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On the Efficiency of Monetary and Fiscal Policy in Open Economies

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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 under some conditions, stochastic government spending can affect the efficiency of global monetary policy rules that replicate the real allocations under flexible wages. When stochastic government spending is present, unlike Obstfeld and Rogoff (2000), we find that, when the above-mentioned conditions are satisfied, the monopoly distortions can also affect the efficiency of global monetary policy rules that replicate the real allocations under flexible wages. The combination of proportional subsidy policies used to completely eliminate monopoly distortions and the monetary policy rules replicating the real allocations under flexible wages, contrary to Obstfeld and Rogoff (2000), can not achieve utility level under competitive equilibrium in our settings. Fiscal policy is found to be unable to replicate the real allocations under flexible wages.

Key Words: New open-economy macroeconomics; Efficiency of global monetary policy rules; Stochastic government spending; Monopoly distortions.

JEL Classification Numbers: E52, E61, E62, E63, F33.

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1. INTRODUCTION

Much recent research has focused on the choice of optimal global monetary policy rules in open economies with imperfect competition and price stickiness.[1] One of conclusions of the research is that optimal global monetary policy rules involve replicating the real allocations 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[2], Benigno and Benigno (hereafter BB, 2003) under some restrictive conditions, among many others. Equivalently, the conclusion means that global monetary policy rules replicating the real allocations under flexible prices are efficient. The point is easy to understand, *inter alia,* when government has access to a subsidy financed with lump-sum taxes to dismantle the inefficiency introduced by imperfect competition in product and factor markets, flexible prices can induce an efficient allocation of resources across different uses and times.

We revisit this problem and verify whether global monetary policy rules replicating the real allocations under flexible prices are efficient or not when we introduce stochastic government spending shocks in OR (2000). Though the practice is similar to that adopted in the recent literature on the interactions between monetary and fiscal policy in open economies[3], the fiscal role played by the government in our analysis is different. We just assume that the government spending is exogenously given shock, when we analyze the efficiency of the global monetary policy rules that replicate the real allocations under flexible wages[4].

The introduction of stochastic government spending can change substantially 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 global monetary policy rules that replicate the real allocations under flexible wages when monopoly distortions are completely eliminated by government's proportional subsidy policies are efficient. However, after we introduce the stochastic government spending, the result can be overturned under some conditions. It means that stochastic government spending can affect the efficiency of global monetary policy rules that replicate the real allocations under flexible wages . The key is that the monopoly distortions both

[1] 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.

[2] PCP is the abbreviation of producer currency pricing. By comparison, another specification is local currency pricing or LCP

[3] 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.

[4] OR (2000, 2002) assumes sticky nominal wages but perfect flexible output prices and believes that it is more closer to the reality.

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 policies to Pareto improve ones that replicate the real allocations under flexible wages and stochastic government spending shares, when monopoly distortions are completely eliminated. Otherwise, the global monetary policy rules that replicate the real allocations under flexible wages and stochastic government spending shares but without monopoly distortions are efficient.

The above-mentioned conditions require: the markups in both output and labor markets being large; the expected values of the government spending shares being large; the variances of the government spending shares satisfying voluntary participation constraints; the variances of both Home exogenous monetary shock and it's Foreign counterpart being small and close in values; the covariance between Home exogenous monetary shock and it's Foreign counterpart being small; and the variances of productivity shocks being small. These conditions are relevant in view of the voluntary participation constraints imposed in our model.

After we introduce the stochastic government spending, monopoly distortions turn to be important for the efficiency of the global monetary policy rules that replicate the real allocations under flexible wages. As emphasized in the last paragraph, one of our conclusions is that the global monetary policy rules that replicate the real allocations 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 conditions above-specified. By comparison, global monetary policy rules that replicate the real allocations under flexible wages and stochastic government spending shares, when the government leaves the monopoly distortions to be intact, are efficient. Comparison means that complete removal of monopoly distortions in both labor and product markets will, under above-listed conditions, change the global monetary policy rules that replicate the real allocations under flexible wages and stochastic government spending shares from being efficient to inefficient.

In OR (2000, 2002), the global monetary policy rules that replicate the real allocations under flexible wages, when monopoly distortions are completely eliminated, can achieve Pareto optimal utility levels. After introducing the stochastic government spending, we depart from the conclusion and show that the expected utility provided by global monetary policy rules that replicate the real allocations 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 rules accompanied by some specially-chosen subsidy policies. However, the global monetary policy rules accompanied by the specially-chosen subsidy policies can also be Pareto improved by exogenous monetary policies, when the same conditions as those mentioned above are satisfied. Otherwise, they are efficient.

One potential merit of our introducing stochastic government spending is that we can analyze endogenous global fiscal policy rules. We assume that the government can endogenously choose the fiscal policy as a stabilization tool after observing the productivity shocks and monetary shocks. However, similar to what obtained in Lombardo and Sutherland (2004), the endogenous fiscal policy rules can't replicate the real allocations 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 rules that replicate the real allocations under flexible wages; Section 6 analyzes the endogenous fiscal policy rules; 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 closely parallel those 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 and each of them is a point in the interval $[0, 1]$. And as in OR (2000, 2002) and other recent research, we consider a single period only which is justified by the separability of utility function in tradables and nontradables and perfect international sharing of consumption risks in tradable goods. In the following analysis, we use asterisks to denote Foreign variables.

2.1. Preferences

All individuals have identical preferences and a Home individual of type i maximizes the expected value of

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

where

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

and $v > 1$.[5] In equation (1), M is exogenous stochastic money supply, K is a stochastic Home productivity shock and a fall in K represents a positive productivity shock. For any individual i, the overall consumption index C is a geometric average of tradables and nontradables and it's form 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

$$C_T = 2C_H^{\frac{1}{2}} C_F^{\frac{1}{2}}. \tag{2}$$

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

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

[5] 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 many others.

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

In addition, domestic price index for C_T is

$$P_T = P_H^{\frac{1}{2}} P_F^{\frac{1}{2}}, \tag{3}$$

for C is

$$P = P_T^{\gamma} P_N^{1-\gamma}. \tag{4}$$

Cost minimization yields the following domestic commodity demand functions

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

$$C_H = \frac{1}{2} \left(\frac{P_H}{P_T} \right)^{-1} C_T, \quad C_F = \frac{1}{2} \left(\frac{P_F}{P_T} \right)^{-1} C_T,$$

$$C_T(h) = \left[\frac{P_T(h)}{P_H} \right]^{-\theta} C_{H,} \quad C_T(f) = \left[\frac{P_T(f)}{P_F} \right]^{-\theta} C_F,$$

$$C_N(h) = \left[\frac{P_N(h)}{P_N} \right]^{-\theta} C_N.$$

In line with O&R (1995), we assume that both Home and Foreign government spending do not directly affect private utility and the government spending index takes the same form as the individual's. It implies G_H, index of government spending on tradables, and G_N, index of government spending on nontradables, are respectively

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

and

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

In addition, we suppose that government spending accounts for an identical proportion both in traded and nontraded sector, which means that $\frac{G_H}{\int_0^1 Y_H(j)dj} = \frac{G_N}{\int_0^1 Y_N(j)dj}$.As in Barro (1990), we let $g = \frac{G_H}{\int_0^1 Y_H(j)dj}$

$= \frac{G_N}{\int_0^1 Y_N(j)dj}$ denote government size. We also assume that 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

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

We also follow Beetsma and Jensen (2005), and assume a complete home bias in government spending. Therefore, we don't construct an aggregate index for government spending as we do for individual consumption.

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

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

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

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

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

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

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

2.3. Asset markets and budget constraints

All domestic profits and initial stock of domestic currency are shared equally by Home individuals. And as explained in OR (2000, 2002), it doesn't exist ex ante equity trade between Home and Foreign.

Home individual i has the following budget constraint

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

where Π_H and Π_N are profits payed by firms and T is per capita lump-sum tax denominated by composite consumption good.

The government finances its spending by levying a lump-sum tax on households and issuing money to collect Seigniorage. Therefore, its 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, it means that, ex post, workers will meet any unexpected changes in the amount of labor that the firms demand at the agreed-on wage. As emphasized by Corsetti and Pesenti (2001, 2005), our analysis below is meaningful only when the variances of the shocks are sufficiently small and participation constraints are never violated.

3.1. Optimal wage setting

Solving individual's optimization problem yields the first-order condition for the optimal preset nominal wage $W(i)$:

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

The above equation, in the absence of uncertainty, requires that the marginal utility of the real wage be a constant markup $\frac{\phi}{\phi-1}$ over the marginal disutility of labor.

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

Though monopolistic firms can freely charge prices, it's optimal for them to charge a fixed markup over cost both in Home and Foreign, when facing constant and identical elasticities of demand at home and abroad. It implies that

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

in which $\mathcal{E}$ is nominal exchange rate, expressed as the home currency per unit of Foreign currency. The real exchange rate is

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

The relative price of Home imports in terms of Home exports— the terms of trade—is expressed as

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

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), and Devereux and Engel (2003) in the case of PCP. 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 $C_T = C_T^*$.

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 household spending $Z \equiv C_T + \left(\frac{P_N}{P_T}\right) C_N$ is identical to Foreign household 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

Using national income identity $PC = (1-g)\,[P_H Y_H + P_N Y_N] = P_T Z$, pricing equation (10) and the equation $L = Y_H + Y_N$ which is obtained by symmetry and aggregation, we can rewrite wage setting equation (9) as

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

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

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

As we show in the following, equations (13) and (14) will lead to a simple closed-form solution to describe wages, expected expenditure, and the expected terms of trade.

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 let lower case letters denote natural logs and $E\kappa = E\kappa^*$ and $\sigma_\kappa^2 = \sigma_{\kappa^*}^2$.

4.1. Solutions for expected terms of trade and world spending

Taking logs to equation (14) yields

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

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

(15) yields

$$Ez = \frac{1}{\upsilon}\left\{\log\left[\frac{(\phi-1)(\theta-1)}{\phi\theta}\right] - E\kappa - \frac{1}{2}\sigma_\kappa^2\right\} - \frac{\nu}{2}\sigma_z^2 - \frac{\upsilon}{8}\sigma_e^2 - \frac{1}{2}\left(\sigma_{\kappa z} + \sigma_{\kappa^* z}\right)$$
$$- \frac{1}{4}\left(\sigma_{\kappa e} - \sigma_{\kappa^* e}\right) + \frac{(\nu-1)}{2\nu}\left[E\log(1-g) + E\log(1-g^*)\right]$$
$$+ \frac{\left(1-\upsilon^2\right)}{4\nu}\left(\sigma^2_{\log(1-g)} + \sigma^2_{\log(1-g^*)}\right) + \frac{1}{2}\left(\sigma_{\kappa\log(1-g)} + \sigma_{\kappa^*\log(1-g^*)}\right)$$
$$+ \frac{\upsilon}{4}\left(\sigma_{e\log(1-g)} - \sigma_{e\log(1-g^*)}\right) + \frac{\upsilon}{2}\left(\sigma_{z\log(1-g)} + \sigma_{z\log(1-g^*)}\right). \qquad (16)$$

If the government spending disappears, equations (15) and (16) are identical to their counterparts in OR (2000), and have the same explanations. After we introduce the government spending, however, they 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 equation (15), A positive covariance between productivity shock κ and $1-g$ (remaining output fraction left to individuals after government buys a fraction of 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, which induces firms employ more labor and produce more products, accordingly, Home's expected terms of trade $E\tau$ deteriorates. The explanations of the effects of $\sigma_{e\log(1-g)}$ 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 $E\log(1-g)$[6]. A higher expected government spending in all states will affect expected output by two different channels. 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 comparison of depressing effect of higher ex ante wage and direct stimulating effect of higher expected government spending.[7] Anyway, a higher expected government spending will crowd out expected private consumption.[8] 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

[6]A higher value of Eg implies a more negative value of $E\log(1-g)$.

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

[8]From the equation $Ec = Ez + \frac{1-\gamma}{2}E\tau$ and the expressions for Ez and $E\tau$, the statement is obvious.

whether Home expected government spending exceeds that of Foreign or not. If the former is true, domestic private tradables will be scarcer as a result of a larger crowding effect, consequently, Home's expected TOT will improve. Now we analyze the effect of variance of government spending share g on 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 government spending share will lower the output, thus, the tradables for private transaction. Accordingly, Home's expected TOT is improved.[9] Explanations of effects of terms in equation (16) , which appear after we introduce stochastic government spending, on expected spending measured in terms of tradables are also similar to those of the effects 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

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

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

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

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

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 equations (15) and (16) , both Ez and $E\tau$ are affected by government spending.

[9] Of course, the statement is true only under the condition that the volatility of domestic government spending share is larger than that of the Foreign.

4.3. Solutions for variances

Before we solve for covariances in equations (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 equations (15) and (16) can be calculated as follows:

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

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

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

We will consider the endogenous monetary and fiscal policy in later discussion.

4.4. Solving explicitly for expected utilities

In order to analyze the efficiency of monetary and fiscal policy, we need calculate expected utilities under alternative wage setting and monopoly distortions circumstances. As in O&R (1995, 2000, 2001, 2002) and many others, we consider the limiting case as $\chi \to 0$ which means that the derived utility from real balances is small as a share of total utility..

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

Using wage setting equation and national income identity, we can express expected utility of Home individual under sticky wages, stochastic government spending shares and monopoly distortions as the following

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

where Ω and Φ are respectively

$$\begin{aligned}\Omega =& -\frac{1}{2\upsilon}\sigma_{\kappa}^{2}-\frac{\upsilon}{2}\sigma_{z}^{2}-\frac{\upsilon}{8}\sigma_{e}^{2}-\frac{(1-\gamma)\,\upsilon}{2}\sigma_{ez}-\frac{1}{2}\left[(2-\gamma)\,\sigma_{\kappa z}+\gamma\sigma_{\kappa^{*}z}\right]\\&-\frac{1}{4}\left[(2-\gamma)\,\sigma_{\kappa e}-\gamma\sigma_{\kappa^{*}e}\right]\end{aligned}$$

and

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

The component Ω is identical to that in OR (2000) which reflects the effects of productivity shock and monetary policies. However, a new component Φ appears in equation (22)after we introduce stochastic government spending, 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. In order to illustrate the channels through which the fiscal policy affects the expected utility level, we analyze respectively the effects of expected government spending and the variation of it. 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 $\frac{(\upsilon-1)}{2\upsilon}\left[(2-\gamma)\,E\log(1-g)+\gamma E\log(1-g^{*})\right]$. 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 bring about more disutility from labor.[10] 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 $\frac{\left(1-\upsilon^{2}\right)}{4\upsilon}\left[(2-\gamma)\,\sigma_{\log(1-g)}^{2}+\gamma\sigma_{\log(1-g^{*})}^{2}\right]$. In addition, as reflected

[10]From equation (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 supply.

by the term

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

a more volatile government spending share will produce more disutility from labor.[11] A positive covariance between κ 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.

Foreign individual's expected utility, by using the same logic, can be expressed as

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

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

$$\begin{aligned}
\Omega^* = &-\frac{1}{2\upsilon}\sigma^2_\kappa - \frac{\upsilon}{2}\sigma^2_z - \frac{\upsilon}{8}\sigma^2_e + \frac{(1-\gamma)\upsilon}{2}\sigma_{ez} - \frac{1}{2}\left[\gamma\sigma_{\kappa z}+(2-\gamma)\sigma_{\kappa^* z}\right]\\
&- \frac{1}{4}\left[\gamma\sigma_{\kappa e}-(2-\gamma)\sigma_{\kappa^* e}\right]
\end{aligned}$$

and

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

[11]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 supply.

The analysis of the effects of fiscal policy 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 θ and φ do not enter the components Ω, Ω^*, Φ and Φ^*.

4.4.2. Expected utilities under flexible wages, stochastic government spending shares but without monopoly distortions

Monopoly distortions both in labor and output markets can be eliminated completely by giving individuals a proportional wage subsidy of $\frac{1}{\varphi-1}$ and firms a proportional production subsidy of $\frac{1}{\theta-1}$. Home worker's wage setting equation would be $\frac{1}{PC}W = KL^{\upsilon-1}$ when wages are flexible and monopoly distortions are completely eliminated. Since $PC = (1-g)\,W\,(Y_H+Y_N) = (1-g)\,WY$ and $Y = L$, we have Home output under flexible wages, stochastic government spending shares but without monopoly distortions (the variables under flexible wages, without monopoly distortions are denoted by hats)

$$\hat{Y} = \hat{L} = \left(\frac{1}{(1-g)\,K}\right)^{\frac{1}{\upsilon}}. \tag{24}$$

Similarly, its Foreign counterpart is

$$\hat{Y}^* = \hat{L}^* = \left(\frac{1}{(1-g^*)\,K^*}\right)^{\frac{1}{\upsilon}}. \tag{25}$$

Eqations (24) and (25) imply $\frac{\partial\hat{y}}{\partial\kappa} = \frac{\partial\hat{y}^*}{\partial\kappa^*} = -\frac{1}{\upsilon} < 0$, which means workers produce more output by supplying more labor after a positive productivity shock. In addition, we have $\frac{\partial\hat{y}}{\partial g} = \frac{1}{\upsilon(1-g)} > 0$ and $\frac{\partial\hat{y}^*}{\partial g^*} = \frac{1}{\upsilon(1-g^*)} > 0$, which mean that a higher government spending share leads 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.

Home individual's expected utility under flexible wages, stochastic government spending shares but without monopoly distortions is

$$
\begin{aligned}
E\hat{U} =& \frac{1}{\upsilon}\left\{-\exp\left[-E\log(1-g)+\frac{\sigma^2_{\log(1-g)}}{2}\right]-E\kappa\right\} \\
&+\frac{(\upsilon-1)}{2\upsilon}\left[(2-\gamma)E\log(1-g)+\gamma E\log(1-g^*)\right].
\end{aligned}
$$

Similarly it's Foreign counterpart is

$$
\begin{aligned}
E\hat{U}^* =& \frac{1}{\upsilon}\left\{-\exp\left[-E\log(1-g^*)+\frac{\sigma^2_{\log(1-g^*)}}{2}\right]-E\kappa\right\} \\
&+\frac{(\upsilon-1)}{2\upsilon}\left[\gamma E\log(1-g)+(2-\gamma)E\log(1-g^*)\right]. \qquad (26)
\end{aligned}
$$

4.4.3. 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 Home and Foreign outputs in this circumstance are the following respectively

$$
\tilde{Y}=\tilde{L}=\tilde{L}_H+\tilde{L}_N=\left[\frac{(\theta-1)(\varphi-1)}{\theta\varphi K(1-g)}\right]^{\frac{1}{\upsilon}} \qquad (27)
$$

and

$$
\tilde{Y}^*=\tilde{L}^*=\tilde{L}^*_F+\tilde{L}^*_N=\left[\frac{(\theta-1)(\varphi-1)}{\theta\varphi K^*(1-g^*)}\right]^{\frac{1}{\upsilon}}. \qquad (28)
$$

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

Home typical individual's expected utility in this circumstance is

$$
\begin{aligned}
E\tilde{U} =& \frac{1}{\upsilon}\left\{\log\frac{(\varphi-1)(\theta-1)}{\varphi\theta}-\frac{(\varphi-1)(\theta-1)}{\varphi\theta}\exp\left[-E\log(1-g)+\frac{\sigma^2_{\log(1-g)}}{2}\right]-E\kappa\right\} \\
&+\frac{(\upsilon-1)}{2\upsilon}\left[(2-\gamma)E\log(1-g)+\gamma E\log(1-g^*)\right], \qquad (29)
\end{aligned}
$$

and it's Foreign counterpart is

$$E\tilde{U}^{*}=\frac{1}{\upsilon}\left\{\log\frac{(\varphi-1)(\theta-1)}{\varphi\theta}-\frac{(\varphi-1)(\theta-1)}{\varphi\theta}\exp\left[-E\log(1-g^{*})+\frac{\sigma^{2}_{\log(1-g^{*})}}{2}\right]-E\kappa\right\}$$
$$+\frac{(\upsilon-1)}{2\upsilon}\left[\gamma E\log(1-g)+(2-\gamma)E\log(1-g^{*})\right]. \tag{30}$$

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

5. EFFICIENCY OF GLOBAL MONETARY POLICY

In OR (2000, 2002), a main conclusion is that global monetary policy rules that replicate the allocations under flexible wages are constrained-efficient. The point is also documented in DE(2003), Corsetti and Pesenti (2005) for the case of PCP, BB (2003) when shocks are symmetric or underlying structural distortions are identical. Constrained efficiency, as clarified in OR (2000), means that the induced allocations will maximize an average of Home and Foreigh expected utilities subject to optimal behaviors of the players in the model.

A further investigation into OR (2000) reveals that the combination of subsidy policies and global monetary policy rules that replicate the real allocations under flexible wages can achieve Pareto optimal allocations.[12] Do the same conclusion hold after we introduce stochastic government spending?

PROPOSITION 1. *After observing both productivity shocks K, K^{*} and fiscal spending shocks g and g^{*}, by giving a proportional wage subsidy of $\frac{1}{\varphi-1}$ and proportional subsidy of $\frac{1}{\theta-1}$ to eliminate monopoly distortions, both Home and Foreign governments can use monetary policies to replicate the real allocations under flexible wages, stochastic government spending shares but without monopoly distortions.*

[12]In order to get rid of monopoly distortions, Home government need to give workers a proportional wage subsidy of $\frac{1}{\varphi-1}$ and firms a proportional production subsidy of $\frac{1}{\theta-1}$, Foreign government ditto.

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

$$\begin{aligned} m = Em &+ \frac{1}{2\upsilon\varepsilon}\left\{\gamma\left(\varepsilon-1\right)\left(\kappa^*-E\kappa^*\right)-\left(2+\gamma\left(\varepsilon-1\right)\right)\left(\kappa-E\kappa\right)\right\}+ \\ &\frac{1}{2\varepsilon}\left(1-\frac{1}{\upsilon}\right)\left\{\left(2-\gamma\left(1-\varepsilon\right)\right)\left(\log\left(1-g\right)-E\log\left(1-g\right)\right)\right. \\ &\left.+\gamma\left(1-\varepsilon\right)\left(\log\left(1-g^*\right)-E\log\left(1-g^*\right)\right)\right\}, \end{aligned} \tag{31}$$

and it's Foreign counterpart is

$$\begin{aligned} m^* = Em^* &+ \frac{1}{2\upsilon\varepsilon}\left\{\gamma\left(\varepsilon-1\right)\left(\kappa-E\kappa\right)-\left(2+\gamma\left(\varepsilon-1\right)\right)\left(\kappa^*-E\kappa^*\right)\right\}+ \\ &\frac{1}{2\varepsilon}\left(1-\frac{1}{\upsilon}\right)\left\{\gamma\left(1-\varepsilon\right)\left(\log\left(1-g\right)-E\log\left(1-g\right)\right)\right. \\ &\left.+\left(2-\gamma\left(1-\varepsilon\right)\right)\left(\log\left(1-g^*\right)-E\log\left(1-g^*\right)\right)\right\}. \end{aligned} \tag{32}$$

(2). The global monetary policy rules given by eqations (31) *and* (32) *can be Pareto improved if*

$$\begin{aligned} &\frac{1}{\upsilon}\exp\left[-E\log\left(1-g\right)+\frac{\sigma^2_{\log(1-g)}}{2}\right]\left[1-\frac{\left(\varphi-1\right)\left(\theta-1\right)}{\varphi\theta}\right] \\ &-\frac{\left(1-\gamma\right)\upsilon}{2}\left(\frac{\varepsilon^2}{1-\gamma+\gamma\varepsilon}\right)\frac{\left(\sigma^2_m-\sigma^2_{m^*}\right)}{2} \\ &>-\frac{1}{\upsilon}\log\frac{\left(\varphi-1\right)\left(\theta-1\right)}{\varphi\theta}+\Theta-\frac{\left(1-\upsilon^2\right)}{4\upsilon}\left[\left(2-\gamma\right)\sigma^2_{\log(1-g)}+\gamma\sigma^2_{\log(1-g^*)}\right] \end{aligned} \tag{33}$$

and

$$\begin{aligned} &\frac{1}{\upsilon}\exp\left[-E\log\left(1-g^*\right)+\frac{\sigma^2_{\log(1-g^*)}}{2}\right]\left[1-\frac{\left(\varphi-1\right)\left(\theta-1\right)}{\varphi\theta}\right] \\ &+\frac{\left(1-\gamma\right)\upsilon}{2}\left(\frac{\varepsilon^2}{1-\gamma+\gamma\varepsilon}\right)\frac{\left(\sigma^2_m-\sigma^2_{m^*}\right)}{2} \\ &\geqslant-\frac{1}{\upsilon}\log\frac{\left(\varphi-1\right)\left(\theta-1\right)}{\varphi\theta}+\Theta-\frac{\left(1-\upsilon^2\right)}{4\upsilon}\left[\gamma\sigma^2_{\log(1-g)}+\left(2-\gamma\right)\sigma^2_{\log(1-g^*)}\right] \end{aligned} \tag{34}$$

hold simultaneously. In which $\Theta = \frac{1}{2\upsilon}\sigma^2_\kappa + \frac{\upsilon\varepsilon^2}{8}\left(\sigma^2_m+2\sigma_{mm^*}+\sigma^2_{m^*}\right) + \frac{\upsilon}{8}\left(\frac{\varepsilon}{1-\gamma+\gamma\varepsilon}\right)^2\left(\sigma^2_m-2\sigma_{mm^*}+\sigma^2_{m^*}\right) > 0$. *Or inequality* (33) *with sign* $\geqslant$

replacing sign $>$ and inequality (34) *with sign $>$ replacing sign $\geqslant$ hold simultaneously. Otherwise, the global monetary policy rules given by eqations* (31) *and* (32) *are efficient.*

Proof. (1) To obtain (31) and (32), we take logs to (24) and (25) and get $\hat{y} = \frac{1}{\upsilon}\left[-\log\left(1-g\right)-\kappa\right]$ and $\hat{y}^{*} = \frac{1}{\upsilon}\left[-\log\left(1-g^{*}\right)-\kappa^{*}\right]$. Eqations (31) and (32) 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). $EU > E\hat{U}$ and $EU^{*} \geq E\hat{U}^{*}$ can be obtained after we add the term

$$-\frac{1}{\upsilon}E\kappa + \frac{(\upsilon-1)}{2\upsilon}\left[(2-\gamma)\,E\log\left(1-g\right)+\gamma E\log\left(1-g^{*}\right)\right]$$

to both sides of inequality (33) and

$$-\frac{1}{\upsilon}E\kappa + \frac{(\upsilon-1)}{2\upsilon}\left[\gamma E\log\left(1-g\right)+(2-\gamma)\,E\log\left(1-g^{*}\right)\right]$$

to both sides of inequality (34) and then rearrange both enlarged inequalities. Similarly, $EU \geqslant E\bar{U}$ and $EU^{*} > E\bar{U}^{*}$ can hold simultaneously. Either case means that there exist other global monetary policy rules to Pareto dominate ones given by eqations (31) and (32). Clearly, if neither case holds, then the global monetary policy rules given by eqations (31) and (32) are efficient. ▮

Comparison between the conclusion implied in OR (2000) and Proposition 1 shows that the introduction of stochastic government spending can affect the efficiency of the global monetary policy rules that replicate the real allocations under flexible wages when monopoly distortions are completely eliminated. What Proposition 1 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 1 clearly tells us that the endogenous monetary policies to replicate real allocation under flexible wages and stochastic government spending shares are not efficient 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.[13] 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 φ) will make firm's demand for labor more stable[14]. 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 $\frac{1}{v}\frac{(\varphi-1)(\theta-1)}{\varphi\theta}\exp\left[-E\log(1-g)+\frac{\sigma^2_{\log(1-g)}}{2}\right]$ with the term $\frac{1}{v}\exp\left[-E\log(1-g)+\frac{\sigma^2_{\log(1-g)}}{2}\right]$ confirms our analysis. When the benefit ($\frac{1}{v}\exp\left[-E\log(1-g)+\frac{\sigma^2_{\log(1-g)}}{2}\right]\left[1-\frac{(\varphi-1)(\theta-1)}{\varphi\theta}\right]$) is large enough, it leaves room for improvement to the endogenously-chosen monetary polices given by equations (31) and (32). Under what conditions do inequalities (33) and (34) hold? Taking Taylor expansions to the terms $\frac{1}{v}\exp\left[-E\log(1-g)+\frac{\sigma^2_{\log(1-g)}}{2}\right]\left[1-\frac{(\varphi-1)(\theta-1)}{\varphi\theta}\right]$ and $-\frac{1}{v}\log\frac{(\varphi-1)(\theta-1)}{\varphi\theta}$ on

[13]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 $\frac{1}{v}\exp\left[-E\log(1-g)+\frac{\sigma^2_{\log(1-g)}}{2}\right]\left[1-\frac{(\varphi-1)(\theta-1)}{\varphi\theta}\right]+\frac{1}{v}\log\left[\frac{(\varphi-1)(\theta-1)}{\varphi\theta}\right]$, which is approximated by $\frac{1}{v}\left[-E\log(1-g)+\frac{\sigma^2_{\log(1-g)}}{2}\right]\left[1-\frac{(\varphi-1)(\theta-1)}{\varphi\theta}\right]>0$, after we take Taylor expansions to $\exp\left[-E\log(1-g)+\frac{\sigma^2_{\log(1-g)}}{2}\right]$ and $\log\left[\frac{(\varphi-1)(\theta-1)}{\varphi\theta}\right]$.

[14]Note that φ is the wage elasticity of labor demand.

both sides of the inequality (33) and rearranging yield the following [15]

$$\frac{1}{\upsilon}\left[1-\frac{(\varphi-1)(\theta-1)}{\varphi\theta}\right]\left[-E\log(1-g)+\frac{\sigma^2_{\log(1-g)}}{2}\right]$$
$$-\frac{(1-\gamma)\upsilon}{2}\left(\frac{\varepsilon^2}{1-\gamma+\gamma\varepsilon}\right)\frac{\left(\sigma^2_m-\sigma^2_{m^*}\right)}{2}$$
$$>\Theta-\frac{\left(1-\upsilon^2\right)}{4\upsilon}\left[(2-\gamma)\sigma^2_{\log(1-g)}+\gamma\sigma^2_{\log(1-g^*)}\right].$$

The immediately above inequality indicates that following conditions should be satisfied: the markups in both output and labor markets being large; the expected values of the government spending shares being large; the variances of the government spending shares satisfying voluntary participation constraints; the variances of both Home exogenous monetary policy and it's Foreign counterpart being small and close in values; the covariance between Home exogenous monetary policy and it's Foreign counterpart being small; and the variances of productivity shocks being small. As before, these 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 allocations under flexible wages and stochastic government spending shares?

Proposition 2. *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 allocations under flexible wages, stochastic government spending shares is

$$m=Em+\frac{1}{2\upsilon\varepsilon}\left\{\gamma(\varepsilon-1)(\kappa^*-E\kappa^*)-(2+\gamma(\varepsilon-1))(\kappa-E\kappa)\right\}+$$
$$\frac{1}{2\varepsilon}\left(1-\frac{1}{\upsilon}\right)\{(2-\gamma(1-\varepsilon))(\log(1-g)-E\log(1-g))$$
$$+\gamma(1-\varepsilon)(\log(1-g^*)-E\log(1-g^*))\},\tag{35}$$

[15] We can get a similar inequality from inequality (45) by taking the same steps.

and it's Foreign counterpart is

$$
\begin{aligned}
m^* = {} & Em^* + \frac{1}{2\upsilon\varepsilon}\left\{\gamma(\varepsilon-1)(\kappa - E\kappa) - (2+\gamma(\varepsilon-1))(\kappa^* - E\kappa^*)\right\} + \\
& \frac{1}{2\varepsilon}\left(1-\frac{1}{\upsilon}\right)\{\gamma(1-\varepsilon)(\log(1-g) - E\log(1-g)) \\
& + (2-\gamma(1-\varepsilon))(\log(1-g^*) - E\log(1-g^*))\}.
\end{aligned} \tag{36}
$$

(2). The global monetary policy rules given by equations (35) *and* (36) *are efficient.*

Proof. (1). Both equations (35) and (36) are identical to their counterparts in proposition 2, and can be obtained by taking the same methods.

(2). Suppose that there exist other global monetary policy rules such that both $EU > E\tilde{U}$ and $EU^* \geqslant E\tilde{U}^*$ hold simultaneously or both $EU \geqslant E\tilde{U}$ and $EU^* > E\tilde{U}^*$ hold simultaneously. From equations (19), (20), (21), (22), (23), (29) and (30), that both $EU > E\tilde{U}$ and $EU^* \geqslant E\tilde{U}^*$ hold simultaneously means

$$
\begin{aligned}
& -\frac{(1-\gamma)\upsilon}{2}\left(\frac{\varepsilon^2}{1-\gamma+\gamma\varepsilon}\right)\frac{\left(\sigma_m^2 - \sigma_{m^*}^2\right)}{2} \\
> & \Theta - \frac{\left(1-\upsilon^2\right)}{4\upsilon}\left[(2-\gamma)\sigma^2_{\log(1-g)} + \gamma\sigma^2_{\log(1-g^*)}\right]
\end{aligned} \tag{37}
$$

and

$$
\begin{aligned}
& \frac{(1-\gamma)\upsilon}{2}\left(\frac{\varepsilon^2}{1-\gamma+\gamma\varepsilon}\right)\frac{\left(\sigma_m^2 - \sigma_{m^*}^2\right)}{2} \\
\geqslant & \Theta - \frac{\left(1-\upsilon^2\right)}{4\upsilon}\left[\gamma\sigma^2_{\log(1-g)} + (2-\gamma)\sigma^2_{\log(1-g^*)}\right]
\end{aligned} \tag{38}
$$

hold simultaneously. Given the conditions that $\varphi > 1$, $\theta > 1$, $\upsilon > 1$, $0 \leqslant \gamma \leqslant 1$, $\varepsilon > 0$, $\sigma_\kappa^2 > 0$, $\sigma_z^2 > 0$, $\sigma_e^2 > 0$, $\sigma^2_{\log(1-g)} > 0$ and $\sigma^2_{\log(1-g^*)} > 0$, inequalities (37) and (38) can not hold simultaneously. As a result, $EU > E\tilde{U}$ and $EU^* \geqslant E\tilde{U}^*$ can not hold simultaneously. Similarly $EU \geqslant E\tilde{U}$ and $EU^* > E\tilde{U}^*$ can not hold simultaneously. The above analysis contradicts that there exists other global monetary policy rules to Pareto improve ones given by equations (35) and (36). ∎

Comparison between Proposition 1 and Proposition 2 shows that the monopoly distortions are essential for the efficiency of the global monetary policy that replicates the real allocations under flexible wages and stochastic government spending shares. In addition, the government uses the same monetary policy to replicate the real allocations 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 $\tilde{y}$.

Now we say something more on the monetary policies in Proposition 2. When $\gamma = 0$ (no tradable goods), or $\varepsilon = 1$ (no over/undershooting), a country's monetary policy will only respond to it's 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

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

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 achieve Pareto optimal utility level by using the combination of subsidy and monetary policies to replicate the real allocations under flexible wages but without monopoly distortions. After we introduce the stochastic government spending shares, the government can still replicate the real allocations 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 allocations under flexible wages and stochastic government spending shares. But the expected utility provided by monetary policy, after we introduce stochastic government spending, that replicates the real allocations under flexible wages and stochastic government spending shares when monopoly distortions are completely eliminated is lower than that provided by the same monetary policy accompanied by specially-chosen subsidy policies. Two candidates of subsidy policies, which can be specially chosen, are either the combination of a proportional wage subsidy of $\frac{\varphi}{\varphi-1}\exp\left[E\log(1-g)\right]-1$ and a proportional production subsidy of $\frac{\theta}{\theta-1}\exp\left[-\frac{\sigma^2_{\log(1-g)}}{2}\right]-1$ or the combination of a proportional wage subsidy of $\frac{\varphi}{\varphi-1}\exp\left[-\frac{\sigma^2_{\log(1-g)}}{2}\right]-1$ and a proportional production subsidy of $\frac{\theta}{\theta-1}\exp\left[E\log(1-g)\right]-1$.[16] Foreign government can adopt the same subsidy measures as those of Home with g^* replacing g. Is the global monetary policy that replicates the real allocations 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 1, we can conclude that the global monetary policy rules in this circumstance can be Pareto improved when the same conditions are satisfied as those in Proposition 1. Otherwise, they are efficient.

6. THE FISCAL POLICY

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

PROPOSITION 3. *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 (24), (25), (27) and (28), we know that these real allocations all depend on the stochastic government spending

[16]The subsidy policies are obtained by choosing $\frac{(\varphi-1)(\theta-1)}{\varphi\theta}$ to maximize

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

shares. It's obvious that the government can't replicate them with endogenously-chosen fiscal policy. ▮

The result here is 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, after we introduce stochastic government spending in OR (2000), the global monetary policy rules to replicate the real allocations under flexible wages, stochastic government spending shares when monopoly distortions are completely eliminated can be Pareto improved when some conditions are satisfied. Otherwise, they are efficient. Our conclusion contrasts with what is obtained in OR (2000, 2002) that global monetary policy rules that replicate the real allocations under flexible wages when monopoly distortions are completely eliminated are efficient, The reason 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. 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 allocations under flexible wages when monopoly distortions are completely eliminated. However, when the government endogenously chooses monetary policy to replicate the real allocations under flexible wages, stochastic government spending shares when monopoly distortions are intact, as in OR (2000, 2002), the global monetary policy rules are efficient. Comparison of the conclusion in Proposition 1 and that in Proposition 2 shows, unlike what is implied in OR (2000, 2002) and many others, that the monopoly distortions can also affect the efficiency of global monetary policy rules.

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

As far as fiscal policy is concerned, the government can't choose endogenously the fiscal policy to replicate the real allocations 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. *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. *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 Internationl 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? *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. *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 ecnomics*, **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. *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 Internationl Economics* **77**, 1-10.

Gali, J., Monacelli, T., 2005. Monetary policy and exchange rate volatility in a small open economy. *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. *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. *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.