the removal of dual distortions caused by sticky wages and monopoly distortions, it seems that the individual's expected utility in the distortions-removed world should be unconditionally higher than that in the distortions-remained world. But Proposition 2 clearly tells us that the endogenous monetary policies to replicate real allocation under flexible wages and stochastic government spending shares are not globally optimal under some conditions when

monopoly distortions both in labor and output markets are eliminated, why? The key is that the monopoly distortions both in labor and output markets will decrease the disutility from labor when the wages are sticky. The presence of stochastic government spending causes the benefit of a lower disutility from labor to outweigh adverse effect of monopoly distortions on expected utility from consumption.<sup>21</sup> The greater is the firm's monopoly power (a higher mark-up  $\frac{\theta}{\theta-1}$ ), the higher is the output price, and the individual will decrease the labor supply when facing a lower real wage. A greater labor monopoly power (a higher mark-up  $\frac{\varphi}{\varphi-1}$ , equivalently, a lower value of  $\varphi$ ) will make firm's demand for labor more stable<sup>22</sup>. The above analysis shows that the disutility from labor when monopoly distortions both in output and labor markets are remained is lower than that when monopoly distortions are eliminated. The comparison of the term  $\frac{1}{v} \frac{(\varphi-1)(\theta-1)}{\varphi\theta} \exp \left[ -E \log(1-g) + \frac{\sigma_{\log(1-g)}^2}{2} \right]$  with the term  $\frac{1}{v} \exp \left[ -E \log(1-g) + \frac{\sigma_{\log(1-g)}^2}{2} \right]$  confirms our analysis. When the benefit  $\left( \frac{1}{v} \exp \left[ -E \log(1-g) + \frac{\sigma_{\log(1-g)}^2}{2} \right] \left[ 1 - \frac{(\varphi-1)(\theta-1)}{\varphi\theta} \right] \right)$  is large enough, it leaves room for improvement to the endogenously chosen monetary policies given by Eqs. (42) and (43). Under what conditions do inequalities (44) and (45) hold? Taking Taylor expansions to the terms  $\frac{1}{v} \exp \left[ -E \log(1-g) + \frac{\sigma_{\log(1-g)}^2}{2} \right] \left[ 1 - \frac{(\varphi-1)(\theta-1)}{\varphi\theta} \right]$  and  $-\frac{1}{v} \log \frac{(\varphi-1)(\theta-1)}{\varphi\theta}$  on both sides of the inequality (44) and rearranging yield the following<sup>23</sup>

$$\begin{aligned} & \frac{1}{v} \left[ 1 - \frac{(\varphi-1)(\theta-1)}{\varphi\theta} \right] \left[ -E \log(1-g) + \frac{\sigma_{\log(1-g)}^2}{2} \right] - \frac{(1-\gamma)v}{2} \left( \frac{\varepsilon^2}{1-\gamma+\gamma\varepsilon} \right) \frac{(\sigma_m^2 - \sigma_{m^*}^2)}{2} \\ & > \Theta - \frac{(1-v^2)}{4v} \left[ (2-\gamma)\sigma_{\log(1-g)}^2 + \gamma\sigma_{\log(1-g^*)}^2 \right]. \end{aligned}$$

The immediately above inequality indicates that following conditions should be satisfied: the markups in both output and labor market are large; the expected values of the government spending shares are large; the variances of the government spending shares satisfy voluntary participation constraints; the variances of both Home exogenous monetary policy and its Foreign counterpart are small and close in values; the covariance between Home exogenous monetary policy and its Foreign counterpart is small; and the variances of productivity shocks are small. As before, these

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<sup>21</sup>Here the presence of stochastic government spending is vital for our departure from the conclusion in OR (2000). In OR (2000), the benefit of a lower disutility from labor is  $\frac{1}{v} \left[ 1 - \frac{(\varphi-1)(\theta-1)}{\varphi\theta} \right]$  and the adverse effect of monopoly distortions on expected utility from consumption is  $\frac{1}{v} \log \left[ \frac{(\varphi-1)(\theta-1)}{\varphi\theta} \right]$ . The net effect of monopoly distortions is  $\frac{1}{v} \left[ 1 - \frac{(\varphi-1)(\theta-1)}{\varphi\theta} \right] + \frac{1}{v} \log \left[ \frac{(\varphi-1)(\theta-1)}{\varphi\theta} \right]$ , which is approximated by zero after taking Taylor expansions to  $\log \left[ \frac{(\varphi-1)(\theta-1)}{\varphi\theta} \right]$ . However, after introducing the stochastic government spending, the net effect of monopoly distortions is  $\frac{1}{v} \exp \left[ -E \log(1-g) + \frac{\sigma_{\log(1-g)}^2}{2} \right] \left[ 1 - \frac{(\varphi-1)(\theta-1)}{\varphi\theta} \right] + \frac{1}{v} \log \left[ \frac{(\varphi-1)(\theta-1)}{\varphi\theta} \right]$ , which is approximated by  $\frac{1}{v} \left[ -E \log(1-g) + \frac{\sigma_{\log(1-g)}^2}{2} \right] \left[ 1 - \frac{(\varphi-1)(\theta-1)}{\varphi\theta} \right] > 0$ , after we take Taylor expansions to  $\exp \left[ -E \log(1-g) + \frac{\sigma_{\log(1-g)}^2}{2} \right]$  and  $\log \left[ \frac{(\varphi-1)(\theta-1)}{\varphi\theta} \right]$ .

<sup>22</sup>Note that  $\varphi$  is the wage elasticity of labor demand.

<sup>23</sup>We can get a similar inequality from inequality (45) by taking the same steps.

conditions are relevant in view of the voluntary participation constraints imposed in our model.

What would happen if the government lets the individuals reap the benefit of a lower disutility from labor caused by monopoly distortions and endogenously chooses the monetary policy to replicate real allocation under flexible wages and stochastic government spending shares?

**Proposition 3.** *If the government leaves the monopoly distortions to be intact and chooses endogenously monetary policy after observing both productivity shocks  $K$ ,  $K^*$  and fiscal spending shocks  $g$  and  $g^*$ , then*

(1). *Home monetary policy to replicate the real allocation under flexible wages, stochastic government spending shares is*

$$m = Em + \frac{1}{2v\varepsilon} \{ \gamma(\varepsilon - 1)(\kappa^* - E\kappa^*) - (2 + \gamma(\varepsilon - 1))(\kappa - E\kappa) \} + \frac{1}{2\varepsilon} \left( 1 - \frac{1}{v} \right) \{ (2 - \gamma(1 - \varepsilon))(\log(1 - g) - E \log(1 - g)) + \gamma(1 - \varepsilon)(\log(1 - g^*) - E \log(1 - g^*)) \}, \quad (46)$$

and its Foreign counterpart is

$$m^* = Em^* + \frac{1}{2v\varepsilon} \{ \gamma(\varepsilon - 1)(\kappa - E\kappa) - (2 + \gamma(\varepsilon - 1))(\kappa^* - E\kappa^*) \} + \frac{1}{2\varepsilon} \left( 1 - \frac{1}{v} \right) \{ \gamma(1 - \varepsilon)(\log(1 - g) - E \log(1 - g)) + (2 - \gamma(1 - \varepsilon))(\log(1 - g^*) - E \log(1 - g^*)) \}. \quad (47)$$

(2). *The global monetary policy given by Eqs. (46) and (47) is efficient.*

**Proof.** (1). Both Eqs. (46) and (47) are identical to their counterparts in proposition 2, and can be obtained by taking the same methods.

(2). Suppose that there exists other global monetary policy such that both  $EU > E\tilde{U}$  and  $EU^* \geq E\tilde{U}^*$  hold simultaneously or both  $EU \geq E\tilde{U}$  and  $EU^* > E\tilde{U}^*$  hold simultaneously. From Eqs. (19), (20), (21), (22), (23), (34) and (35), that both  $EU > E\tilde{U}$  and  $EU^* \geq E\tilde{U}^*$  hold simultaneously means

$$-\frac{(1 - \gamma)v}{2} \left( \frac{\varepsilon^2}{1 - \gamma + \gamma\varepsilon} \right) \frac{(\sigma_m^2 - \sigma_{m^*}^2)}{2} > \Theta - \frac{(1 - v^2)}{4v} \left[ (2 - \gamma)\sigma_{\log(1-g)}^2 + \gamma\sigma_{\log(1-g^*)}^2 \right] \quad (48)$$

and

$$\frac{(1 - \gamma)v}{2} \left( \frac{\varepsilon^2}{1 - \gamma + \gamma\varepsilon} \right) \frac{(\sigma_m^2 - \sigma_{m^*}^2)}{2} \geq \Theta - \frac{(1 - v^2)}{4v} \left[ \gamma\sigma_{\log(1-g)}^2 + (2 - \gamma)\sigma_{\log(1-g^*)}^2 \right] \quad (49)$$

hold simultaneously. Given the conditions that  $\varphi > 1$ ,  $\theta > 1$ ,  $v > 1$ ,  $0 \leq \gamma \leq 1$ ,  $\varepsilon > 0$ ,  $\sigma_\kappa^2 > 0$ ,  $\sigma_z^2 > 0$ ,  $\sigma_e^2 > 0$ ,  $\sigma_{\log(1-g)}^2 > 0$  and  $\sigma_{\log(1-g^*)}^2 > 0$ , inequalities (48) and (49) can not hold simultaneously. As a result,  $EU > E\tilde{U}$  and  $EU^* \geq E\tilde{U}^*$  can not hold simultaneously. Similarly

$EU \geq E\tilde{U}$  and  $EU^* > E\tilde{U}^*$  can not hold simultaneously. The above analysis contradicts that there exists other global monetary policy to Pareto improve one given by Eqs. (46) and (47). ■

Comparison between Proposition 2 and Proposition 3 shows that the monopoly distortions are essential for the efficiency of the global monetary policy that replicates the real allocation under flexible wages and stochastic government spending shares. In addition, the government uses the same monetary policy to replicate the real allocation under flexible wages and stochastic government spending shares irrespective of monopoly distortions. The result comes from separability of effect of monopoly distortions on  $\tilde{y}$  from other factor's effects on the same  $\tilde{y}$ . The marked difference between Proposition 3 and Propositions 1 and 2 is that the global monetary policy given in Proposition 3 is efficient. By contrast, those given in Propositions 1 and 2 can be Pareto improved under some conditions.

Now we say something more on the monetary policies in Proposition 3. When  $\gamma = 0$  (no tradable goods), or  $\varepsilon = 1$  (no over/undershooting), a country's monetary policy will only respond to its own productivity shock and government spending shock. In addition, the Home government will use an expansionary monetary policy as a response to Home positive productivity shock. But the same productivity shock will elicit a contractionary Foreign monetary policy response when  $\varepsilon > 1$ . As far as government spending shock is concerned, the Home government will use a contractionary monetary policy as a response to Home positive government spending shock, and the same government spending shock will result in an expansionary Foreign monetary policy response when  $\varepsilon > 1$ . However, as showed by implied aggregate global monetary policy

$$m + m^* = Em + Em^* - \frac{1}{v\varepsilon} [(\kappa - E\kappa) + (\kappa^* - E\kappa^*)] \\ + \frac{1}{\varepsilon} \left(1 - \frac{1}{v}\right) [(\log(1-g) - E\log(1-g)) + (\log(1-g^*) - E\log(1-g^*))],$$

the positive productivity shock whether occurred in the Home or Foreign will lead to expansionary net global monetary response. By comparison, the positive government spending shock whether occurred in the Home or Foreign will cause contractionary net global monetary response.

In OR (2000), the government can attain the highest expected utility using the combination of subsidy and monetary policies to replicate the real allocation under flexible wages but without monopoly distortions. After we introduce the stochastic government spending shares, the government can still replicate the real allocation under flexible wages, stochastic government spending shares but without monopoly distortions by the combination of subsidy policies that eliminate monopoly distortions and monetary policy that replicates the real allocation under flexible wages and stochastic government spending shares. But the expected utility provided by monetary policy that replicates the real allocation under flexible wages and stochastic government spending shares when monopoly distortions are completely eliminated is lower than that provided by the same global monetary policy accompanied by specially-chosen subsidy policies. Two types of subsidy policies can be specially chosen, they are either the combination of a proportional wage subsidy of  $\frac{\varphi}{\varphi-1} \exp[E\log(1-g)] - 1$  and a proportional production subsidy of  $\frac{\theta}{\theta-1} \exp\left[-\frac{\sigma_{\log(1-g)}^2}{2}\right] - 1$  or the combination of a proportional wage subsidy of  $\frac{\varphi}{\varphi-1} \exp\left[-\frac{\sigma_{\log(1-g)}^2}{2}\right] - 1$  and a proportional produc-

tion subsidy of  $\frac{\theta}{\theta-1} \exp [E \log (1-g)] - 1$ .<sup>24</sup> Is the global monetary policy that replicates the real allocation under flexible wages and stochastic government spending shares when the governments adopt the above-mentioned subsidy policies efficient? By the same methods that we use in the proof of Proposition 2, we can conclude that the global monetary policy in this circumstance can be Pareto improved when the same conditions are satisfied as those in Proposition 2. Otherwise, it is efficient.

## 6. The fiscal policy

The results in last section demonstrate that the government can choose endogenously monetary policy to replicate the real allocation under flexible wages and stochastic government spending shares. Can the government chooses endogenously fiscal policy to achieve the same purpose?

**Proposition 4.** *The government can't choose endogenously fiscal policy to replicate the real allocation under flexible wages, stochastic government spending shares, irrespective of monopoly distortions. Even if the government makes choice after observing productivity shocks  $K$ ,  $K^*$  and monetary shocks  $M$  and  $M^*$ .*

**Proof.** From the expressions (28), (29), (32) and (33), we know that these real allocations all depend on the stochastic government spending shares. It's obvious that the government can't replicate them with endogenously-chosen fiscal policy. ■

The result here is somewhat like that obtained in Lombardo and Sutherland (2004), but in a more simple way.

## 7. Conclusion

This paper has investigated the efficiency of global monetary policy in a two-country general equilibrium model with monopolistic competition and wage stickiness. We found that, when the government keeps the monopoly distortions to be intact and endogenously chooses the monetary policy to replicate the real allocation under flexible wages, constant government spending shares, the global monetary policy is efficient under the conditions  $\log (1-g_c) \geq E \log (1-g)$  and  $\log (1-g_c^*) \geq E \log (1-g^*)$ . But under the conditions  $\log (1-g_c) < E \log (1-g)$  and  $\log (1-g_c^*) < E \log (1-g^*)$ , it can be either efficient or Pareto improved depending on whether some requirements are satisfied. As compared with the conclusion implied in OR (2000, 2002) that global monetary policy that replicates the real allocation under flexible wages when monopoly distortions are completely eliminated is efficient, after we introduce stochastic government spending, the global monetary policy to replicate the real allocation under flexible wages, stochastic government spending shares when monopoly distortions are completely eliminated can be Pareto improved when some conditions are satisfied. Otherwise, it is efficient. The reason is that the monopoly distortions both in labor and output markets will decrease the disutility from labor when the wages

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<sup>24</sup>The subsidy policies are obtained by choosing  $\frac{(\varphi-1)(\theta-1)}{\varphi\theta}$  to maximize

$$\log \frac{(\varphi-1)(\theta-1)}{\varphi\theta} - \frac{(\varphi-1)(\theta-1)}{\varphi\theta} \exp \left[ -E \log (1-g) + \frac{\sigma_{\log(1-g)}^2}{2} \right].$$

are sticky. The presence of stochastic government spending causes the benefit of a lower disutility from labor to outweigh adverse effect of monopoly distortions on expected utility from consumption. The complete elimination of monopoly distortions in labor and output markets will remove the potentially large gains when stochastic government spending is present. The distinction between our finding and what is implied in OR (2000, 2002) indicates that the stochastic government spending can affect the efficiency of global monetary policy with which the government replicates the real allocation under flexible wages when monopoly distortions are completely eliminated. However, when the government endogenously chooses monetary policy to replicate the real allocation under flexible wages, stochastic government spending shares when monopoly distortions are intact, as in OR (2000, 2002), the global monetary policy is efficient. Comparison of the conclusion in Proposition 2 and that in Proposition 3 shows, unlike what is implied in OR (2000, 2002), that the monopoly distortions can also affect the efficiency of global monetary policy.

Another departure from OR (2000, 2002) is the global monetary policy that replicates the real allocation under flexible wages and stochastic government spending shares when monopoly distortions are completely eliminated provides less utility than the same global monetary policy when the government chooses special subsidy policies. However, the global monetary policy with the specially-chosen subsidy policies can also be Pareto improved by exogenous global monetary policy when some conditions are satisfied. Otherwise, it is efficient.

As far as fiscal policy is concerned, the government can't choose endogenously the fiscal policy to replicate the real allocation under flexible wages, stochastic government spending shares, irrespective of monopoly distortions.

## References

- Adao, B., Correia, I., Teles, P., 2009. On the relevance of exchange rate regimes for stabilization policy. *Journal of Economic Theory* 144, 1468-1488.
- Barro, R.J., 1990. Government spending in a simple model of endogenous growth. *The Journal of Political Economy* 98, S103-S125.
- Beetsma, R., Jensen, H., 2005. Monetary and fiscal policy interactions in a micro-founded model of a monetary union. *Journal of International Economics* 67, 320-352.
- Benigno, G., Benigno, P., 2003. Price stability in open economies. *The Review of Economic Studies* 70, 743-764.
- Benigno, G., Paoli, B.D., 2010. On the international dimension of fiscal policy. *Journal of Money, Credit and Banking* 42, 1523-1542.
- Benigno, P., 2004. Optimal monetary policy in a currency area. *Journal of International Economics* 63, 293-320.
- Betts, C., Devereux, M.B., 2000. Exchange rate dynamics in a model of pricing-to-market. *Journal of International Economics* 50, 215-244.
- Chari, V.V., Kehoe, P.J., McGrattan, E.R., 2002. Can sticky price models generate volatile and persistent real exchange rates? *The Review of Economic Studies* 69, 533-563.
- Clarida, R., Gali, J., Gertler, M., 2002. A simple framework for international monetary policy analysis. *Journal of Monetary Economics* 49, 879-904.
- Corsetti, G., Pesenti, P., 2001. Welfare and macroeconomic interdependence. *The Quarterly Journal of Economics* 116, 421-445.
- Corsetti, G., Pesenti, P., 2005. International dimensions of optimal monetary policy. *Journal of Monetary Economics* 52, 281-305.



- Corsetti, G., Dedola, L., Leduc, S., 2011. Optimal monetary policy in open economies, in: Friedman, B.M., Wordford, M. (Eds.), *Handbook of monetary economics*, Vol. 3. Elsevier, pp.861-934.
- Devereux, M.B., Engel, C., 2003. Monetary policy in the open economy revisited: price setting and exchange rate flexibility. *The Review of Economic Studies* 70, 765-783.
- Duarte, M., Obstfeld, M., 2008. Monetary policy in the open economy revisited: the case for exchange-rate flexibility restored. *Journal of International Monetary and Finance* 27, 949-957.
- Engel, C., 2011. Currency misalignments and optimal monetary policy: a reexamination. *American Economic Review* 101, 2796-2822.
- Farhi, E., Gopinath, G., Itskhoki, O., 2011. Fiscal devaluations. Harvard University Working Paper.
- Ferrero, A., 2009. Fiscal and monetary rules for a currency union. *Journal of International Economics* 77, 1-10.
- Gali, J., Monacelli, T., 2005. Monetary policy and exchange rate volatility in a small open economy. *The Review of Economic Studies* 72, 707-734.
- Gali, J., Monacelli, T., 2008. Optimal monetary and fiscal policy in a currency union. *Journal of International Economics* 76, 116-132.
- Hau, H., 2000. Exchange rate determination: the role of factor price rigidities and nontradeables. *Journal of International Economics* 50, 421-447.
- Kirsanova, T., Satchi, M., Vines, D., Wren-Lewis, S., 2007. Optimal fiscal policy rules in a monetary union. *Journal of Money, Credit and Banking* 39, 1759-1784.
- Lombardo, G., Sutherland, A., 2004. Monetary and fiscal interactions in open economies. *Journal of macroeconomics* 2004, 319-347.
- Obstfeld, M., Rogoff, K., 1995. Exchange rate dynamics redux. *The Journal of Political Economy* 1995, 103, 624-660.
- Obstfeld, M., Rogoff, K., 2001. Risk and Exchange rates. Prepared for the conference in honor of Assaf Razin.
- Obstfeld, M., Rogoff, K., 2000. New directions for stochastic open economy models. *Journal of International Economics* 50, 117-153.
- Obstfeld, M., Rogoff, K., 2002. Global implications of self-oriented national monetary rules. *The Quarterly Journal of Economics* 117, 503-535.
- Schmitt-Grohé, S., Uribe, M., 2004. Optimal fiscal and monetary policy under sticky prices. *Journal of Economic Theory* 114, 198-230.
- Tille, C., 2001. The role of consumption substitutability in the international transmission of monetary shocks. *Journal of International Economics* 53, 421-444.
- Woodford, M.D., 2003. *Interest and prices*. Princeton University Press.
- Zou, Heng-fu., 1993. Dollarization and inflation in a two-country optimization model. *Journal of International Money and Finance* 12, 209-220.
- Zou, Heng-fu., 1994. Short-run analysis of fiscal policy and the current account in a finite horizon model. *Journal of macroeconomics* 16 (2), 347-357.