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A Revisit to Tax Policy and Stability in a Model with Sector-Specific Externalities*

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ABSTRACT

This study re-visits the stabilization of income tax policies proposed by Guo and Harrison (2001, *Review of Economic Dynamics*). I show that given an empirically relevant extent of sector-specific externality, both progressive and regressive tax schedules can stabilize the economy against sunspot fluctuations, if the government's tax revenues are used to purchase goods as public services, rather than to return them to households as lump-sum transfers. A progressive tax schedule is more robust than a regressive tax schedule in terms of suppressing the belief-driven fluctuations. I also find that income taxes are more likely to suppress the sunspot fluctuations, if the government uses its revenues to purchase an investment good, instead of a consumption good. These results sharply differ from Guo and Harrison's (2001) propositions. Thus, our study complements Guo and Harrison's (2001) analysis and provides new policy implications to the literature.

Key Words: tax policy, aggregate (in)stability, government spending, sector-specific externality

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I. Introduction

Since the seminal works of Benhabib and Farmer (1994) and Farmer and Guo (1994), there has been a long list of literature on indeterminacy and sunspots. Equilibrium indeterminacy creates room for Keynesian-type stabilization to insulate the economy from sunspot (belief-driven) fluctuations. In an interesting article of this literature, Guo and Harrison (2001) quantitatively examine the stabilization of income tax policies in a two-sector real business cycle (RBC) model with sector-specific externalities and come to the conclusion that instead of a progressive tax schedule, a regressive tax schedule acts as an automatic stabilizer that suppress the belief-driven fluctuations. This result obviously contradicts the conventional wisdom whereby tax progressivity mitigates business cycle fluctuations, but tax regressivity enhances an economy's cyclical properties (see, e.g., the argument proposed by Guo and Lansing 1998, Christiano and Harrison 1999, and Dromel and Pintus 2007; 2008 within a one-sector model).

While insightful policy implications are provided, the required regressive tax policy that Guo and Harrison (2001) propose is not so realistic, being rarely observed in the actual data. The estimates of Wagstaff et al. (1999) indicate that the personal income tax is progressive in all 12 selected OECD countries. Tax progressivity, in general, is also supported by more updated evidence provided by Pintus (2008) in six selected OECD countries. Besides, in their model, the government is postulated to return all its tax revenues to households as lump-sum transfers. While, in practice, the government's tax revenues are commonly used to purchase goods and services, they do not investigate such a specification (see Guo and Harrison, 2001; 2011 for a corrigendum). Given these facts, this paper revisits the Guo and Harrison model to make a further investigation. I extend their two-sector (consumption and investment sectors) framework to account for the importance of government spending in the (de)stabilization of income taxes. In particular, I allow the government's tax revenues to purchase the consumption good, the investment good, or the composition of both goods. Such a systematic investigation will provide not only a complement to Guo and Harrison's (2001) analysis, but also new policy implications to the literature.

Our study shows that given an empirically relevant extent of sector-specific externality, both progressive and regressive tax schedules can stabilize the economy against the sunspot fluctuations, if the government's tax revenues are used to purchase goods as public services, rather than to return them to households as lump-sum transfers. A progressive tax schedule is more robust than a regressive tax schedule in terms of suppressing the belief-driven fluctuations. This result is inclined to support the conventional argument proposed in a one-sector RBC model, while it differs significantly from that of Guo and Harrison (2001; 2011). Of particular interest, I further find that income taxes are more likely to insulate the economy from the sunspot fluctuations, if the government uses its revenues to purchase the investment good, instead of the consumption good. These results are robust to various elasticities of labor supply, various elasticities of intertemporal substitution, and various compositions of government spending.

II. The Model

I incorporate the composition of government spending into Guo and Harrison's (2001) two-sector RBC model. Consider an economy that consists of households, firms and a government. Households derive utility from consumption and leisure. On the production side, there are two sectors—consumption good and investment good sectors. Based on the empirical finding of Harrison (2003), competitive firms in each sector use identical constant returns-to-scale technology to produce their respective output, but sector-specific externalities are limited to the investment sector. The government runs a balanced budget by levying non-linear income taxes to finance its expenditures.

A. Firms

Each of the consumption and investment goods is produced by a decentralized competitive sector and by using capital K_t and labor L_t in competitive factor markets. Let $K_{c,t}$ and $L_{c,t}$ ($K_{I,t}$ and $L_{I,t}$) be the capital and labor services in the consumption (investment) sector. Thus, the production technologies of a typical firm in the consumption good and investment good sectors are, respectively:

$$Y_{c,t}=K_{c,t}^{\alpha}L_{c,t}^{1-\alpha} \quad \text{and} \quad Y_{I,t}=A_t \cdot K_{I,t}^{\alpha}L_{I,t}^{1-\alpha} \tag{1}$$

Where $A_t=(\overline{K}_{I,t}^{\alpha}\overline{L}_{I,t}^{1-\alpha})^{\theta}$ is productive externalities in the investment sector, the relevant variables with a bar "–" denote the economy-wide average levels, and represents a measures of the sector-specific externalities.

Denote p_t as the relative price of the investment good to the consumption good. Thus, the first-order conditions for the profit maximization of the consumption good and investment good producers with respect to capital and labor are, respectively:

$$r_t=\alpha\frac{Y_{c,t}}{K_{c,t}}=\alpha\frac{p_tY_{I,t}}{K_{I,t}} \quad \text{and} \quad w_t=(1-\alpha)\frac{Y_{c,t}}{L_{c,t}}=(1-\alpha)\frac{p_tY_{I,t}}{L_{I,t}} \tag{2}$$

where w_t is the wage rate and r_t is the interest rate. These are the standard "factor price equalization" conditions under free factor mobility.

Define $\mu_{K,t}$ and $\mu_{L,t}$ as the fractions of capital K_t and labor L_t used in the consumption good industry. Thus, the relative factor intensities are given by $\mu_{K,t}=K_{c,t}/K_t$ and $\mu_{L,t}=L_{c,t}/L_t$. Since firms use identical technologies and face equal factor prices across the two sectors, the two factor intensities must be identical across sectors, i.e., $\mu_{K,t}=\mu_{L,t}=\mu_t$. Due to this factor intensity equalization, it can easily be seen that $p_tY_{I,t}=\frac{1-\mu_t}{\mu_t}Y_{c,t}$, and the production possibility frontier (PPF) can be expressed as follows:

$$Y_t=Y_{c,t}+p_tY_{I,t}=\frac{1}{\mu_t}Y_{c,t}=K_t^{\alpha}L_t^{1-\alpha} \tag{3}$$

It is evident from (2) and (3) that the relative price $p_t=1/A_t=(1-\mu_t)^{-\theta}(K_t^{\alpha}L_t^{1-\alpha})^{-\theta}$ is the slope of the PPF. If there are no externalities ($\theta=0$), the relative price turns out to become constant and hence the PPF is linear. However, as emphasized by Guo and Harrison (2001), in the presence of the specific-sector externality ($\theta>0$) the PPF is convex, as shown in Figure 1.

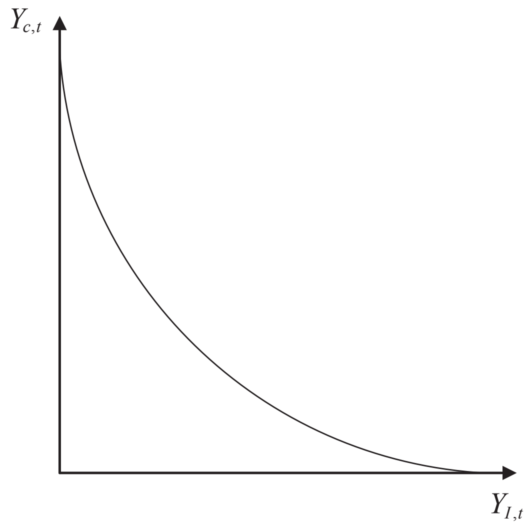

Fig. 1. The PPF with Sectoral Externalities

B. Households

The economy is populated by a unit measure of identical infinitely-lived households. Each (representative) household acts to maximize the following discounted present value of utility function which is separable in consumption C_t and labor L_t. The representative household's optimization problem is specified as:

$$max \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}-1}{1-\sigma} - \xi \frac{L_t^{1+\gamma}}{1+\gamma} \right), \text{ with } \quad \xi > 0. \tag{4}$$

subject to,

$$(1-\tau_t)(w_t L_t + r_t K_t) = C_t + p_t I_t, \tag{5}$$

$$K_{t+1} = I_t + (1-\delta) K_t, \tag{6}$$

where $\beta(>0)$ is the discount factor, σ is the inverse of the elasticity of intertemporal substitution, and $\gamma(\geq 0)$ is the inverse of the labor supply elasticity. Given that τ_t is denoted as the income tax rate, the household budget constraint (5) indicates that an individual allocates his/her wage income $w_t L_t$ and capital income $r_t K_t$ to purchase the consumption good C_t and investment good I_t as well as pay taxes. Given that δ is the depreciation rate, (6) is the law of motion for capital accumulation. Combining (5) and (6) yields the following intertemporal budget constraint:

$$K_{t+1} = \frac{1}{p_t} [(1-\tau_t)(w_t L_t + r_t K_t) - C_t] + (1-\delta) K_t. \tag{7}$$

As in Guo and Harrison (2001), I postulate that τ_t takes the form:

$$\tau_t = 1 - \eta \left(\frac{Y}{Y_t} \right)^{\phi}, \ \eta \in (0,1), \text{ and } \phi \in \left(\frac{\alpha(1+\theta)-1}{\alpha(1+\theta)}, 1 \right), \tag{8}$$

where $Y_t = w_t L_t + r_t K_t$ represents the household's taxable income and Y denotes the steady-state per capita income, which is taken as given by the household. When $\phi > (<0)$, the income tax rate τ_t increases (decreases) with the household's taxable income Y_t, and hence, the tax schedule is characterized by progressivity (regressivity). That is, households with taxable income above Y face a higher (lower) income tax rate than those with income below Y. When $\phi = 0$, households face a constant income tax rate $0 < \tau = 1 - \eta < 1$ regardless of their taxable income. In conformity with Guo and Harrison (2001), some regularity conditions are needed: (i) the marginal tax rate of income $\tau_t^m = 1 - \eta(1-\phi)\left(\frac{Y}{Y_t} \right)^{\phi}$ is smaller than one (hence, $\phi < 1$) so that households have an incentive to supply labor and capital services to firms and (ii) the equilibrium after-tax interest rate $(1 - \tau_t^m) r_t$ is strictly increasing in capital $\left(\text{hence, } \phi > \frac{\alpha(1+\theta)-1}{\alpha(1+\theta)} \right)$ in order to ensure the existence of an interior steady state.[1] Under the restriction of $\left(\phi \in \frac{\alpha(1+\theta)-1}{\alpha(1+\theta)}, 1 \right)$, the marginal tax rate is increasing and convex in ϕ.

1 See Guo and Harrison (2001) for a more detailed illustration.

By taking into account this tax schedule above, the optimal conditions necessary for the household's optimization problem are given by:

$$\xi C_t^{\sigma} L_t^{\gamma} = w_t \eta (1-\phi) \left(\frac{Y}{Y_t} \right)^{\phi}, \tag{9}$$

$$\frac{C_{t+1}^{\sigma}}{C_t} = \beta \left[\frac{\eta(1-\phi)\left(\frac{Y}{Y_{t+1}} \right)^{\phi} \cdot r_{t+1} + (1-\delta) p_{t+1}}{p_t} \right]. \tag{10}$$

together with the budget constraint (7) and the transversality condition $\lim_{t\to\infty} \beta^t (K_{t+1}/C_t^{\sigma}) = 0$. These two first-order conditions are identical to those of Guo and Harrison (2001).

C. Government

As in Guo and Harrison (2001), the government chooses the tax policy and balances its budget each period. Unlike their setting, I follow Chang et al. (2015; 2019) to set that the government uses its tax revenues to purchase the consumption and investment goods, while the tax revenues are only used to provide rebates to all households in a lump-sum manner in the Guo and Harrison (2001) analysis. Guo and Harrison (2011) have clarified that the results of Guo and Harrison (2001) only hold under the situation where the government is postulated to return its revenues to households as a lump-sum transfer. To make a further analysis and to highlight the role of government spending, I modify the government budget constraint as:

$$\tau_t Y_t = G_t = G_{c,t} + p_t \cdot G_{I,t}, \tag{11}$$

where G_t is the government's total spending and $G_{c,t}$ and $G_{I,t}$ are the government purchases on the consumption good and the investment good, respectively. For the sake of illustration, I set ω as a composition factor and accordingly, $G_{c,t} = \omega G_t$ and $p_t G_{I,t} = (1-\omega) G_t$. Thus, $\omega = 1 (\omega = 0)$ indicates that to balance its budget, the government purchases the consumption (investment) good as its public services.

D. Competitive Equilibrium

By putting the firm's optimal conditions (2), the government's budget constraint (11), and the household's budget constraint (7) together, the market-clearing conditions for the consumption good and investment good markets, respectively, are given by:

$$Y_{c,t} = G_{c,t} + K_{c,t} \quad \text{and} \quad Y_{I,t} = C_I + G_{I,t} \tag{12}$$

It is important to note that if the government's tax revenues are used to provide rebates to households in a lump-sum manner, this government expenditure does not enter the market clearing condition to play a role in terms of affecting the dynamics of a market equilibrium (see Guo and Harrison, 2011). However, if tax revenues are used to purchase goods as public services, the government spending will enter the market-clearing condition, playing a crucial role in terms of governing the economy's dynamics property. This will be decisive in the analysis that follows. For factor sectors, market clearing in the capital and labor markets requires that

$$K_t = K_{c,t} + K_{I,t} \quad \text{and} \quad L_t = L_{c,t} + L_{I,t} \tag{13}$$

With aggregate consistency (i.e., $K_{I,t} = \bar{K}_{I,t}$ and $L_{I,t} = \bar{L}_{I,t}$) and the given initial capital stock K_0, this model economy defines a competitive equilibrium by a tuple of paths for quantities $\{C_t, I_t, K_{t+1}, L_t, Y_t, \mu_t, Y_{c,t}, K_{c,t}, L_{c,t}, Y_{I,t}, K_{I,t}, L_{I,t}\}_{t=0}^{\infty}$, prices $\{p_t, r_t, w_t\}_{t=0}^{\infty}$, and policy variables $\{\tau_t(\tau_t^m), G_{c,t}, G_{I,t}\}_{t=0}^{\infty}$, that satisfy: (i) the firm's profit maximization conditions: (2); (ii) the household's utility maximization conditions: (9), (10) and (7); (iii) the government's budget constraint: (11); and (iv) the market-clearing conditions: (12) and (13).

E. Dynamics

By using (1), (3), (12), and (9) with (2), we have the relationships for the factor intensity and labor as follows:

$$\mu_t = \frac{C_t}{K_t^{\alpha} L_t^{1-\alpha}} + \omega(1 - \eta Y^{\phi} K_t^{-\alpha\phi} L_t^{-(1-\alpha)\phi}), \tag{14}$$

$$L_t = \left[\frac{\eta(1-\phi)(1-\alpha) Y^{\phi} K_t^{\alpha\phi}}{\xi C_t^{\sigma}} \right]^{\frac{1}{1+\gamma-(1-\alpha)(1-\phi)}}. \tag{15}$$

In addition, substituting (12), (1), and (11) into (6) yields:

$$K_{t+1} = [\omega + (1-\omega)\eta Y^{\phi} K_t^{-\alpha\phi} L_t^{-(1-\alpha)\phi} - \mu_t](1-\mu_t)^{\theta} K_t^{\alpha(1+\theta)} L_t^{(1-\alpha)(1+\theta)} + (1-\delta)K_t, \tag{16}$$

With (2), I rewrite (10) as the following consumption Euler equation:

$$\frac{C_{t+1}^{\sigma}}{C_t^{\sigma}} = \beta(1-\mu_t)^{\theta} K_t^{\alpha\theta} L_t^{(1-\alpha)\theta} \cdot \Gamma \tag{17}$$

where $\Gamma = \alpha\eta(1-\phi) Y^{\phi} K_{t+1}^{\alpha(1-\phi)-1} L_{t+1}^{(1-\alpha)(1-\phi)} + (1-\delta)(1-\mu_{t+1})^{-\theta} K_{t+1}^{-\alpha\theta} L_{t+1}^{-(1-\alpha)\theta}$. By substituting (14), (15) into (16) and (17), it has a 2×2 dynamical system in terms of capital and consumption.

By taking log-linear approximations to the dynamical system in the neighborhood of the steady state, we then have the 2×2 Jacobian matrix as follows:

$$\begin{bmatrix}\hat{K}_{t+1}\\ \hat{C}_{t+1}\end{bmatrix}=\begin{bmatrix}J_{11} & J_{12}\\ J_{21} & J_{22}\end{bmatrix}\begin{bmatrix}\hat{K}_{t}\\ \hat{C}_{t}\end{bmatrix},\ \hat{K}_0 \quad \text{given,} \tag{18}$$

where the hat variables denote percentage deviations from their steady-state values and the J_{ij} are elements of Jacobian matrix in (18), specifically,

$$J_{11}=\frac{a\delta(1+\gamma)(\Omega_1+\Omega_2\Phi)}{\Delta[\omega-\mu+(1-\omega)\eta]}+1-\delta,\ J_{12}=-\frac{\delta\{\sigma(1-\alpha)(\Omega_1+\Omega_2\Phi)+\Delta[\mu-\omega(1-\eta)]\Phi\}}{\Delta[\omega-\mu+(1-\omega)\eta]},$$

$$J_{21}=\frac{1}{(\sigma-\Psi_1)}\left\{\alpha\theta\Omega_3\left[1+\frac{(1+\gamma)\Omega_2+(1-\alpha)(1-\phi)(1-\mu)}{\Delta(1-\mu)}\right]+\Psi_2J_{11}\right\},$$

$$J_{22}=\frac{1}{(\sigma-\Psi_1)}\left\{\Omega_3\left[\sigma-\frac{\theta\Delta[\mu-\omega(1-\eta)]+\theta\sigma(1-\alpha)(\Omega_2+1-\mu)}{\Delta(1-\mu)}\right]+\Psi_2J_{12}\right\},$$

where $\Delta=1+\gamma-(1-\alpha)(1-\phi)$, $\Omega_1=(1+\theta-\phi)\eta(1-\omega)+(\omega-\mu)(1+\theta)$,

$\Omega_2=\mu-\omega+\eta\omega(1-\phi)$, $\Omega_3=\dfrac{1}{\beta}+\delta-1+\beta(1-\delta)$, $\Phi=1-\dfrac{\theta}{1-\mu}[\mu-\omega-\eta(1-\omega)]$,

$$\Psi_1=\frac{1}{\Delta}\left\{\frac{\beta(1-\delta)\theta}{(1-\mu)}\{\Delta[\mu-\omega(1-\eta)]+\sigma(1-\alpha)(\Omega_2+1-\mu)\}-\sigma(1-\alpha)\left(\frac{1}{\beta}+\delta-1\right)(1-\phi)\right\},$$

$$\Psi_2=-\frac{1}{\Delta}\left\{\frac{\alpha(1+\gamma)\beta(1-\delta)\theta(\Omega_2+1-\mu)}{1-\mu}-\left(\frac{1}{\beta}+\delta-1\right)[\alpha(1+\gamma)(1-\phi)-\Delta]\right\}.$$

Notice that the steady-state factor intensity is $\mu=\omega+(1-\omega)\eta-\dfrac{\alpha\delta\eta(1-\phi)}{1/\beta-1+\delta}$. The model consists of a control (jump) variable C_t and a predetermined (non-jump) variable K_t. Thus, local determinacy requires the system to exhibit *saddle-path* stability in which one eigenvalue lies inside the unit circle and the other one lies outside the unit circle. When both eigenvalues lie inside the unit circle, the steady-state equilibrium is indeterminate (*sink*). When both eigenvalues lie outside the unit circle, the steady-state equilibrium exhibits a totally unstable *source*.

III. Quantitative Analysis

In order to make our point more striking, most parameters presented in Table 1 are taken from Guo and Harrison (2001). Specifically, I follow Guo and Harrison (2001) and set $\alpha=0.3$, $\sigma=1$, $\xi=1$, $\delta=0.025$, $\gamma=0.25$, $\beta=1/1.01$, and $\eta=0.8$ (hence, the steady-state income tax rate equals $\tau=0.2$). Moreover, I set $\theta=0.108$, which is located within the plausible range of the evidence from the U.S. economy, as estimated by Harrison (2003). Both scenarios ($\omega=1$ and $\omega=0$) are considered in the benchmark. These parameterizations imply that in the steady state $C/Y=0.63$, $pI/Y=0.17$, $G/Y=0.2$ and $\mu=0.6286$ ($\mu=0.8286$) when $\omega=0$ ($\omega=1$); these are located within the empirically relevant range of actual data and well within the range that is

Table 1

Benchmark Parameter Values							
γ	0.25	σ	1	ξ	1	β	0.99
δ	0.025	α	0.3	η	0.8	θ	0.108

common in the literature.[2] The benchmark parameter values are summarized below.

Given the above parameterizations, I use figures (Figures 2 through 6) in which the space is separated into regions of "*Det*," "*Indet*," and "*Source*," to display how the model's local stability properties depend on the value of sector-specific externalities and the slope of the tax schedule. The region of "*Det*" implies that the economy exhibits saddle-path stability and equilibrium uniqueness. The region of "*Indet*" means that the model possesses an indeterminate steady state, and the steady state becomes a totally unstable source if located in the region of "*Sourc*e."

A. Tax Policy and the Government's Purchases

In this quantitative analysis, I will show that government spending plays a crucial role in terms of governing the stabilizing effect of tax policy. For the sake of more clarity in exposition, I first deal with the scenario in which the government tax revenues are used to purchase the consumption good and in turn discuss the scenario in which the tax revenues are used to purchase the investment good. By shedding light on these two cases, I will indicate that in the presence of government spending, a progressive tax schedule, rather than a regressive tax schedule, is more likely to have a stabilizing effect on the economy against sunspot fluctuations. This sharply contradicts Guo and Harrison's (2001) result.

By following Guo and Harrison (2001), I use $\theta=0.108$ (consistent with the realistic value of the U.S. economy) to act as a focal point, and utilize Figures 2-1 and 2-2 to illustrate the stabilizing effect of incomes taxes under our parameterization. By focusing on the scenario in which the government uses its tax revenues to purchase the consumption good (ω=1), Figure 2-1 shows that given $\theta=0.108$, both progressive and regressive tax schedules can prevent indeterminacy and suppress belief-driven fluctuations, provided that the tax schedule is not too progressive or regressive. That is, a less progressive or a less regressive ($-0.126\geq\phi\geq0.283$) is needed to prevent sunspot fluctuations. Figure 2-2 indicates that if the government's tax revenues are used to purchase the investment good ($\omega=0$), under the situation where the sector-specific externality is $\theta=0.108$ a progressive tax schedule can

2 I drop out time subscripts to denote steady-state values.

definitely eliminate indeterminacy, while a tax schedule with sufficiently less regressivity ($1 \geq \phi \geq -0.601$) is still needed to prevent sunspot fluctuations.

These results provide quite different policy implications from those of Guo and Harrison (2001). First, under the focal point of $\theta = 0.108$, Guo and Harrison (2001; 2011) point out that only the regressive tax schedule can stabilize the economy against sunspot fluctuations in a two-sector model with sector-specific externalities, although such a required regressive tax policy is not realistic, being rarely observed in the actual data. Our study shows that if the government's tax revenues are used to purchase either the consumption good or the investment good (rather than to return households as a lump-sum transfer), a progressive tax schedule is more likely to generate the stabilizing effect on the economy against belief-driven fluctuations. This

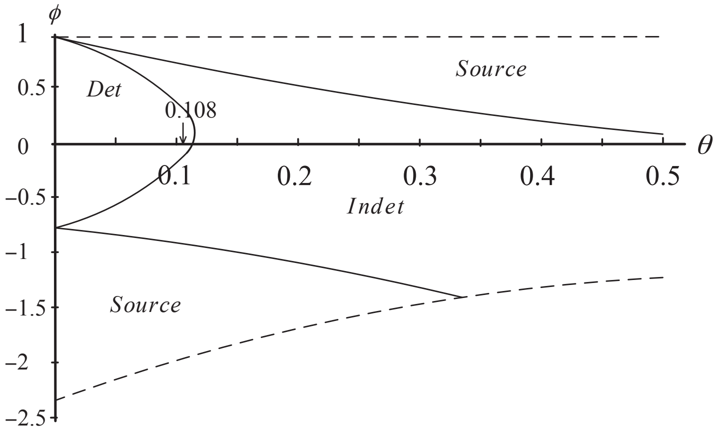

Fig. 2-1. Purchases of the Consumption Good

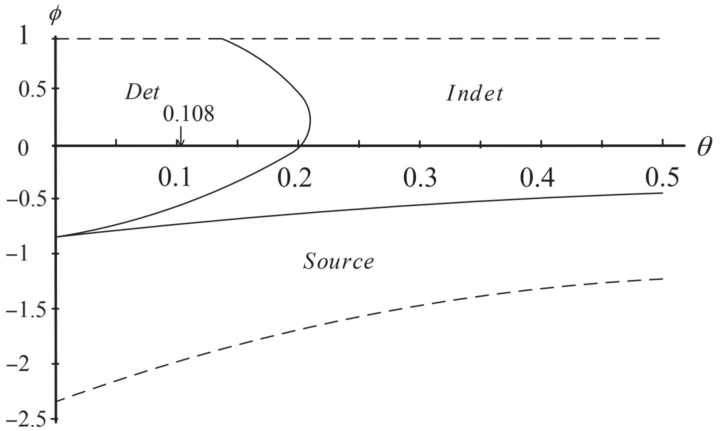

Fig. 2-2. Purchases of the Investment Good

is consistent with the conventional notion predicted by a one-sector RBC model with aggregate externalities, such as in Guo and Lansing (1998), Christiano and Harrison (1999), and Dromel and Pintus (2007; 2008). Most notably, this tax progressivity is supported by the empirical studies of Wagstaff et al. (1999) and recent Pintus (2008) for most OECD countries. Second, under the situation where $\theta=0.108$, a flat tax policy ($\phi=0$) could also stabilize the economy against the sunspot fluctuations, provided that the government's tax revenues are used to purchase goods as public services, rather than returning lump-sum transfers to households, as in Guo and Harrison (2001; 2011). Furthermore, a flat tax schedule can stabilize the economy under the situation where $\theta\leq 0.113$ ($\theta\leq 0.205$), if the government uses its revenues to purchase the consumption good (the investment good).[3]

B. Interpretation

In order to glean the intuition for the stabilizing effect of various tax schedules, I rewrite the consumption Euler equation as follows:

$$\frac{C_{t+1}^{\sigma}}{C_t^{\sigma}}=\beta\cdot NRK_{t+1}\beta\left[\frac{(1-\tau_{t+1}^{m})r_{t+1}+(1-\delta)p_{t+1}}{p_t}\right], \tag{19}$$

where r_{t+1} is the interest rate in period $t+1$ and hence the net (after-tax) rate of return on capital is $NRK_{t+1}=\frac{(1-\tau_{t+1}^{m})r_{t+1}+(1-\delta)p_{t+1}}{p_t}$. As regards NRK_{t+1}, the first term $\frac{(1-\tau_{t+1}^{m})r_{t+1}}{p_t}$ represents the after-tax real interest rate, discounted by the current price p_t, and the second term $\frac{(1-\delta)p_{t+1}}{p_t}$ can be viewed as the real capital gain or loss, due to the change in the relative price. The economy starts from the steady-state equilibrium in period t. Suppose that agents become optimistic about the future returns on capital, say, the next period's return on capital r_{t+1}. Acting upon this belief, the representative household will increase investment today I_t (the *investment effect*) and reduce his/her consumption C_t for more investment today (the *consumption effect*) when the agent is optimistic. The *investment effect* leads to an increase in the future capital stock K_{t+1}, and given that labor and capital are complements, the future working hours L_{t+1} and output Y_{t+1} increase and the future consumption C_{t+1} follows.

3 Besides the slope of the tax schedule (ϕ), we also examine the stabilizing effect of the level of the tax schedule (η). In terms of the stabilizing effect of income tax rate, we found the same results as Chang et al. (2019), that is, an increase in the level of the tax schedule (lower η), (i) has no impact on the stabilization policies when the government only purchases the consumption good, and (ii) can provide a stronger stabilizing effect, suppressing sunspot fluctuations, when the government only purchases the investment good. We thank an anonymous referee for point this out to us.

A lower C_t and a higher C_{t+1} indicate that the value of the LHS of (19) increases because of households' optimism. On the other hand, given a convex PPF (resulting from sufficiently high sectoral externalities), the agents' optimism leads more resources from the consumption-good sector shift to the investment-good sector, and hence that decreases today's relative price of the investment good p_t and increases tomorrow's relative price of capital p_{t+1} (the *price effect*) as shown in Figure 1.

The *price effect* gives rise to an increase in the real capital gain $\frac{(1-\delta)p_{t+1}}{p_t}$ and as a result, the RHS of (19) increases as well. Thus agents' optimistic expectations are self-fulfilling and the sunspot fluctuations occur. Note that in the model with aggregate externalities, local indeterminacy can occur even though the interest rate r_{t+1} is decreasing in the future capital stock K_{t+1}, provided that the real capital gain $\frac{(1-\delta)p_{t+1}}{p_t}$ increases as a result of a high enough sectoral externality θ.

I now explain why the income tax schedules can stabilize the economy against belief-driven fluctuations, if the government's revenues are used to purchase the consumption good ($\omega=1$) or the investment good ($\omega=0$). For ease of exposition, I start with the case where the tax rate is flat, i.e., $\phi=0$. Let us first focus on the scenario where $\omega=1$ and hence $\tau_t Y_t = G_{c,t}$. When output Y_{t+1} increases in response to the agents' optimism, the government's tax revenues increase as well, motivating the government to purchase more consumption goods $G_{c,t+1}$. Given that there is an expansion in the public sector, the government extracts private sector resources through taxation, which reduces the whole economy's resources available to the private sector (the *resource withdrawal effect*) and giving rise to a negative effect on household's consumption C_{t+1}.[4] At the same time, since the resources shift from the consumption sector towards the investment sector, the relative price p_{t+1} falls due to a convex PPF. These reverse both the abovementioned consumption and price effects, resulting in a decrease in NRK_{t+1}, which contradicts the intertemporal Euler equation. Since this contradiction invalidates the initial rise in the expected return on capital, the government's income policy then stabilizes the economy. This result sharply differs from the prediction of Guo and Harrison (2001; 2011) in the model in which tax revenues are returned to households as a lump-sum transfer. In their scenario, an increase in the tax revenues is associated with a higher level of the lump-sum transfer. This gives rise to a positive impact on consumption C_{t+1} and on the relative price p_{t+1}. Once both consumption and price effects become stronger, a flat income tax is incapable of being a stabilizer which insulates the economy from

4 See Turnovsky (1995: 245) for a discussion of the *resource withdrawal effect*.

belief-driven fluctuations.

I am ready to illustrate why a less progressive (regressive) tax schedule is needed to prevent sunspot fluctuations. Notice that if the tax rate is income-dependent, in response to the increase in Y_{t+1}, whether the government's tax revenues $\tau_{t+1}Y_{t+1}$ increase or decrease will depend on the tax schedule's slope ϕ. Let's still stick with the scenario where $\omega=1$. If $\phi>0$ (a progressive tax schedule), the government's tax revenues $\tau_{t+1}Y_{t+1}$ will increase as the future output Y_{t+1} increases. Thus, the government purchase of the consumption good $G_{c,t+1}$ will increase, leading to a decrease in tomorrow's consumption C_{t+1} and a fall in the relative price p_{t+1} (due to the resources withdrawal effect). As mentioned above, since the consumption and price effects are reversed, the progressive tax schedule gives rise to a stabilizing effect on the economy. By contrast, a progressive tax schedule means that agents will face a higher marginal tax rate τ^m_{t+1}. Given the facts that (i) by the diminishing marginal productivity of capital, r_{t+1} is decreasing in K_{t+1} in the absence of aggregate production externalities (see Benhabib and Farmer, 1996) and (ii) by assumption, $(1-\tau^m_{t+1})r_{t+1}$ is also decreasing in K_{t+1} (see Guo and Harrison, 2001), a higher τ^m_{t+1} (or a lower $(1-\tau^m_{t+1})$) will decrease the margin effect of the reduction of the interest rate. It is evident from (19) that since the magnitude of the reduction in the real interest rate $(1-\tau^m_{t+1})r_{t+1}$ decreases with τ^m_{t+1}, a progressive tax schedule may give rise to a destabilizing effect on the economy.[5] When the marginal tax rate is strictly increasing and convex in ϕ, the latter direct effect will become more pronounced as the tax progressivity ϕ is higher. Therefore, a less progressive tax is needed to eliminate indeterminacy.

By analogy, under a regressive tax schedule ($\phi<0$) there also are two conflicting effects in terms of governing the stabilization of tax policy. On the one hand, as $\phi<0$ the increase in the future output Y_{t+1} tends to decrease the government's tax revenues $\tau_{t+1}Y_{t+1}$ and hence the government purchase $G_{c,t+1}$. Due to the resources withdrawal effect, consumption C_{t+1} and the relative price p_{t+1} increase as a response. Since the consumption and price effects become stronger, the regressive tax schedule destabilizes the economy. On the other hand, the households face a lower marginal tax rate under the regressive tax schedule. A lower τ^m_{t+1} amplifies the margin effect

5 This effect is different from that in a one-sector model with aggregate production externalities, as proposed in Guo and Lansing (1998). To ensure the existence of indeterminacy, the real interest rate r_{t+1} must increase in response to the agents' optimism in a one-sector economy without the consideration of tax policies. However, indeterminacy can occur in the two-sector model without aggregate externalities even though the interest rate is decreasing in the capital stock K_{t+1}, provided that the real capital gain increases as a result of a sufficiently high sectoral externality.

of the reduction of the real interest rate r_{t+1}. This leads the regressive tax schedule to stabilize the economy. Since the marginal tax rate is increasing and convex in ϕ, the later direct effect becomes weaker and is more likely to dominate as the tax regressivity is higher (a lower ϕ). Thus, a less regressive tax schedule is needed to remove indeterminacy.

By focusing on the scenario where $\omega=0$, in which the government only purchases the investment good, instead of the consumption good, the government's rising public sector spending on the investment good drives down or even eliminates private sector spending on the investment good (the *crowding-out effect*). By taking this effect into account, households are less willing to give up today's consumption in exchange for more capital accumulation tomorrow. Thus, in addition to the reversed consumption and price effects, this crowding-out further reverses the investment effect, prohibiting agents' optimistic expectations from being self-fulfilling. That is why the stabilizing effect of tax policies is more robust when the government's tax revenues are used to purchase the investment good as public services.

C. Sensitivity

A sensitivity analysis is helpful towards a better understanding of the stabilization of income tax policies. This subsection will consider various parameterizations with respect to the inverse of labor supply (γ), the coefficient of risk aversion (σ), and the composition of government spending (ω).

(A) The Inverse of Labor Supply (γ)

I first consider three various values of parameters of the inverse of labor supply, $\gamma=0.1$, 0.25, and 0.5, which allow us to gauge the sensitivity of the stabilizing effect of tax policy. Intuitively, with more elastic labor supply (lower values of γ), agents are more willing to move out of leisure into labor and hence, the investment effect turns out to become stronger. It turns out that household's optimism is more likely to become self-filling, generating indeterminacy, as shown in Benhabib and Farmer (1994). By focusing on the scenario in which the tax revenues are used to purchase the consumption good ($\omega=1$), Figure 3-1 indicates that given $\theta=0.108$, income taxes (regardless of progressivity or regressivity) are no longer a stabilizer that mitigates endogenous business cycles when $\gamma=0.1$. In effect, under our parameterization with $\theta=0.108$ the tax policy will have no stabilizing effect on the economy if $\gamma<0.208$. This result differs from that of Guo and Harrison (2001), who show that with more elastic labor supply ($\gamma=0.1$), a regressive tax schedule still can stabilize the economy, if the government's tax revenues are returned to households as a lump-sum transfer, rather than used to purchase goods. By contrast, as compared

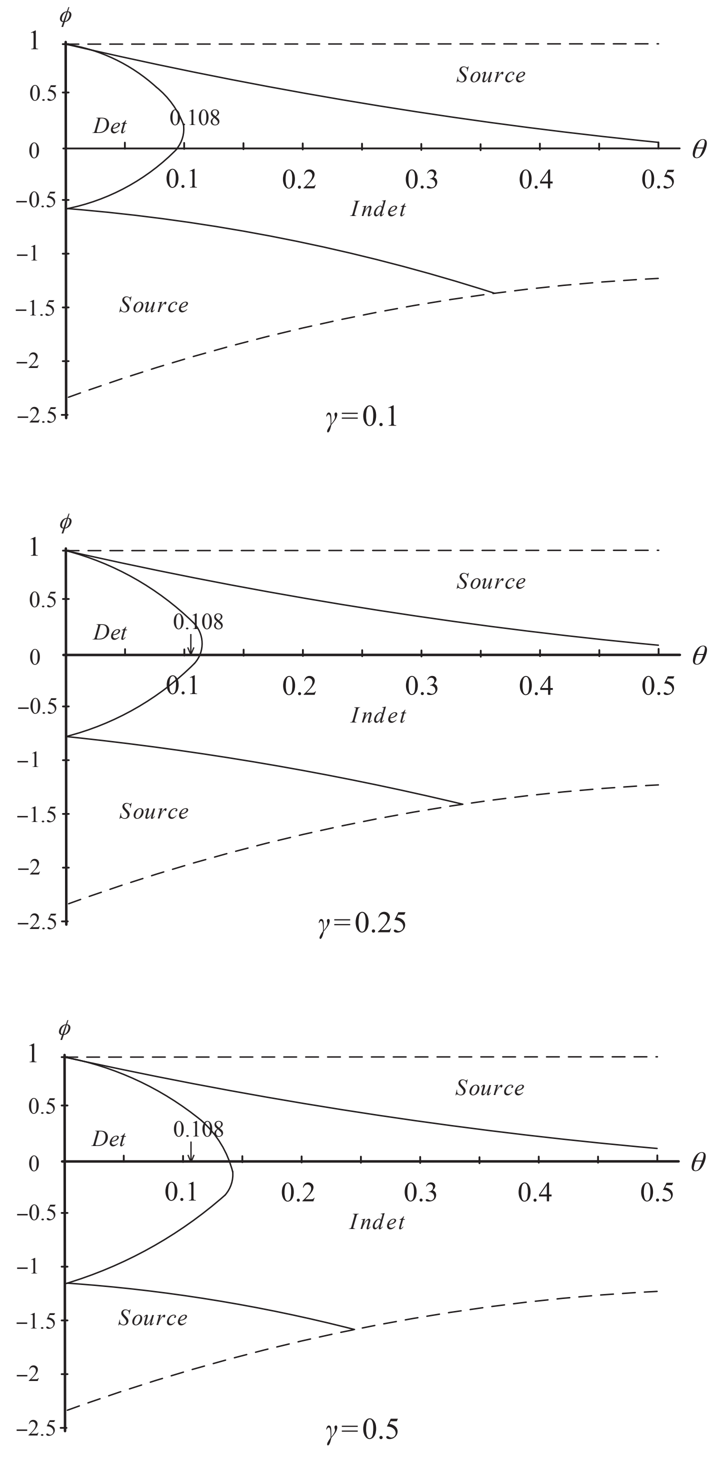

Fig. 3-1. The Inverse of Labor Supply: The Scenario where ω=1

with the benchmark case where $\gamma=0.25$, the stabilizing effect of income taxes becomes more robust in the presence of less elastic labor supply (e.g., $\gamma=0.5$).

If the government uses its tax revenues to purchase the investment good ($\omega=0$), Figure 3-2 shows that income taxes can stabilize the economy against sunspot fluctuations even though labor supply appears to be more elastic, $\gamma=0.1$ (in fact, the stabilization of income taxes is still valid in an extreme case $\gamma=0$, which is adopted by Benhabib and Farmer, 1996). This confirms the result reported in Section III(A) whereby income taxes are more likely to suppress sunspot fluctuations if the government uses its revenues to purchase the investment good, instead of the consumption good.

(B) The Coefficient of Risk Aversion (σ)

In this subsection, I examine how the stabilizing effect of income tax policy is sensitive to the intertemporal elasticity of substitution of consumption (captured by the parameter of risk aversion, σ). Intuitively, if agents have a high intertemporal elasticity of substitution of consumption (lower value of σ), agents become less risk averse and more willing to give up today's consumption in exchange for higher investment, with more resources moving from the consumption good sector to the investment good sector, thus generating stronger investment and price effects. Under the case of low risk aversion ($\sigma=0.5$), Figure 4-1 indicates that given $\theta=0.108$, the tax policy (regardless of progressivity or regressivity) can't stabilize the economy when government only purchases the consumption good ($\omega=1$). Conversely, if government only purchases the investment good ($\omega=0$), Figure 4-2 shows that a progressive income tax is able to stabilize the economy against sunspot fluctuations.

By contrast, in the case of high risk aversion ($\sigma=2$), Figure 4-1 and Figure 4-2 indicate that given $\theta=0.108$, a progressive tax schedule can have a stronger stabilizing effect, rather than a regressive tax schedule.

(C) The Composition of Government Spending (ω)

In the benchmark case, the government purchases either the consumption good or the investment good. In this extended investigation, I allow the government purchases to be composite, i.e., $0<\omega<1$. By following the classification of Kneller et al. (1999), I aggregate the OECD's functional classifications of fiscal data (OECD stat.) for six selected countries into two main categories: government investment and government consumption.[6] The former includes general public services, defence, housing, and educational and health expenditures, while the latter includes public

6 The countries include France, Germany, Italy, Japan, the U.K., and the U.S.

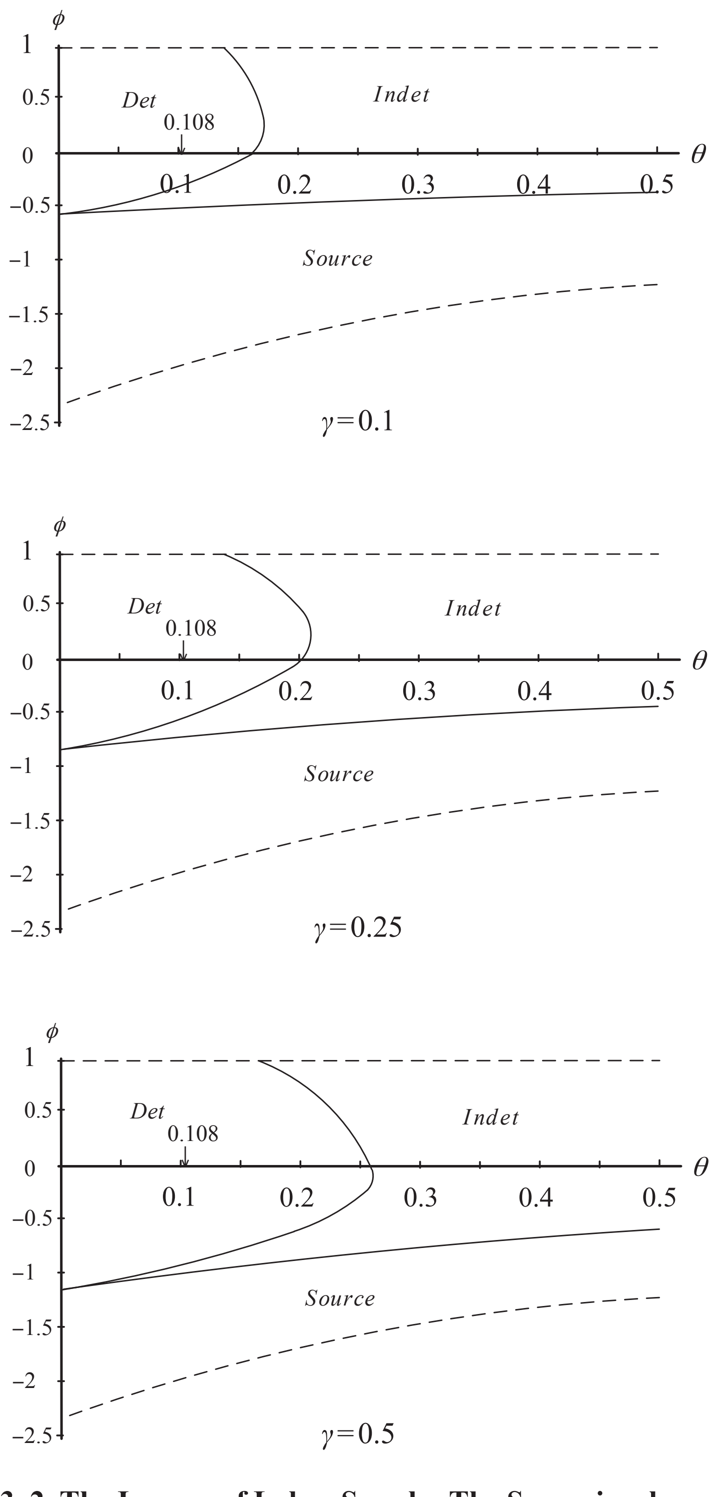

Fig. 3-2. The Inverse of Labor Supply: The Scenario where $\omega=0$

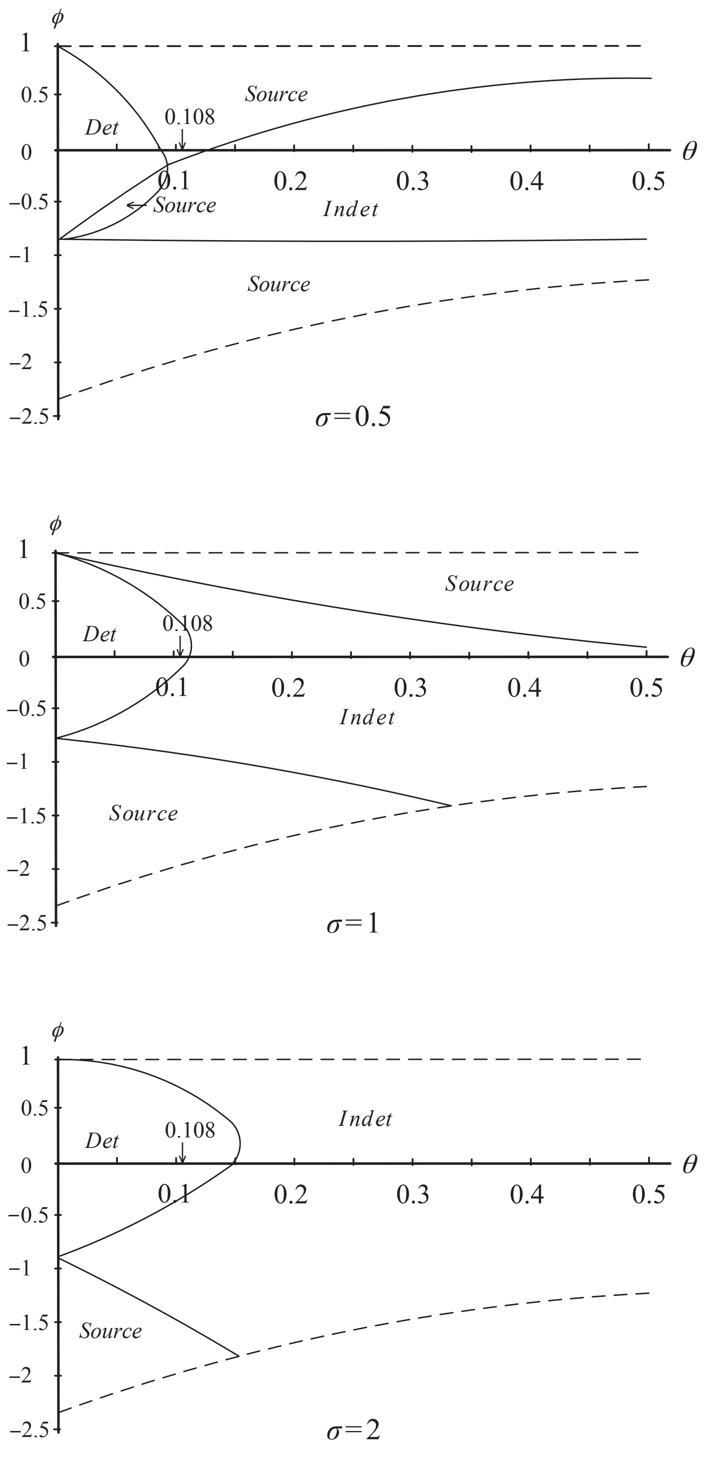

Fig. 4-1. The Risk Aversion: The Scenario where $\omega=1$

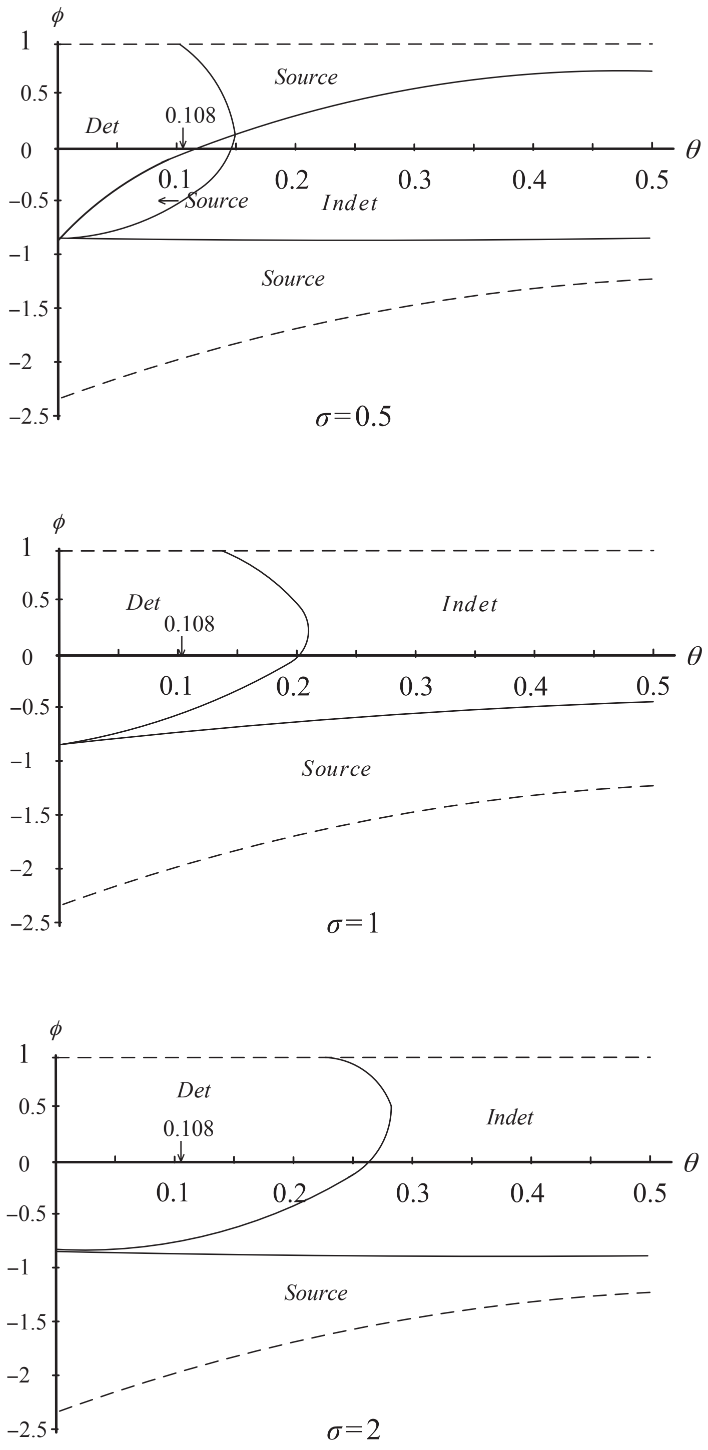

Fig. 4-2. The Risk Aversion: The Scenario where $\omega=0$

order and safety, economic affairs, environmental protection, social protection, and recreational expenditures. It is found that on average the composition of government spending of these OECD countries during the period of 2001–2018 is around $\omega=0.526$. Thus, I choose three various parameterizations: $\omega=0.417$ (the lowest value for Germany), $\omega=0.526$, $\omega=0.647$ (the highest value for the U.S.). Figure 5 shows that there are very similar numerical results for distinct values of ω, indicating that our result are robust to various compositions of government spending. It can be found again from Figure 5 that (i) the stabilization of income taxes is more robust if the tax revenues are used to purchase a larger proportion of the investment good (lower ω) and (ii) relative to the policy of tax regressivity, a progressive tax schedule is more likely to suppress the sunspot fluctuations, given a specific extent of sectoral externalities.[7]

IV. Discussion

In this section, I will discuss the coordination of government stabilization policies under different values of sector-specific externalities: $\theta=0.07$, 0.09, and 0.108. To focus on stabilization policies, in Figure 6 I indicate that the region of determinacy lies in the (ω, ϕ) space. In our numerical analysis, Figure 6, indicates that the steady-state equilibrium is determinate, when (i) given that a tax policy (regardless of progressivity or regressivity) is fixed, government purchases more investment good (a lower value of ω), and the critical value of $(1-\hat{\omega})$ for determinacy is increasing with sector-specific externalities, hence $\frac{\partial(1-\hat{\omega})}{\partial\theta}$. (ii) Given that the composition of government spending is fixed, a progressive tax schedule is more robust than a regressive tax schedule in terms of suppressing the belief-driven fluctuations, and the range of the slope of the tax schedule has become narrow, with higher sector-specific externalities.

Obviously, our results suggest that a different composition of government spending and/or tax schedule (regardless of progressivity or regressivity) will have a dramatically different stabilizing effect. By developing a variant of the Bond et al. (1996) model with the goods and education sectors, Raurich (2001) shows that an expansionary fiscal policy may facilitate belief-driven fluctuations if the government only makes purchases in the goods sector. In contrast to his result, I point out that

7 These main results hold when we consider a case in which the government not only purchases the consumption goods and/or the investment goods but also returns the lump-sum transfers to households. I thank an anonymous referee for pointing this out to me.

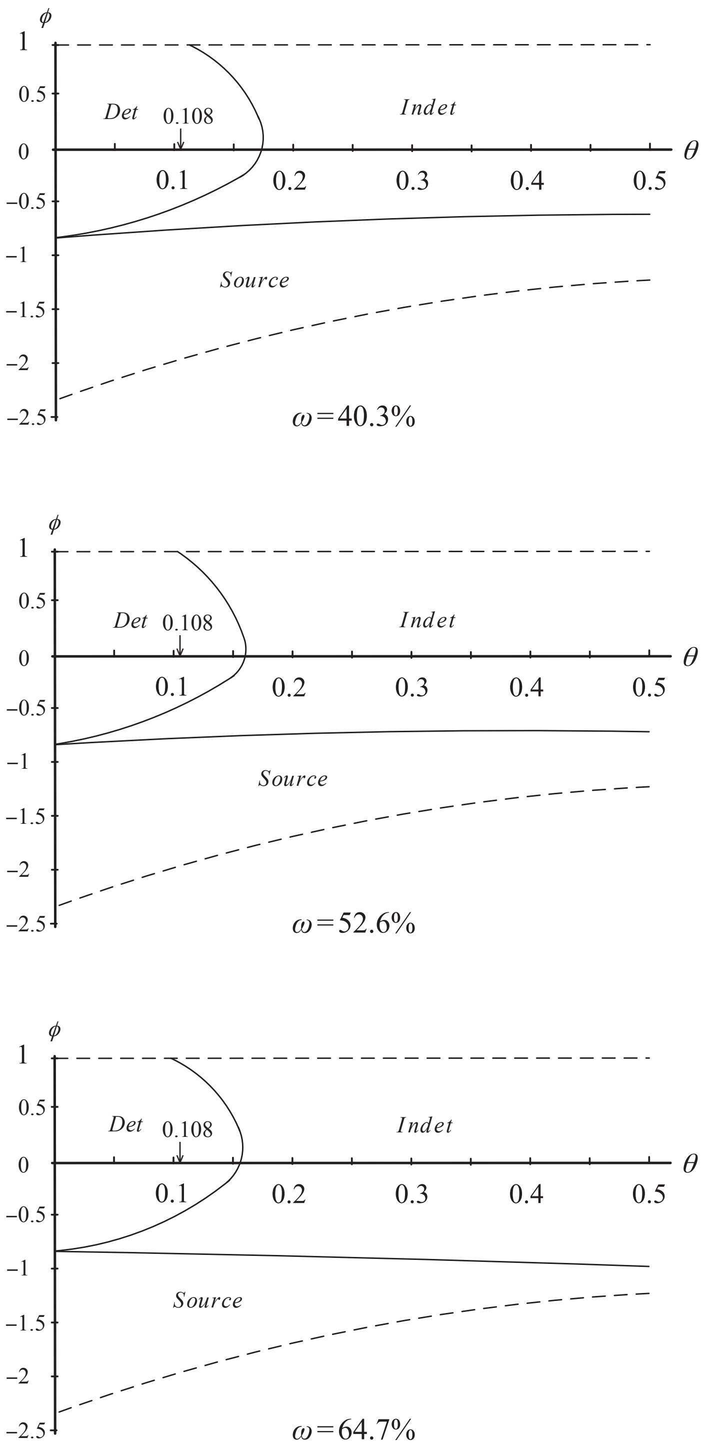

Fig. 5. The Composition of Government Spending

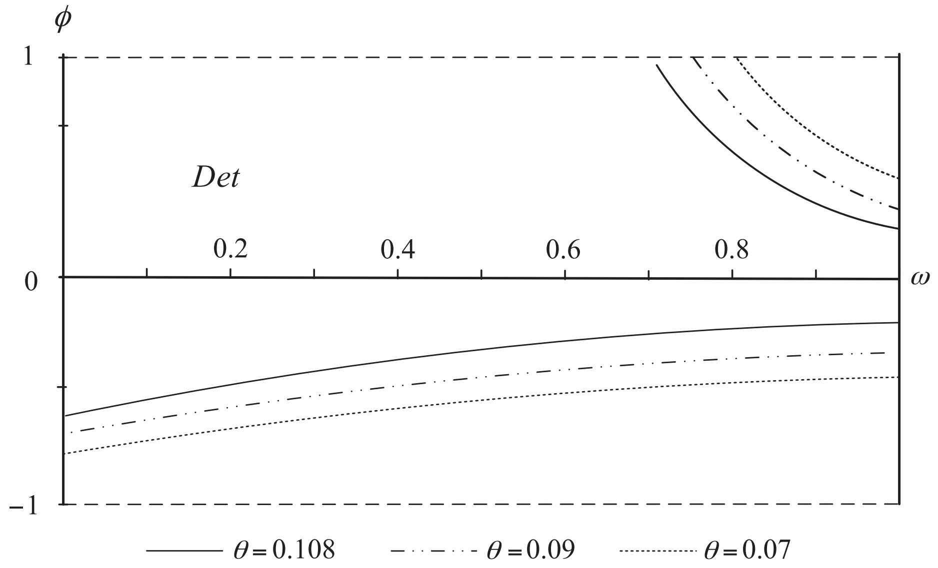

Fig. 6. The Stabilization Region with Various θ

government spending on the investment good will suppress, rather than facilitate, sunspot fluctuations. Nevertheless, sunspot fluctuations are more likely to occur if the government provides public services by only purchasing consumption goods. Moreover, a progressive tax schedule is more robust than a regressive tax schedule in terms of suppressing the belief-driven fluctuations. This again runs counter to compared to Guo and Harrison's (2001; 2011) proposition.

Two new and important policy implications are that, (i) compared to government spending, the composition of government spending may be more crucial in terms of affecting macroeconomic stability; (ii) compared to a regressive tax schedule, a progressive one can provide a stronger stabilizing effect.

V. Concluding Remarks

This study has re-investigated the stabilization of income tax policies proposed by Guo and Harrison (2001; 2011), proving novel policy implications which sharply differ from those of theirs. My results have suggested that given an empirically relevant extent of sector-specific externality, both progressive and regressive tax schedules can stabilize the economy against the sunspot fluctuations, if the government's tax revenues are used to purchase goods as public services, rather than them returned to households as lump-sum transfers. In this aspect, the present paper's policy implication is different not only from that of Guo and Harrison (2001; 2011), but also from the prediction in a one-sector model (e.g., Guo and Lansing, 1998; Christiano and Harrison, 1999; Dromel and Pintus, 2007; 2008). Moreover, a progressive tax schedule is more robust than a regressive tax schedule in terms of suppressing belief-driven fluctuations. This again contradicts to Guo and Harrison's (2001; 2011) proposition. Finally, I have found that income taxes are more likely to suppress the sunspot fluctuations if the government uses its revenues to purchase the investment good, instead of the consumption good. These results have been shown to be robust via a sensitivity analysis with respect to the various elasticities of labor supply, coefficient of risk aversion, and composition of government spending.

This paper can be extended in several directions. For example, it would be worthwhile to explore my modeled economy under a non-separable preference formulation *a la* Linnemann (2008) or useful government spending (includes productive- and utility-generating government spending) *a la* Guo and Harrison (2008).

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部門特定外部性下的稅收政策與安定性之再探討

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摘　　要

本文重新審視 Guo and Harrison（2001, *Review of Economic Dynamics*）所提出的所得稅率安定政策。本文的研究發現，當特定產業存在部門外部性，若政府將稅收用於購買商品來做爲公共服務使用，而不是移轉性支付給家計單位的話，累進與累退的所得稅政策都能使經濟體系更爲穩定；且累進稅比累退稅的所得稅政策更具有安定效果。同時，本文也發現政府購買投資財比購買消費財具有更佳的安定效果。這些結果與 Guo and Harrison（2001）的主張截然不同，因此，本文的結果補充了 Guo and Harrison（2001）的分析，並且爲文獻提供了新的政策意涵。

關鍵字：稅收政策、總體（不）安定、政府支出、部門特定外部性

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