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Macroeconomic Effect of Consumption Tax on "Dynamic" and "Myopic" Agents

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Abstract

We analyze the effect of consumption tax on the economy with heterogeneous agents, that is, with a dynamic capitalist and a myopic worker. We suppose that the revenue which is raised for government expenditure and is included in the worker's utility is only from consumption tax and that the constant tax rate for each agent may be different. We theoretically find that it is beneficial for all agents if the capitalist as the dynamic agent becomes more patient and increases his "spirit of capitalism", whereas controlling tax rates faces a trade-off between the economic scale and the difference of agent, although heterogeneous taxes may have different effects to some extent.

Keywords: government expenditure in utility, consumption tax, heterogeneous agents, dynamic and myopic.

JEL Classification Numbers: E62, H20.

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1 Introduction

We analyze the effect of consumption tax on the economy with heterogeneous agents, i. e., a dynamic capitalist and a myopic worker.

Heterogeneity of agents is one of the main themes in theoretical economics. The literature mainly assumes the difference in time discount rate, such as Mino and Nakamoto (2012). In relation to fiscal policy, Andrés et al. (2016) investigate the effect of different tax rates in the economy including the "patient" and "impatient" agents, and show that opposite effects on each type of agent may produce.

In our study, we introduce heterogeneity similar to that introduced by Di Bartoromeo and Rossi (2007), i. e., in the form of "dynamic" and "myopic" agents. They analyze a New-Keynesian economy including sticky prices and monopolistic competition. We assume a neo-classical (flexible-price) economy, and an orthodox Cobb-Douglas structure of output in which capital and labor are productive factors, but suppliers of each factor are different. The capitalist as a "dynamic" agent faces optimal decisions over time, while the worker solves the one-shot optimization.

We suppose that the revenue for government expenditure is only from consumption tax and that the constant tax rate levied on each agent may be different.¹ We can interpret this as setting a sort of reduced tax rate. As claimed by McKnight (2016) who shows that consumption taxes are more desirable than income taxes in view of equilibrium determinacy with monetary policy of the interest-rate control type (the so-called "Taylor rule"), many countries shift from direct to indirect taxation, which is well expressed in our model.

Further, we assume that the capitalist does not obtain his utility from the government service, while he derives pleasure from accumulating capital as in Chen and Guo (2009). In other words, the worker receives benefit from the government expenditure as discussed by Guo and Harrison (2008) and Hori and Maebayashi (2013), that is, his tax payments partly return to himself.

Our economy is always stable in that equilibrium is determinate, owing to the structure not being highly complicated. Therefore, we can focus on the level of the steady state to consider the effect of policy. Higher tax rates negatively affect most of the economic variables around the steady state, but the sum of consumption and government expenditure which benefits the worker increases with the capitalist's tax rate, in contrast to the worker's tax

¹In Bambi and Venditti (2016), consumption tax rate are time-varying and government expenditure is used for production. They show that there exists a unique balanced growth path but that sunspot equilibria based on self-fulfilling expectations emerge under counter-cyclical consumption taxes.

rate, so that the difference between agents may shrink. Controlling tax rates faces a trade-off between the economic scale and the difference of agents. On the other hand, we analytically find that lower weight of consumption relative to capital and the time discount rate have positive effects on the steady-state levels, and thus such change of the capitalist as dynamic agent, which implies the deeper desire for capital relative to consumption and stronger forbearance with regard to the future, is also the means of improving the economy.

2 Model

The output technology using capital k and labor l is in the form of the Cobb-Douglas function,

$$y = k^\alpha l^{1-\alpha}, \quad 0 < \alpha < 1. \quad (1)$$

We assume that each productive factor is provided by a heterogeneous agent of each type existing as one unit.

Capitalist solves the dynamic optimization problem,

$$\max \int_0^\infty \frac{[c^\theta k^{1-\theta}]^{1-\sigma}}{1-\sigma} e^{-\rho t} dt, \quad \rho > 0, \quad \sigma > 0, \quad 0 < \theta \leq 1, \quad (2)$$

subject to

$$\dot{k} = rk - (1 + \bar{\tau}_c)c, \quad \bar{\tau}_c \geq 0, \quad (3)$$

and the non-Ponzi condition, where ρ is the time discount rate, consumption c , rental rate $r = \frac{\alpha y}{k}$, and consumption tax rate $\bar{\tau}_c$ is constant. In addition, $(1 - \theta)$ implies "the spirit of capitalism".² The conditions for this optimization are summarized as follows:

$$c = c(k, \lambda) = \left[\frac{\theta k^{(1-\theta)(1-\sigma)}}{\lambda(1 + \bar{\tau}_c)} \right]^{\frac{1}{1-\theta(1-\sigma)}}, \quad (4)$$

$$\dot{\lambda} = \left(\rho - \frac{\alpha y}{k} - \frac{1-\theta}{\theta} \frac{(1 + \bar{\tau}_c)c}{k} \right) \lambda, \quad (5)$$

with transversality condition, where λ is a shadow value of capital.

²The setting of social status preference for the capital-in-the-utility is usually introduced as the individual capital relative to the average capital, as discussed by Tamai (2008), Chen and Guo (2011) and Fujisaki (2012). For simplicity, we use only the level of individual capital as Chen and Guo (2009).

On the other hand, the worker's decision is myopic and he can receive the services from the government. That is, in each period he maximizes the utility

$$\frac{(c' + g)^{1-\sigma}}{1-\sigma} - \frac{l^{1+\chi}}{1+\chi}, \quad \sigma > 0, \quad \chi \geq 0, \quad (6)$$

subject to

$$wl = (1 + \bar{\tau}'_c)c', \quad \bar{\tau}'_c \geq 0 \quad (7)$$

where worker's consumption c' , wage $w = \frac{(1-\alpha)y}{l}$, and his consumption tax rate $\bar{\tau}'_c$ is constant and may not be equal to the capitalist's rate. An inverse of the intertemporal elasticity of substitution σ is equal to that of the capitalist's. In addition, government expenditure g is financed only by consumption taxes, such that the following holds true;

$$\bar{\tau}_c \cdot c + \bar{\tau}'_c \cdot c' = g. \quad (8)$$

Since $c' + g = \bar{\tau}_c \cdot c + wl$ from Eqs. (7) and (8), the optimal condition is contracted as follows:

$$\left(\frac{1 + \bar{\tau}'_c}{1 - \alpha} k^{-\alpha} l^{\alpha + \chi} \right)^{-\frac{1}{\sigma}} = (1 - \alpha)k^{\alpha} l^{1 - \alpha} + \bar{\tau}_c \left[\frac{\theta k^{(1-\theta)(1-\sigma)}}{\lambda(1 + \bar{\tau}_c)} \right]^{\frac{1}{1-\theta(1-\sigma)}}. \quad (9)$$

Therefore, labor can be written as $l = l(k, \lambda)$, satisfying that

$$l_k = \frac{\partial l}{\partial k} \Big|_{ss} = \frac{\bar{l}}{k} \left[(1 - \alpha) \frac{1 - \sigma}{\sigma} + \bar{\tau}_c \left(\frac{1 - \sigma + \sigma\alpha}{\sigma} - \frac{(1 - \theta)(1 - \sigma)}{1 - \theta(1 - \sigma)} \right) \right] \cdot \left[\frac{1 - \alpha}{\alpha} \left(\frac{\alpha + \chi}{\sigma} + 1 - \alpha \right) + \bar{\tau}_c \left(\frac{\alpha + \chi}{\sigma\alpha} + \frac{(1 - \alpha)^2}{\alpha} \right) \right]^{-1},$$

$$l_\lambda = \frac{\partial l}{\partial \lambda} \Big|_{ss} = \frac{\bar{l}}{\bar{\lambda}} \frac{\bar{\tau}_c}{1 - \theta(1 - \sigma)} \left[\frac{1 - \alpha}{\alpha} \left(\frac{\alpha + \chi}{\sigma} + 1 - \alpha \right) + \bar{\tau}_c \left(\frac{\alpha + \chi}{\sigma\alpha} + \frac{(1 - \alpha)^2}{\alpha} \right) \right]^{-1},$$

around the steady state described in detail in the next section.

3 Analysis around the Steady State

The following equations describe the dynamic system, which implies the goods-market equilibrium condition and the Euler equation:

$$\dot{k} = \alpha k^\alpha l(k, \lambda)^{1-\alpha} - (1 + \bar{\tau}_c)c(k, \lambda), \quad (10)$$

$$\dot{\lambda} = \left(\rho - \alpha \left(\frac{l(k, \lambda)}{k} \right)^{1-\alpha} - \frac{1 - \theta}{\theta} \frac{(1 + \bar{\tau}_c)c(k, \lambda)}{k} \right) \lambda. \quad (11)$$

We examine the properties around the unique steady state, which satisfies the following conditions;

$$\begin{aligned} \frac{\bar{y}}{\bar{k}} &= \frac{(1 + \bar{\tau}_c)\bar{c}}{\alpha \bar{k}} = \frac{\theta \rho}{\alpha}, \quad \bar{y} = \frac{\theta \rho}{\alpha} \bar{k}, \quad \bar{c} = \frac{\theta \rho}{1 + \bar{\tau}_c} \bar{k}, \quad \bar{c}' = \frac{(1 - \alpha)\theta \rho}{(1 + \bar{\tau}_c)\alpha} \bar{k}, \\ \bar{g} &= \left[\frac{\bar{\tau}_c}{1 + \bar{\tau}_c} \alpha + \frac{\bar{\tau}_c'}{1 + \bar{\tau}_c'} (1 - \alpha) \right] \frac{\theta \rho}{\alpha} \bar{k}, \quad \bar{c}' + \bar{g} = \left(\frac{1 - \alpha + \bar{\tau}_c}{1 + \bar{\tau}_c} \right) \frac{\theta \rho}{\alpha} \bar{k}. \end{aligned} \quad (12)$$

3.1 Equilibrium Determinacy

The coefficient matrix of the linearized system of the original Eqs. (10) and (11) around the steady state is

$$J = \begin{bmatrix} \dot{k}_k & \dot{k}_\lambda \\ \dot{\lambda}_k & \dot{\lambda}_\lambda \end{bmatrix},$$

where

$$\dot{k}_k = \left. \frac{\partial \dot{k}}{\partial k} \right|_{ss} = (1 + \bar{\tau}_c) \left[\frac{\alpha \bar{c}}{\bar{k}} - c_k + \frac{(1 - \alpha)l_k \bar{c}}{\bar{l}} \right], \quad \dot{k}_\lambda = \left. \frac{\partial \dot{k}}{\partial \lambda} \right|_{ss} = (1 + \bar{\tau}_c) \left[\frac{(1 - \alpha)l_\lambda \bar{c}}{\bar{l}} - c_\lambda \right],$$

$$\dot{\lambda}_k = \left. \frac{\partial \dot{\lambda}}{\partial k} \right|_{ss} = -(1 + \bar{\tau}_c) \frac{\bar{\lambda}}{\bar{k}^2} \left[(1 - \alpha) \frac{\bar{c}}{\bar{l}} (l_k \bar{k} - \bar{l}) + \frac{1 - \theta}{\theta} (c_k \bar{k} - \bar{c}) \right],$$

$$\dot{\lambda}_\lambda = \left. \frac{\partial \dot{\lambda}}{\partial \lambda} \right|_{ss} = -(1 + \bar{\tau}_c) \frac{\bar{\lambda}}{\bar{k}} \left[\frac{(1 - \alpha)l_\lambda \bar{c}}{\bar{l}} + \frac{1 - \theta}{\theta} c_\lambda \right].$$

Thus, the following holds true;

$$\begin{aligned}
DetJ &= \mu_1\mu_2 = \dot{k}_k \cdot \dot{\lambda}_\lambda - \dot{k}_\lambda \cdot \dot{\lambda}_k \\
&= (1 + \bar{\tau}_c)^2 \frac{\bar{\lambda}}{\bar{k}} \frac{1 - \alpha}{\theta} \bar{c} \left[\frac{l_\lambda}{\bar{l}} \left(c_k - \frac{\bar{c}}{\bar{k}} \right) + c_\lambda \left(-\frac{l_k}{\bar{l}} + \frac{1}{\bar{k}} \right) \right] \\
&= - \left((1 + \bar{\tau}_c) \frac{\bar{c}}{\bar{k}} \right)^2 \frac{1 - \alpha (\chi + \sigma)(1 - \alpha + \bar{\tau}_c)}{\theta \alpha \sigma [1 - \theta(1 - \sigma)]} \\
&\quad \cdot \left[\frac{1 - \alpha}{\alpha} \left(\frac{\alpha + \chi}{\sigma} + 1 - \alpha \right) + \bar{\tau}_c \left(\frac{\alpha + \chi}{\sigma \alpha} + \frac{(1 - \alpha)^2}{\alpha} \right) \right]^{-1}, \tag{13}
\end{aligned}$$

$$\begin{aligned}
TraceJ &= \mu_1 + \mu_2 = \dot{k}_k + \dot{\lambda}_\lambda \\
&= \theta \rho \left(\left\{ (1 - \alpha) \left(\frac{1 - \sigma}{\sigma} \right) + \bar{\tau}_c \left(\frac{1 - \sigma + \alpha \sigma}{\sigma} + \frac{\sigma}{1 - \theta(1 - \sigma)} \right) \right\} \right. \\
&\quad \left. \left[\frac{1 - \alpha}{\alpha} \left(\frac{\alpha + \chi}{\sigma} + 1 - \alpha \right) + \bar{\tau}_c \left(\frac{\alpha + \chi}{\sigma \alpha} + \frac{(1 - \alpha)^2}{\alpha} \right) \right]^{-1} + \alpha + \frac{1 - \theta}{\theta} \right). \tag{14}
\end{aligned}$$

There is one jump variable, λ , and one predetermined variable, k , in the dynamic system so that the steady state satisfies local determinacy, if one eigenvalue is positive, that is, $DetJ = \mu_1\mu_2 < 0$. From Eq. (13), it holds true so that this economy is stable around the steady state in that the equilibrium path is uniquely determined. This may be because the structure of this economy is simple,³ and thus the government can focus on the level of the steady state to consider the tax policy.

3.2 Effect of Varying Taxes

Next, we examine the effect around the steady state of the change of some parameters such as constant taxes. From Eqs. (1), (7), (9) and (12), it holds that $\bar{l} = \left(\frac{\theta \rho}{\alpha} \right)^{\frac{1}{1-\alpha}} \bar{k}$ and thus

$$\frac{1}{\bar{k}} \left(\frac{1 + \bar{\tau}'_c}{1 - \alpha} \left(\frac{\theta \rho}{\alpha} \right)^{\frac{\alpha + \chi}{1 - \alpha}} \bar{k}^\chi \right)^{-\frac{1}{\sigma}} = \frac{\theta \rho (1 - \alpha)}{\alpha} + \frac{\theta \rho \bar{\tau}_c}{1 + \bar{\tau}_c}. \tag{15}$$

³In connection with determinacy, Kamiguchi and Tamai (2011) state that the source of indeterminacy is income tax financing under a balanced-budget rule rather than the presence of productive government spending.

Table 1: Comparative Statics

	\bar{k}	\bar{y}	\bar{c}	\bar{c}'	\bar{g}	$\bar{c}' + \bar{g}$
θ	-	-	-	-	-	-
ρ	-	-	-	-	-	-
$\bar{\tau}_c$	-	-	-	-	+	+
$\bar{\tau}'_c$	-	-	-	-	?	-

+ : higher, - : lower, ? : depending on other parameters

Therefore, the steady-state value of capital is

$$\bar{k} = \left[\frac{1 - \alpha}{1 + \bar{\tau}'_c} \left(\frac{\theta \rho}{\alpha} \right)^{-\frac{\alpha + \chi + \sigma(1 - \alpha)}{1 - \alpha}} \left(\frac{1 + \bar{\tau}_c}{1 - \alpha + \bar{\tau}_c} \right)^\sigma \right]^{\frac{1}{\sigma + \chi}}. \quad (16)$$

Combining this and Eq. (12), we summarize the results of comparative statics in Table 1.

When the weight of consumption in the capitalist's utility and the time discount rate are higher, the steady-state values of important economic variables such as output become lower. Although these parameters do not seem to directly affect the worker's decisions, he depresses capital accumulation as the source of output which affects the income of both type of agents. In other words, it benefits all that the dynamic agent becomes more patient and loves capital more.

A higher tax rate on the capitalist has two effects. First, an extra effort for the same level of capital accumulation is needed. Second, the rate of return of capital should be higher so that capital decreases due to the non-arbitrage condition. In total, the latter is stronger. However, the sum of the worker's consumption and the government expenditure, which positively affects the worker's felicity, becomes large, since the impact of increasing the rate itself is superior to the lower consumption and the worker's tax rate does not change.

Higher worker's tax rate has enough effect to depress the sum, but it raises the government service under the low tax rate (we can interpret this as Laffer curve of consumption-tax version), and thus the total negative effect weakens to some extent.

In sum, although discriminatory consumption tax rates may have various impacts on the economy, controlling tax rates faces a trade-off between the

economic scale and the difference of agents. Moreover, such a policy is politically difficult to implement. Instead, it would be easier and more desirable for all agents that the capitalist as the dynamic agent changed his attitude as discussed above, that is, he became more persevering and increased the spirit of capitalism.

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