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Via Voltapaletto, 11 – 44100 Ferrara

Quaderno n. 24/2007

November 2007

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Abstract This paper analyses the role of the composition of government consumption in a non-scale R&D based model of growth by drawing a distinction between two broad categories of government spending: final goods purchases and public employee compensation. The composition of public expenditure plays a crucial role because changes in the goods and the employment components have different effects on the long run equilibrium of the economy. Unlike an increase in government spending in final goods, an increase in public employment reallocates labour away from the private sector with a negative effect on per capita output, research effort and innovation. In addition, for given level of public expenditure a change in the composition affects the steady-state allocation of resources and influences the economy's transitional dynamics by varying the speed of convergence toward the steady state.

JEL Classification: O4, H5

Keywords: public consumption, government expenditure composition, economic growth, fiscal policy

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1. Introduction

The role of the composition of government spending in growth models has been analyzed by drawing a distinction between public investment and public consumption on goods and services (e.g. Barro, 1990; Turnovsky, 1996, 2000; Chen, 2006). Empirically, however, wages and salaries for government employees represents a large share of public consumption in national accounts. The different effects on the economy arising from shocks to government good purchases and shocks to government employment has been recognized in some real business cycle models (Finn,1998; Ardagna, 2001). However the role of the composition of public consumption when distinguished between these two broad categories has not been explored in an endogenous growth framework yet.

In this note we examine the long run effects of the goods and the employment expenditure components of government consumption by extending a R&D based growth model, first proposed by Romer(1990) and Grossman and Helpman(1991). A semi-endogenous version of this class of models is used which does not exhibit the *scale effect* that has been questioned on empirical ground (Jones 1995, 1999).

We show that the composition of public consumption expenditure plays a crucial role because changes in the goods and the employment components have different effects on the long run equilibrium of the economy. Unlike an increase in government spending in final goods, an increase in public employment reallocates labour away from the private sector with a negative effect on per capita output, research effort and innovation. In addition, for given level of public expenditure a change in the composition between wages and salaries for government employees and public spending on final goods affects the steady-state allocation of resources and influences the economy's transitional dynamics by varying the speed of convergence toward the steady state.

2. The model

We consider a R&D based growth model of the increasing variety type with three sectors. The final output Y is produced using a set of intermediate goods x_i:

$$Y = \left[\int_0^A x_i^{\varepsilon} di \right]^{\frac{1}{\varepsilon}}, \qquad 0 < \varepsilon < 1. \tag{1}$$

The stock of intermediates A can be expanded employing labour (L_A) in the research sector in accordance with the following production function

$$\dot{A} = L_A A^{\phi}, \qquad \phi < 1. \tag{2}$$

As in Jones (1999), the parameter ϕ discriminates between two classes of growth models. The restriction $\phi < 1$ represents the easiest way to eliminate the scale effect, while with $\phi = 1$ the model exhibits a traditional endogenous growth setup.

In the sector of intermediates each variety i is produced by a monopolistically competitive firm using labour L_i:

$$x_i = L_i, \tag{3}$$

The final good sector is competitive. Given (1) profit maximization implies the following price rule under symmetry

$$P = A^{\frac{\varepsilon-1}{\varepsilon}} p, \tag{4}$$

where the price of a single intermediate p is determined as a constant markup over marginal labour costs $p = \frac{1}{\varepsilon}w$.

Calling $L_x = xA$ total employment in the intermediate good sector, the flow of profits for any intermediate producer is

$$\pi = \frac{1-\varepsilon}{\varepsilon} w \frac{L_x}{A}. \tag{5}$$

As the innovation sector is competitive, free entry forces profits to zero. The cost of a single blueprint must be equal to the discounted perpetual flow of profit v, generated by the new intermediate variety

$$\frac{w}{A^{\phi}} = v. \tag{6}$$

Households

The economy is populated by identical individuals; L is the size of population growing over time at the constant rate μ. Each individual is endowed with one unit of time and derives utility from consumption good c and leisure $(1 - l_S)$. The maximization problem of the representative individual

$$\max U = \int_0^{\infty} \exp[-\rho t] \left[\alpha \ln c(t) + (1-\alpha) \ln(1 - l_S(t))\right] dt \tag{7}$$

$$\dot{A} = \frac{1}{v} \left(\pi A + w l_S L - P c L - \tau L\right), \tag{8}$$

where τ is lump sum taxation, yields the following dynamic and static optimal conditions

$$\frac{\dot{z}}{z}=\frac{\dot{P}}{P}+\frac{\dot{c}}{c}=\frac{\pi}{v}+\frac{\dot{v}}{v}-(\mu+\rho) \tag{9}$$

$$w\left(1-l_S\right)=\frac{1-\alpha}{\alpha}Pc. \tag{10}$$

The Government

Government consumption consists of final good purchases and employee compensation. To finance consumption the government withdraws a fixed amount τ of income from every individual. Therefore $T=\tau L$ represents overall lump sum taxation. A fraction η of T is allocated to consumption of final output, and the remaining $(1-\eta)$ to wage compensation.

$$C_G=\frac{\eta T}{P_D} \quad , \quad L_G=\frac{(1-\eta)T}{w} \tag{11}$$

where L_G represents the labour employed in the public sector and C_G is the public consumption of final output

Equilibrium Conditions and Steady State

To solve the model we start from the per capita equilibrium conditions in the final good ($c+c_G=y$) and the labour market ($l_s=l_x+l_A+l_G$). Recalling that $x=L_x/A$ from (1) and (2) we get

$$c+c_G=y=A^{\frac{1-\varepsilon}{\varepsilon}}l_x \tag{12}$$

$$\dot{a}=a^{\phi}(l_S-l_x-l_G)-\frac{\mu}{1-\phi}a. \tag{13}$$

Lower case letters indicate per capita quantities, while $a=A/L^{\frac{1}{1-\phi}}$ defines the stationary level of the stock of intermediates, since from (2), the long run growth rate of innovation is $\frac{\dot{A}}{A}=\frac{\mu}{1-\phi}$. The wage rate is taken as the numeraire: $w=1$.Given (5), (6) and (13) we rewrite the optimal dynamic path of per capita consumption expenditure z in (9) as

$$\frac{\dot{z}}{z}=l_x a^{\phi-1}\frac{1-\varepsilon}{\varepsilon}-\phi a^{\phi-1}(l_s-l_x-l_G)-(\mu+\rho) \tag{14}$$

By using (10), (11), (12) and (14) we obtain the two differential equations describing the equilibrium dynamics of the economy

$$\dot{z} = \left\{ a^{\phi-1}\left[\frac{(1-\varepsilon)\alpha+\phi(1-\alpha+\alpha\varepsilon)}{\alpha}z+\psi\tau-\phi\right]-(\mu+\rho)\right\}z \quad (15)$$

$$\dot{a} = a^{\phi}\left[1-\frac{(1-\alpha+\alpha\varepsilon)}{\alpha}z-(1-\eta+\eta\varepsilon)\tau\right]-\frac{\mu}{1-\phi}a \quad (16)$$

where $\psi=[(1-\varepsilon)\eta+\phi(1-\eta+\eta\varepsilon)]$. By setting $\dot{z}=0$ and $\dot{a}=0$ in (15) and (16) , the steady state values of A and z are obtained:

$$A^* = \left[\frac{(1-\varepsilon)(1-\phi)(\alpha+\tau(\eta-\alpha)}{\mu+(1-\alpha+\alpha\varepsilon)\rho(1-\phi)}L\right]^{\frac{1}{1-\phi}} \quad (17)$$

$$z^* = \frac{[\mu+\rho(1-\phi)](\alpha+\tau(\eta-\alpha)}{\mu+(1-\alpha+\alpha\varepsilon)\rho(1-\phi)}-\eta\tau \quad (18)$$

Given (2), (3), (10), (17) and (18) the steady state level of employment, output, and the sectoral labour shares are easily derived:

$$l_s^* = \frac{\alpha[\mu+\varepsilon(1-\phi)\rho]+(1-\alpha)[\mu+(1-\phi)\rho(1-(1-\epsilon)\eta)]\tau}{\mu+(1-\alpha+\alpha\varepsilon)\rho(1-\phi)} \quad (19)$$

$$l_A^* = \frac{(1-\varepsilon)\mu(\alpha+\tau(\eta-\alpha)}{\mu+(1-\alpha+\alpha\varepsilon)\rho(1-\phi)} \quad (20)$$

$$l_x^* = \frac{\varepsilon[\mu+\rho(1-\phi)](\alpha+\tau(\eta-\alpha)}{\mu+(1-\alpha+\alpha\varepsilon)\rho(1-\phi)} \quad (21)$$

$$y^* = A^{*\frac{1-\varepsilon}{\varepsilon}}l_x^* \quad (22)$$

Notice that in this non-scale innovation based growth model fiscal variables do not influence the long run growth rate, but they affect the steady state level of per capita output and employment and the long run allocation of labour across sectors.

3. Effects of Changes in Public Consumption Composition

In the present setting, government expenditure policy can be implemented through three different tools, the two components of public consumption, c_G and l_G, and its composition η.

The long run effects of a balanced budget change in c_G or l_G can be evaluated by using equations (17) through (22)[1]. Since taxation is non distortionary a rise in c_G or l_G crowds out private consumption expenditure,

[1] The effects of $dl_G=d\tau$ and $dc_G=d\tau$ can be evaluated by setting $\eta=0$ and $\eta=1$

and increases labour supply. However, the two fiscal instruments exert opposite effects on final output through a reallocation of labour across sectors. The additional demand for the final good generated by a rise in c_G increases demand and profits in the intermediates sector, thus stimulating $R\&D$ investment. Conversely, an increase in l_G is accommodated only partially by an expansion in l_s with a shift of labour out of the private sector and into the government sector. Rising public employment indirectly depresses research activity through a reduced demand for the final good, resulting in a downward shift of the time path of A. In addition, our model allows to investigate the consequences of a change in the composition of public consumption for given level of total public expenditure. The steady state effects of a change in η are summarized by the following derivatives:

$$\frac{\partial A^*}{\partial \eta} > 0, \frac{\partial z^*}{\partial \eta} > 0, \frac{\partial l_x^*}{\partial \eta} > 0, \frac{\partial l_A^*}{\partial \eta} > 0, \frac{\partial l_s^*}{\partial \eta} < 0, \frac{\partial y^*}{\partial \eta} > 0.$$

A rise in η implies that a greater fraction of public expenditure is devoted to the purchase of final output (l_G^* decreases). The higher demand for the final good increases the share of labour employed in the intermediate good industry. As a consequence of the higher demand for intermediates, any new invented variety promises a higher flow of profits, which actively stimulates a greater research effort. Thus, the share of labour in the $R\&D$ industry rises as well. This, in turn determines an upward shift of the growth path of productivity, as A^* permanently increases. The higher level of disposable income, however, causes an increase both of final good consumption and leisure, so that the equilibrium supply of labour decreases.

Transitional dynamics and speed of convergence.

To study the behaviour of the economy along the transitional path, we linearize the dynamic system (15) and (16) about the steady state:

$$\begin{pmatrix} \dot{a} \\ \dot{z} \end{pmatrix} = \begin{pmatrix} -\mu & -\frac{[\alpha(\varepsilon-1)+1]a^{*\phi}}{\alpha} \\ -\frac{(1-\phi)(\mu+\rho)z^*}{a^*} & a^{*(\phi-1)}\frac{[(1-\varepsilon)\alpha+\phi(1-\alpha+\alpha\varepsilon)}{\alpha}z^* \end{pmatrix} \begin{pmatrix} a-a^* \\ z-z^* \end{pmatrix} \tag{23}$$

The two eigenvalues associated to the Jacobian matrix in (23) are of

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respectively in the derivatives of (17) through (22) with respect to τ:

$$\begin{aligned} \frac{\partial z^*}{\partial l_G} &< 0, \frac{\partial l_s^*}{\partial l_G} > 0, \frac{\partial l_x^*}{\partial l_G} < 0, \frac{\partial l_A^*}{\partial l_G} < 0, \frac{\partial A^*}{\partial l_G} < 0, \frac{\partial y^*}{\partial l_G} < 0 \\ \frac{\partial z^*}{\partial c_G} &< 0, \frac{\partial l_s^*}{\partial c_G} > 0, \frac{\partial l_x^*}{\partial c_G} > 0, \frac{\partial l_A^*}{\partial c_G} > 0, \frac{\partial A^*}{\partial c_G} > 0, \frac{\partial y^*}{\partial c_G} > 0 \end{aligned}$$

opposite sign. Therefore, the transitional dynamics is characterized by a unique stable saddle path. We denote λ the stable (negative) root:

$$\begin{aligned} \lambda &= -\frac{1}{2\alpha a^*}\left[-z^*[(\varepsilon-1)(\phi-1)+\phi)]a^{*\phi}+\alpha\mu a^*+\sqrt{\Delta}\right] \quad (24) \\ \Delta &= \left[-z^* a^{*\phi}[\alpha(1-\varepsilon)(1-\phi)+\phi]+\alpha\mu a^*\right]^2+4\alpha z^* a^{*\phi+1}[(1-\alpha+\alpha\varepsilon)(1-\phi)\rho+\mu] \end{aligned}$$

Starting from $a(0) = a_0$, the stable solution to (23) is

$$\begin{aligned} a(t) &= a^* + (a_0 - a^*)\, e^{\lambda t} \\ z(t) &= z^* + (a_0 - a^*)\, h_{21} e^{\lambda t} \end{aligned}$$

where $h_{21} = \frac{2z^*\alpha(\mu+\rho)(1-\phi)}{z^* a^{*\phi}[\alpha(1-\varepsilon)(1-\phi)+\phi]+\alpha\mu a^*+\sqrt{\Delta}}$ represents the slope of the transitional path in the (z, a) space, which can be shown to be strictly positive[2].

We focus on the transitional effects of a permanent change in the composition of public spending η described in Figure 1, that displays the $\dot{z} = 0$ and $\dot{a} = 0$ curves obtained from equations (15) and (16) and the unique stable saddle path trajectory following an increase in η. Starting from the steady state equilibrium in E, the impact effect of an increase in the share of public purchases of final goods is the crowding out of per capita consumption expenditure, which falls from E to point B. Households react to the reduction in their disposable income by supplying more labour. However, this initial crowding-out causes a reallocation of labour across sectors, that starts a crowding-in transitional path toward permanently higher levels of a and z. The higher value of η increases the demand for the final good. Given a, this rises the demand in the monopolistic sector of intermediates, increasing l_x and profits. At the same time, the prospect of higher profits stimulates *R&D* activity and therefore the share of labour allocated to research increases. These initial effects start the new transition along the saddle path BE'. Approaching the new steady state, the expanding stock of varieties increases profits and thus the transition growth rate of private expenditure is positive, which implies a positive growth rate of l_A and a negative growth rate of labour supply. Moreover, in our model a change in the composition varies the speed of adjustment toward the steady state. It can be shown that the absolute value of λ in (24) is a decreasing function of η. Thus, a rise in public employment speeds up the transitional dynamics, while a greater share of expenditure in the final good slows down the convergence to the steady state[3].

[2] The term h_{21} corrisponds to the element of the normalized eigenvector associated with

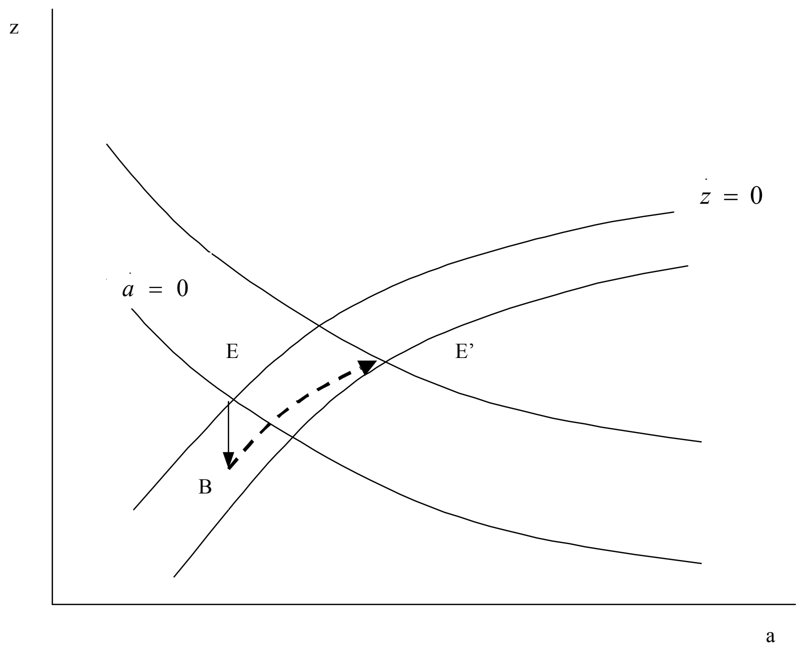

Figure 1: A rise in η

4. Final Remarks

This study explores the effects of government consumption composition on economic activity by drawing a distinction between two broad categories of government spending: final goods purchases and public employee compensation. In both cases, a rise in public consumption reduces households' disposable income and crowds out private consumption. However, with an increase in government employment an additional dimension of crowding out emerges through the labour market: public employment displaces private employment. This sectoral reallocation of labour exerts a negative effect on long run per capita output, R&D intensity and innovation.

The R&D based growth model used in this paper can be developed both in a scale and in a non scale version depending on the value of the parameter measuring the intensity of the externality in innovation activity. While in the non scale model developed above long run growth is unaffected by fiscal variables, the analysis can be easily extended within a traditional endogenous growth (scale) setup where the composition of public consumption affects the

the stable root λ.

[3]Along the same lines, it can be shown that a change in l_G or c_G starts a transitional dynamics characterized by negative and positive growth rate of z, a, and y, respectively.

long run balanced rate of growth of innovation and output. In this case, a change in the composition of government consumption more oriented toward good purchases fosters innovation and effectively stimulates long run growth.

Finally, the results presented in this paper offers a new theoretical perspective to the empirical debate concerning the relationship between economic activity and government consumption expenditure. Indeed, the body of evidence pointing at the relationship between growth and government consumption does not show any clear pattern (e.g. Ram, 1986; Barro, 1991; Easterly and Rebelo, 1993). In this paper we have shown that government expenditure on goods and public employment exert opposite effects on long run economic activity. Therefore, taking into account the composition of public spending in empirical analysis might be helpful for a better understanding of evidence.

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