CONTRIBUTI DI RICERCA CRENOS

CRENOS
CENTRO RICERCHE
ECONOMICHE NORD SUD
Università di Cagliari
Università di Sassari

Government Size and the Composition of Public Spending in a Neoclassical Growth Model

Oliviero A. Carboni

Giuseppe Medda

WORKING PAPERS

2007/01

CENTRO RICERCHE ECONOMICHE NORD SUD
(CRENoS)
UNIVERSITÀ DI CAGLIARI
UNIVERSITÀ DI SASSARI

Il CRENoS è un centro di ricerca istituito nel 1993 che fa capo alle Università di Cagliari e Sassari ed è attualmente diretto da Raffaele Paci. Il CRENoS si propone di contribuire a migliorare le conoscenze sul divario economico tra aree integrate e di fornire utili indicazioni di intervento. Particolare attenzione è dedicata al ruolo svolto dalle istituzioni, dal progresso tecnologico e dalla diffusione dell'innovazione nel processo di convergenza o divergenza tra aree economiche. Il CRENoS si propone inoltre di studiare la compatibilità fra tali processi e la salvaguardia delle risorse ambientali, sia globali sia locali.
Per svolgere la sua attività di ricerca, il CRENoS collabora con centri di ricerca e università nazionali ed internazionali; è attivo nell'organizzare conferenze ad alto contenuto scientifico, seminari e altre attività di natura formativa; tiene aggiornate una serie di banche dati e ha una sua collana di pubblicazioni.

www.crenos.it
info@crenos.it

CRENOS – CAGLIARI
VIA SAN GIORGIO 12, I-09100 CAGLIARI, ITALIA
TEL. +39-070-6756406; FAX +39-070- 6756402

CRENOS - SASSARI
VIA TORRE TONDA 34, I-07100 SASSARI, ITALIA
TEL. +39-079-2017301; FAX +39-079-2017312

Titolo: **Government Size and the Composition of Public Spending in a Neoclassical Growth Model**

Government Size and the Composition of Public Spending in a Neoclassical Growth Model

Oliviero A. Carboni*
E-mail: ocarboni@uniss.it

Giuseppe Medda*
E-mail: GMedda@yahoo.it

ABSTRACT

This paper develops a non-linear theoretical relationship between public spending and economic growth. The model identifies the "optimal" size of government and the "optimal" composition of government spending. Given the size of the government, different allocations of public resources lead to different growth rates in the transition dynamics, depending on their elasticity. We argue that neglecting the hypothesis of non-linearity and the different impact different kinds of public spending have on economic performance results in models which suffer from mis-specification. Traditional linear regression analysis may thus be biased.

Keywords: neoclassical and augmented growth models, fiscal policy; public spending composition.

JEL classification: E62, O40, H50, E13, H20.

(*) University of Sassari and CRENoS
Department of Economics (D.E.I.R.)
Via Torre Tonda, 34, 07100 Sassari – ITALY
Tel: +39 0792017332
Fax: +39 0792017312

1. INTRODUCTION

Following the burgeoning empirical research on economic growth in the last twenty years, a vast quantity of literature has analysed the impact of fiscal policy on economic growth without showing evidence of strong and unequivocal support (Levine and Renelt, 1992; Nijkamp and Poot, 2004; Slemrod, 1995).

Public infrastructure, communication and information systems, government-funded education and research and development are the most often cited examples of publicly provided goods which contribute positively to aggregate production (Ram, 1986; Aschauer, 1989; Morrison and Schwartz, 1996).

On the other hand observations in most developed countries that growth in the government spending is accompanied by a slowing of income growth, has given rise to the hypothesis that government size has a negative impact on economic performance. A large government is detrimental to growth because it tends to crowd out private investment. Over burdensome tax regimes, in combination with a system of publicly-mediated transfers, also distort market incentives and have a negative impact on the overall productivity of the economy (Milesi-Feretti and Roubini, 1998; Barro, 1997).

In the original neoclassical growth model introduced by Solow (1956) and Swan (1956), there is no government sector and hence no room for directly analysing the effects of fiscal policy on the growth rate. The long run growth rate of the economy is determined exclusively by the rate of exogenous technological change and population growth.

In their seminal contribution, Arrow and Kurz (1969) develop a neoclassical model of growth where aggregate production benefits from public capital services and government finances public capital by levying a proportional income tax, subtracting resources from private agents (see also Fisher and Turnovsky, 1998). This twofold influence implies a non-linear relationship between government size and growth (as in Bajo-Rubio, 2000). When the share of total government spending (or taxes) is below a certain threshold of the GDP, any expansion of public spending raises growth. Conversely, further increases in taxes hamper growth. Given the properties of diminishing returns to private and public capital, the impact of government policy is limited to the transition path to the steady state to which the economy converges in the long run.

Dissatisfaction with this lack of relationship between policy interventions and long run growth is one of the factors that led to the surge of endogenous growth theories in the late Eighties (Romer, 1994; Solow, 1994). The first contribution in this area is the work of Barro (1990) who develops a model where government plays an active role in influencing long run growth (see also Corsetti and Roubini, 1996, for a generalization). All government spending is implicitly productive, it complements private inputs and it is included in the production function. The model determines the optimal level of public spending, using a non-monotonic relationship between government size and growth. Given the absence of diminishing returns to capital, endogenous models allow government to permanently influence economic growth.

Lee (1992) and Devarajan et al (1996) expand on Barro's model, allowing different kinds of government expenditures to have different impacts on growth. Employing the traditional distinction between productive and non-productive spending (Glomm and Ravikumar, 1997; Kneller et al, 1999), they are able to determine the optimal composition of different kinds of expenditures, based on their relative elasticities. Following a similar line, Chen (2006) investigates the optimal composition of public spending and its relationship to economic growth. He derives the optimal productive public service share of the total government budget and the optimal public consumption share, which is determined by policy and structural parameters.

In this paper we develop an extended neoclassical growth model. It has become widely accepted that the Solow (1956) model, augmented by the inclusion of other productive factors in addition to private capital and labour, is able to explain cross-country differences in growth rates of per capita income (Mankiw et al., 1992; Barro and Sala-i-Martin, 1995; Nonneman and Vanhoudt, 1996). At the same time most of the empirical literature on fiscal policy and growth is not based on an explicit theoretical framework, adding only a proxy of the size of the public sector (usually government consumption) in an *ad hoc* manner to a standard growth equation. Fiscal policy instruments are included in growth models from the perspective of endogenous growth.

Along with these considerations this work tries to supply a theoretical framework which can be applied in empirical studies. The model developed here determines optimal government size and the optimal mix of government expenditures which maximize the rate of growth and the long run level of per capita income. We focus on transitional dynamics to the steady state. There is, indeed, a empirical consensus on the fact that the process of convergence towards the steady state may take many years to play itself out (Barro and Sala-I-Martin, 1992; Islam, 2003). Finally one important conclusion of this work is that neglecting the characteristics of non linearity of public spending and the different impact different types of government have on growth results in mispecified models which bias traditional empirical analysis (Slemrod, 1995; Kneller et al., 1999).

Fiscal policy is aimed at creating different kinds of public capital through accumulation. We divide public capital into two components. Both provide flows of services in proportion to the stocks which form part of the aggregate production function along with private capital, labour, and exogenous labour-augmenting technological progress. Government can influence growth by deciding the extent of its intervention (expressed as a percentage of GDP) and by deciding on the allocation of its resources in the two different components of public capital.

Public services are considered complementary to private inputs and are highly competitive with each other. The rival characteristics of government services, such as roads and ports, make the infrastructure less useful to private agents as more producers use the facilities. This impedes strong externality effects, and rules out the possibility of constant or increasing returns on capital. Given the properties of diminishing returns on public capital, any effect of policy on growth tends to disappear in the long run. This makes this work different from endogenous models where diminishing returns do not arise when government services grow along with private capital, in the same way as aggregate capital or human capital compensate private capital (Romer, 1986 and Lucas, 1988; Barro, 1990).

The remainder of this paper is organized as follows. Section 2 presents the core model. Section 3 develops indications for the maximization of public policies. In section 4 we discuss the implications of the model and compare it with other theories. Conclusions are presented in section 5.

2. THE MODEL

In this section we model the effects of fiscal policy on growth as a part of the aggregate economy, within an augmented neoclassical framework. We explicitly include the public sector in the production function. This generates a potential relationship between government and growth. The introduction of government as a distinct input is based on the rationale that government services are not a substitute for private factors, and resources cannot be easily transferred from one sector to another.. As does Cashin (1994), we consider rival, non-excludable public services which would not be provided by the market due to the difficulty of implementing charges for their use. The rival characteristics of public services impedes the presence of externalities, allowing us to overlook congestion issues.

Although, for simplicity of analysis, most recent literature specifies productive government services as a proportion of the flow of current expenditures (Turnovsky and Fisher, 1995), we employ public capital stock. We follow Arrow and Kurz (1969) by considering all government spending as an accumulation process designed to create productive public capital (Glaeser et al., 2004). Public capital goods provide flows of services proportional to the relative stocks and enter the production function together with private capital, labour, and exogenous labour-augmenting technological change.

The accumulation of physical capital (normally determined only by the share of investment in GDP) is one of the main forces determining the level of real output per capita. The idea here is that government can influence private capital accumulation through the tax rate, and public capital accumulation through public expenditure. Government can decide the composition of its spending while it cannot directly change the amount of public capital stock. This latter can only be changed through an accumulation process deriving from public investment decisions.

We consider all government activities as production-enhancing goods. Following Aschauer (1989) and Baffes and Shah (1998), we allow different types of public capital to have different impacts on economic performance. Core infrastructure (such as roads and highways, infrastructure, telecommunication systems, R&D capital stock) might have a larger impact on overall output than have other public types of capital (such as law and order, health, education, social security, distribution of wealth and public administration services in general). The different impact of each type of government service on productivity makes it all the more necessary to disaggregate the public budget into its various components.

Aggregate production and public capital

Production of output Y is specified in a Cobb-Douglas form:

(1) $$Y = K_P{}^{\alpha}(LE)^{1-\alpha-\gamma_1-\gamma_2} K_{G1}{}^{\gamma_1} K_{G2}{}^{\gamma_2}$$

where K_P is private capital stock, L is total employment, E is labour-augmenting Harrod-neutral technology and K_G is public-sector or government capital. Elasticities are bounded between 0 and 1 implying positive but diminishing returns to single inputs. Constant returns to scale are assumed such that $0 < \alpha + \gamma_1 + \gamma_2 < 1$.

We differentiate public capital into two categories. The first (K_{G1}) is traditional core productive capital. The second (K_{G2}) is a broad concept of capital, namely "institutional" capital embracing all the activities which are designed to improve the environment in which firms can effectively operate (Glaeser et al, 2004). Both components of government expenditure are complementary with private production.

Public capital elasticities differ according to their productivity. In the case of $\gamma_1 = \gamma_2$ we consider a general concept of public capital, with all contributions to production the same across different components. In such a case, the composition of government expenditure would not affect the rate of economic growth.

The accumulation of public capital builds on two conflicting aspects of government spending (G). One is a detrimental effect, taxes which reduces private resources, and the other is a positive one, investment in public capital (Aschauer, 1989).

The rationale for a non-monotonic relationship is fairly simple: the growth rate increases with G up to a maximum level and then starts diminishing. One important target of public spending is to ameliorate growth performance by improving the marginal productivity of the private sector's physical capital and labour. This is generally attained by providing a basic social and economic infrastructure, since this helps private investment and promotes growth. Assuming private maximizing behaviour, the marginal product of capital receives beneficial effects from additional services. At the same time there is a detrimental effect due to taxes, which makes individuals worse off.

The optimal level of government infrastructure occurs when the marginal product of public infrastructure equals marginal social costs. Any public infrastructure beyond this level crowds out private investment, reduces the level of output and frictions growth.

Following the main literature, we assume a permanent balanced government budget and rule out debt-financing of government spending (Fisher and Turnovsky, 1998). Public spending is financed by levying an average flat-rate tax on income $\tau\,(0 < \tau < 1)$

$$(2)\quad \tau \cdot Y = G = G_1 + G_2$$

$$(3)\quad G_1 = \phi \cdot G\,; \quad G_2 = (1-\phi)\cdot G$$

where G_1 are traditional core productive expenditures, G_2 are all others productive government expenditures and $\phi\,(0 \le \phi \le 1)$ is the share of G_1 on total spending.

Public capital accumulation depends on total government revenues. Assuming equal depreciation rates δ for different kinds of public capital, accumulation dynamics are defined by:

$$(4)\quad \overset{\circ}{K}_{G1} = \phi \cdot G - \delta K_{G1}\,; \quad \overset{\circ}{K}_{G2} = (1-\phi)\cdot G - \delta K_{G2}$$

and from eq. (2) we get:

$$(5)\quad \overset{\circ}{K}_{G1} + \overset{\circ}{K}_{G2} + \delta\left(K_{G1} + K_{G2}\right) = \tau \cdot Y$$

where dots indicate time derivatives. If government sets $\phi = 1$, then only accumulation of public capital of type 1 will be financed. For $\phi = 0$, the government sets $G_1 = 0$ and net growth of public capital will involve only capital of type 2.

Equations (2)-(4) also show that, for a given ϕ, if government wants to raise investment in public capital it is necessary to augment the tax rate τ. The economy will benefit from increased public capital but it must support a greater fiscal burden, which subtracts resources from private firms. As long as public capital productivity is equal to private capital productivity, changes in fiscal policy will have neutral effects on overall production. By contrast, a trade-off between private and public capital productivity occurs and, given their different productivity, the effects of an expansion (reduction) in government spending will depend on the composition of expenditure.

Capital accumulation and steady state equilibrium

Private capital accumulation depends positively on the private savings ratio (s_K) and total income, and negatively on the average tax rate. For simplicity we assume a depreciation ratio δ equal to that of public capital.

$$(6)\quad \overset{\circ}{K}_{P} = s_K (1-\tau)\cdot Y - \delta K_P$$

Equation (6) assumes an exogenous private savings ratio. Since we concentrate on the productivity-enhancing role of the government, endogenisation of the savings ratio would simply make the analysis more tedious without providing additional useful information.

All quantities can be expressed in terms of (technology-augmented) labour input, so that accumulation equations (4) and (6) become:

(7) $\overset{\circ}{k}_{G1} = \phi \cdot \tau \cdot y - (\delta + n + x) \cdot k_{G1}$

(8) $\overset{\circ}{k}_{G2} = (1-\phi) \cdot \tau \cdot y - (\delta + n + x) \cdot k_{G2}$

(9) $\overset{\circ}{k}_{P} = s_K (1-\tau) \cdot y - (\delta + n + x) \cdot k_{P}$

where lower case letters indicate variables divided by ($L \cdot E$), n is the labour growth rate and x the labour-augmenting technological progress. Output per unit of technology-augmented labour is:

(10) $$y = k_P{}^{\alpha} k_{G1}{}^{\gamma_1} k_{G2}{}^{\gamma_2}$$

Growth of public and private capital is bounded by the diminishing returns. We can then derive expressions for k_P, k_{G1} and k_{G2} in the steady state, as a result of setting equal to zero equations (7), (8), and (9), given the production function (10):

(11) $$k_P^* = \left[\frac{(s_K (1-\tau))^{1-\gamma_1-\gamma_2} \tau^{\gamma_1+\gamma_2} \phi^{\gamma_1} (1-\phi)^{\gamma_2}}{\delta + n + x} \right]^{\frac{1}{1-\alpha-\gamma_1-\gamma_2}};$$

(12) $$k_{G1}^* = \left[\frac{(s_K (1-\tau))^{\alpha} \tau^{(1-\alpha)} \phi^{(1-\alpha-\gamma_2)} (1-\phi)^{\gamma_2}}{\delta + n + x} \right]^{\frac{1}{1-\alpha-\gamma_1-\gamma_2}};$$

(13) $$k_{G2}^* = \left[\frac{(s_K (1-\tau))^{\alpha} \tau^{(1-\alpha)} (1-\phi)^{(1-\alpha-\gamma_1)} \phi^{\gamma_1}}{\delta + n + x} \right]^{\frac{1}{1-\alpha-\gamma_1-\gamma_2}}$$

where stars denote steady state values.

Substituting (11) – (13) into (10) gives the long-run steady state output per unit of technology-augmented labour:

(14) $$y^* = \left[\frac{s_K{}^{\alpha} (1-\tau)^{\alpha} \tau^{\gamma_1+\gamma_2} \phi^{\gamma_1} (1-\phi)^{\gamma_2}}{\delta + n + x} \right]^{\frac{1}{1-\alpha-\gamma_1-\gamma_2}}$$

The steady state level of output is related to exogenous and endogenous factors, as well as to the elasticities in the production function. Exogenous factors are the private savings ratio (positively related), the rate of depreciation of capital inputs (negatively related), the rate of population growth and technological progress (negatively related).

Endogenous factors are the public policy instruments: *1)* the size of the government, expressed as the ratio of total government spending over total output, τ, and, *2)* the allocation of the public budget to the accumulation of K_{G1} and K_{G2} expressed by ϕ and 1- ϕ.

Public policy instruments have ambiguous effects on the steady state level of output per worker. The term $(1-\tau)^{\alpha}$ in equation (14) represents a detrimental aspect of government spending, since only a fraction $1-\tau$ of total output (i.e. the private agents disposable income) remains to influence production with elasticity α . On the other hand a fraction τ of output is devoted to the creation of productive public capital. This latter positively influences total output at elasticity equal to $\gamma_1+\gamma_2$.

Equation (14) supplies another interesting piece of information. Given the size of government, the composition of public spending plays a significant role in determining the level of output per worker. The level of output per worker and the share of government spending used for investment in public capital of type 1 (type 2), captured by the parameter ϕ (1-ϕ) are linked by a non-linear relationship. As long as $\gamma_1 \neq \gamma_2$, an allocation of resources in favour of public capital with higher elasticity will raise the steady state level of output per worker. However this process of shifting public resources cannot be continued indefinitely due to the diminishing returns on public capital.

Optimal fiscal policy and transitional dynamics

In this section we examine the relationship between τ, ϕ and the level of income per capita in a dynamic framework. Equation (14) represents the level of income per unit of technology augmented labour in the steady state where the growth rate of y, k_P, k_{G1}, k_{G2} is zero. If the economy experiences a shock, transitional dynamics designed to reach a new equilibrium will be stimulated. Equilibrium will be reached after a transition period characterized by positive but declining growth rates. When this process ends the economy is in a new the steady state, the capital stock and output has reached levels at which the new rate of net investment is only sufficient to maintain a constant capital/labour ratio.

Log-linearising equations (7) - (9), and given the production function (10), we can write an expression for the growth rate of output per unit of labour (Barro and Sala-I-Martin, 1995):

$$\text{(15)} \qquad \frac{\overset{\circ}{y}}{y} = \frac{dy}{dt}\bigg/ y = \frac{d\left(\ln y(t)\right)}{dt} \cong \beta \cdot \left(\ln y^* - \ln y(t)\right)$$

where $\beta = (x+n+\delta)\cdot(1-\alpha-\gamma_1-\gamma_2)$ and y^* is the steady state output per unit of labour determined by equation (14).

Equation (15) shows that the rate of growth of output per unit of labour depends, negatively, on the level of *y* at time *t* (the convergence effect β), and, positively, on the level of *y* in the steady state.

The growth rate during the transition is related to the policy instruments τ and ϕ in the same way in which we described above, where we illustrated the influence of policy on the steady state *level* of output per worker. In detail, government can influence the growth rate of *y* by determining the size of its intervention and the relative shares of the two kinds of expenditure, G_1 and G_2, which are committed to the accumulation of public capital K_{G1} and K_{G2}. However, since the relationships between the rate of growth and τ and ϕ are non-monotonic, the influence of the effects of government policy is ambiguous, depending upon the current levels of τ and ϕ.

Using equation (14), taking logs and rearranging equation (15), gives an expression for the average growth rate of *y* between the initial period 0 and time *T*.

$$\text{(16)} \qquad \frac{1}{T}\cdot\frac{\overset{\circ}{y}}{y} = \lambda\left[\begin{array}{l}\frac{\alpha+\gamma_1+\gamma_2}{1-\alpha-\gamma_1-\gamma_2}\cdot\ln\left(x+n+\delta\right)+\frac{\alpha}{1-\alpha-\gamma_1-\gamma_2}\cdot\ln s_K+\frac{\alpha}{1-\alpha-\gamma_1-\gamma_2}\cdot\ln(1-\tau)+\\ \frac{\gamma_1+\gamma_2}{1-\alpha-\gamma_1-\gamma_2}\cdot\ln\tau+\frac{\gamma_1}{1-\alpha-\gamma_1-\gamma_2}\cdot\ln\phi+\frac{\gamma_2}{1-\alpha-\gamma_1-\gamma_2}\cdot\ln(1-\phi)-\ln y(0)\end{array}\right]$$

where $\lambda = \frac{1-e^{-\beta T}}{T}$.

From equation (16) one can see that the government size and the allocation parameter ϕ have two effects on the growth rate. There is a positive effect, due to the productive role of public capital ($\ln(\tau)$ and $\ln(\phi)$), and a negative effect, due to collecting resources from the private sector ($\ln(1-\tau)$) and the (mis)allocation of government expenditures with different levels of productivity ($\ln(1-\phi)$). Taking derivatives with respect to τ and ϕ separately and setting them to zero, we obtain the levels of τ and ϕ which maximize the growth rate:

$$(17) \quad \frac{\partial\left(\overset{\circ}{y}/y\right)}{d\tau} = 0 \Rightarrow \tau_{opt} = \frac{\gamma_1 + \gamma_2}{\alpha + \gamma_1 + \gamma_2};$$

$$(18) \quad \frac{\partial\left(\overset{\circ}{y}/y\right)}{d\phi} = 0 \Rightarrow \phi_{opt} = \frac{\gamma_1}{\gamma_1 + \gamma_2}.$$

Other things being equal, eq. (17) tells us that the optimum level of τ is determined by the ratio of public capital elasticities to the sum of private and public capital elasticities. It is clear that the higher the share of the contribution of public capital to overall production the higher should be government investment in order to maximize growth.

In eq. (18), given the size of the government, the composition of public spending can be set at the optimum level determined by the ratio of elasticity of public capital of type 1 to the sum of public capital elaticities. Such a ratio determines the maximum growth rate during the transition to the steady state.

It is worth noting that eq. (17) and eq. (18) also represent optimizing values for the steady state level of output per worker given by eq. (14). In this state in the long-run the transitional dynamics leave the economy with a growth rate determined by the rate of exogenous technological progress. However, and here we come to the essential point, the level of y^* depends on fiscal policy.

The model described above (eq. (16)) can easily be extended to allow n types of public capital to enter the production function which in an intensive form becomes:

$$(19) \quad y = k_P{}^{\alpha} \prod_{i}^{n} k_{Gi}{}^{\gamma_i}.$$

In such a case, the accumulation of public capital *i* (net of depreciation) is governed by $G_i = \phi_i \cdot \tau \cdot Y$, $\forall i$, where $\sum_i^n \phi_i = 1$.

As a consequence, the equation for the growth rate of the economy during transition to the steady state will be:

$$\text{(20)} \quad \frac{1}{T} \cdot \frac{\overset{\circ}{y}}{y} = \lambda \begin{bmatrix} \frac{\alpha + \sum \gamma_i}{1-\alpha-\sum \gamma_i} \cdot \ln(x+n+\delta) + \frac{\alpha}{1-\alpha-\sum \gamma_i} \cdot \ln s_K + \frac{\alpha}{1-\alpha-\sum \gamma_i} \cdot \ln(1-\tau) + \\ \frac{\sum \gamma_i}{1-\alpha-\sum \gamma_i} \cdot \ln \tau + \sum \frac{\gamma_i}{1-\alpha-\sum \gamma_i} \cdot \ln \phi_i - \ln y(0) \end{bmatrix}$$

where $\lambda = \frac{1-e^{-\beta T}}{T}$, and $\beta = (x+n+\delta) \cdot (1-\alpha-\sum \gamma_i)$.

Note that this generalization does not alter the implications for the effects of government size; *n* optimal conditions for the composition of public spending will be obtained. In particular, equation (18) becomes:

$$\text{(21)} \quad \phi_{opt\,i} = \frac{\gamma_i}{\sum_i^n \gamma_i}, \quad \forall i.$$

3. DISCUSSION AND EMPIRICAL IMPLICATIONS

To analyze the effects of fiscal policy on growth we describe some different scenarios. First, we consider ϕ as fixed and concentrate on the implications of a change in the size of the government. Second, given τ, we explore the growth effects of a policy aimed at redistributing public resources between two kinds of expenditures.

Case 1: optimal government size and growth:

Equation (16) shows a U-inverted relationship between τ and economic growth. For a given ϕ the maximizing value of τ is determined by the relative magnitudes of private and public capital elasticities as an increasing function of the ratio $\gamma_1+\gamma_2\ /\alpha$ (eq (17)).

The optimal level of government spending occurs when the marginal product of public capital equals marginal costs. Any public spending beyond this level crowds out private investment and reduces growth and the final level of output per worker. In other words, up to a certain point the distortional effects of tax are more than compensated for by the productive effects of public investment. As government grows, the detrimental effects of a high level of taxation prevail over productive effects. Further increases in τ will make the situation worse.

Figure 1 illustrates the relationship between goverment size and growth given by equation (16). When government size is below τ_{opt} the marginal product of public capital is above the marginal product of private capital. In this case the economy is not making full use of all public capital potentialities and so it will reach a lower level of steady state income per unit of labour after a transition period characterized by a lower rate of growth compared to the optimum. The opposite occurs for any $\tau > \tau_{opt}$.

The shape of this relationship depends on both private and public capital elasticities. When private and public capital elasticities are such that $\alpha = \gamma_1+\gamma_2$ (curve 1) the optimal level of τ corresponds to an equal allocation of resources between the private and public sectors, i.e. $\tau_{opt}(1) = 0.5$. When $\alpha \neq \gamma_1+\gamma_2$ the curve becomes skewed. For $\alpha > \gamma_1+\gamma_2$ (curve 2) $\tau_{opt}(2)$ is smaller than 0.5. A level of τ above the value 0.5 ($\tau_{opt}(3)$), would maximize the rate of growth when $\alpha < \gamma_1+\gamma_2$ (curve 3).

If τ lies between $\tau_{opt}(2)$ and $\tau_{opt}(1)$, as in the shadowed area, the final effect of an increase in the size of the government is ambiguous, depending on the relative values of α, γ_1 and γ_2. According to curve 2 government should reduce its size in order to achieve a higher growth rate, although not below the level $\tau_{opt}(2)$ determined by eq. (17). In such a case the diminishing returns on private capital become stronger than the diminishing returns on public capital, implying that private investment is less productive than public. By contrast, curves 1 and 3 suggest that an increase in government size would increase investments in public capital. However if τ grows beyond the maximizing level, the beneficial effect of an expanding fiscal policy will end up having a detrimental effect on growth. Simingly, ambiguity occurs in the area between $\tau_{opt}(1)$ and $\tau_{opt}(3)$.

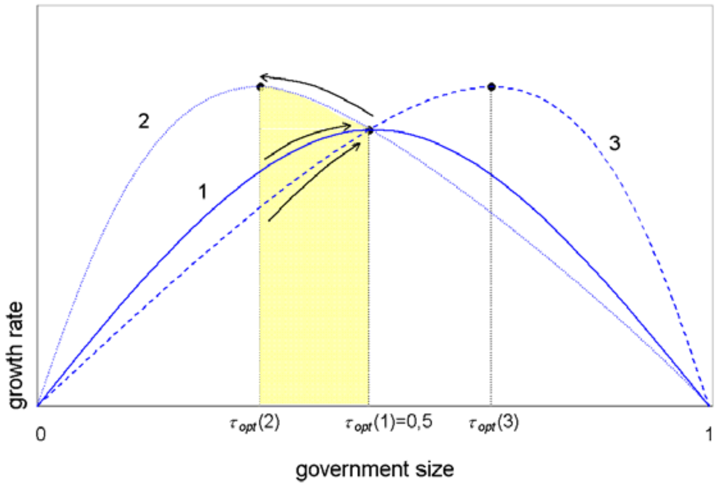

FIGURE 1. RELATIONSHIP BETWEEN GOVERMENT SIZE AND GROWTH: SCENARIOS FOR THREE ECONOMIES WITH (1) $\alpha = \gamma_1+\gamma_2$, (2) $\alpha > \gamma_1+\gamma_2$, AND (3) $\alpha < \gamma_1+\gamma_2$. CURVES ARE BUILT ASSUMING $\alpha+\gamma_1+\gamma_2$ CONSTANT ACROSS ECONOMIES. OPTIMAL SIZES OF THE GOVERNMENT, GIVEN BY EQ. (16) ARE SUCH THAT: τ_{OPT} (1) < τ_{OPT} (2) < τ_{OPT} (3). ARROWS SHOWS ARRANGEMENTS TOWARDS OPTIMIAL τ.

Case 2: the optimal composition of public spending

Similar reasoning can be used to describe the effect of a shift in the composition of public spending. From equation (16), given government size, the share of different kinds of expenditure in the public budget influences the growth rate of the economy during transition to the steady state and also the long run level of output per worker (eq (14)). The direction of the composition effect depends on two aspects: 1) relative elasticities of different kind of public capital γ_1 and γ_2, and 2) the actual share ϕ and 1-ϕ of government spending devoted to the accumulation of two different kinds of public capital.

Figure 2 shows three inverse U-shaped curves which relate ϕ to the growth rate of the economy. The curves represent different economies which differ from each other in their γ_1/γ_2 ratio. Respectively, country (1) $\gamma_1 = \gamma_2$, country (2) is $\gamma_1 < \gamma_2$, and country (3) $\gamma_1 > \gamma_2$.

Growth-maximizing values of ϕ can differ substantially across economies. When $\gamma_1 = \gamma_2$ the best composition of the public budget assigns equal resources to G_1 and G_2, occuring when $\phi = 0.5$ (curve 2). The relationship between ϕ and the growth rate becomes asymmetrical when $\gamma_1 \neq \gamma_2$. In detail, when $\gamma_1 < \gamma_2$ (curve 2) the maximizing level of ϕ is less than 0.5, which corresponds to a relative higher share of resources attributed to G_2. The opposite occurs for $\gamma_1 > \gamma_2$ (curve 3).

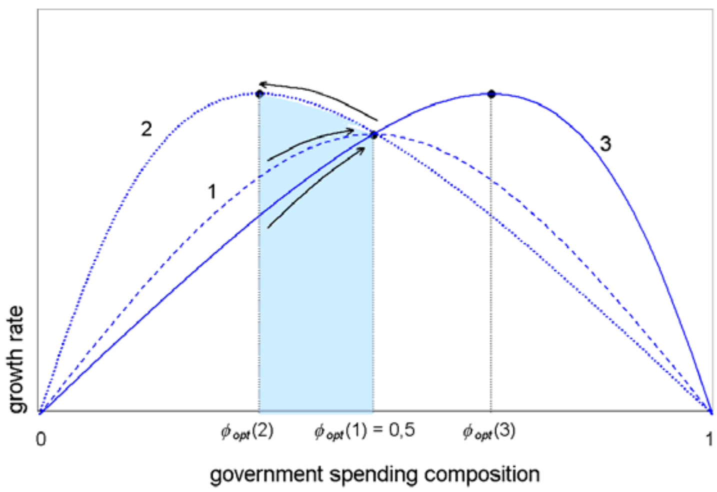

FIGURE 2. RELATIONSHIP BETWEEN GOVERMENT SPENDING COMPOSITION AND GROWTH: SCENARIOS FOR THREE ECONOMIES: (1) $\gamma_1=\gamma_2$, (2) $\gamma_1<\gamma_2$, AND (3) $\gamma_1>\gamma_2$. CURVES ARE BUILT ASSUMING $\gamma_1+\gamma_2$ IS CONSTANT ACROSS THE THREE COUNTRIES. OPTIMAL SPENDING COMPOSITION DERIVES FROM EQ. (17). ARROWS SHOWS ARRANGEMENTS TOWARDS THE OPTIMIZING ϕ.

For low levels of ϕ (specifically when $\phi < \dfrac{\gamma_1}{\gamma_1 + \gamma_2}$), an increment in G_1, which implies an increase in K_{G1}, results in a higher rate of growth for each economy even when $\gamma_1 < \gamma_2$. This is because at low levels K_{G1} exhibits high marginal returns relative to K_{G2}. However beyond a certain limit, determined by eq. (18), there are decreasing returns to K_{G1}. This reduces the advantages of investing in this kind of capital. In the shadowed area the final result of a shift in the composition of public expenditure is ambiguous, since the relative marginal capital contributions do not go in the same direction. Indeterminacy arise also in the area between $\phi_{opt}(1)$ and $\phi_{opt}(3)$.

Empirical implications

Since the resurgence of growth theory in the late 1980's, a vast quantity of literature on empirical analysis of economic growth across countries has been published. Evidence of the good explanatory power of the neoclassical model has been supplied, once this incorporates crucial factors such as human capital (Mankiw et al, 1992), accumulation of technological know-how (Nonneman and Vanhoudt, 1996) and social capital (Temple and Johnson, 1998). In detail, the empirical specification of Mankiw et al. has been used as a starting point for studying the significance of fiscal policy variables for growth. However results have not supplied clear-cut evidence of the long run effects of government intervention on growth (Njikamp and Poot, 2004).

The presence of a non-linear relationship between the growth rate and the government spending ratio on total output may explain the lack of conclusive results in empirical studies across countries (Kneller et al., 1999). Even under the restrictive assumption that different countries have similar elasticities of private and public capital, linear regressions are inadequate for explaining cross-country variations in government size and the growth rate (Barro, 1990; Slemrod, 1995).

In our analysis figure 3 highlights this issue. It shows six economies, which for simplicity of analysis are assumed to have the same values of α and γ, and thus all lie on the same curve deriving from equation (16). Consequently these countries differ from each other in their government size and growth rate. Country 3 attains the optimizing value of τ. Economies 1 and 2 should increase public investment in order to improve growth and the level of output per worker. Countries 4 to 6 have oversized governments and thus should reduce public expenditure. However a linear regression on these countries

(AA) suggests that there is a negative relationship between the government size and the growth rate. This is clearly incorrect. Furthermore if all the countries optimized their government size, i.e. if they were all in the position of country 3, there would be no variation across observations and a linear regression would produce insignificant estimates.

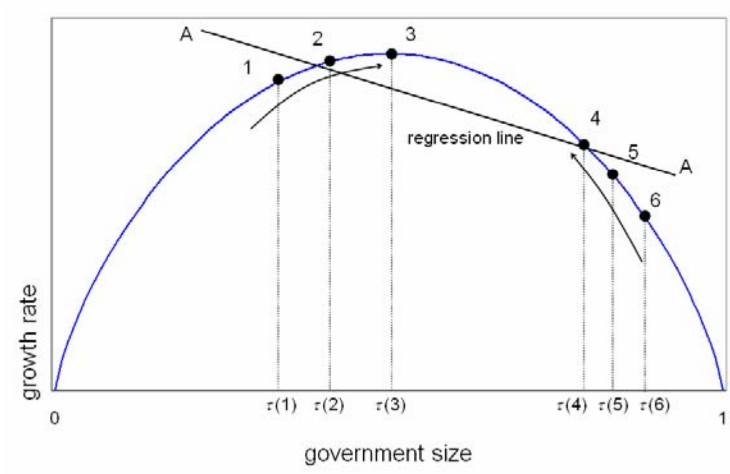

FIGURE 3. LINEAR REGRESSION AND THE NON LINEAR RELATIONSHIP BETWEEN GOVERNMENT SIZE AND GROWTH. ECONOMIES 1 TO 6 HAVE SAME VALUES OF α, γ_1, AND γ_2 BUT DIFFERENT τ AND GROWTH RATES. A LINEAR REGRESSION (AA) ACROSS THESE COUNTRIES WOULD SHOW A NEGATIVE RELATIONSHIP BETWEEN GOVERNMENT SIZE AND THE RATE OF GROWTH.

Allowing elasticities to vary across countries, an even more complex picture emerges. Figure 4 shows the relationship between government size and the growth rate for 4 different countries with equal $\alpha+\gamma_1+\gamma_2$ and ratios $\alpha/\gamma_1+\gamma_2 \geq 1$. Country 1 has a ratio $\alpha/\gamma_1+\gamma_2 > 1$, followed in declining order by country 2, country 3 and country 4.

The line AA in figure 4 shows a situation of non-optimality. All countries should expand their government size in order to reach the maximizing level of τ, the optimum growth rate. However a linear regression of the growth rate on the current level of τ shows a negative relationship, suggesting that the size of the government should be reduced (regression line AA).

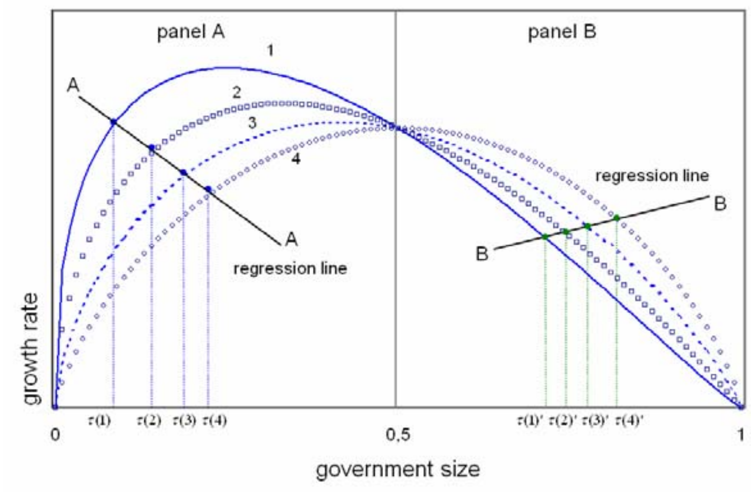

FIGURE 4. LINEAR REGRESSION AND THE NON LINEAR RELATIONSHIP BETWEEN GOVERNMENT SIZE AND GROWTH. CURVES REPRESENT ECONOMIES 1, 2, 3, AND 4 ASSUMING $\alpha+\gamma_1+\gamma_2$ CONSTANT ACROSS ECONOMIES, BUT DIFFERENT RATIOS $\alpha/\gamma_1+\gamma_2$. IN PANEL A THE REGRESSION LINE (AA) HAS NEGATIVE SLOPE, WHILE ECONOMIES SHOULD RAISE THEIR τ TO MAXIMIZE GROWTH RATE. THE OPPOSITE SITUATION OCCURS WHEN THEY LIE IN PANEL B (REGRESSION LINE BB).

Conversely, if countries are positioned as shown on Panel B, a linear regression suggests a positive relationship between τ and the growth rate (regression line BB), while all countries have over-sized governments. Another situation occurs when all countries attain maximizing levels of τ. In such a case, linear regression indicates a negative relationship: governments ought to reduce their size while they should not move from their level. The same analysis applies for the case $\alpha/\gamma_1+\gamma_2<1$. Implications will be obviously the reverse.

Neglecting the public budget structure represented by equation (2) would also give inconsistent estimates of the effect of public expenditure on growth. Most of empirical analyses across countries are based on Barro-type or Mankiw et al (1992) regressions, adding fiscal variables following an ad-hoc approach. Few attempts have been made to incorporate complete formulation of the government budget constraints into a model and test empirically the effect of different components of public spending on economic performance.

Again, results are not conclusive (Devarajan et al, 1996; Mittnik and Neumann, 2003).

This analysis tries to tackle this issue by incorporating the differences in productive impacts across government functions. Even when each component has a positive impact on growth, as we assume, diminishing returns limit the benefit of increases in investment. Morover countries differ in the composition of government spending.

Taking the government decision on τ as given, there remains the question of how to allocate public resources. Figure 5 shows the relationships between the growth rate and ϕ (the share of public capital of type 1) for three countries. For each of them $\gamma_1 < \gamma_2$, while $\gamma_1 + \gamma_2$ is the same for all of them.

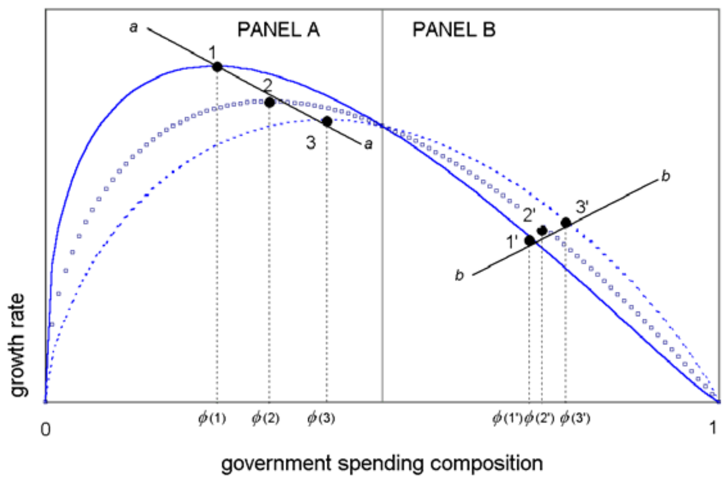

FIGURE 5. LINEAR REGRESSION AND THE RELATIONSHIP BETWEEN SHARE OF GOVERNMENT EXPENDITURES ϕ, AND THE GROWTH RATE. IN PANEL A, THREE ECONOMIES WITH EQUAL $\gamma_1+\gamma_2$. PRESENT INCREASING LEVELS OF ϕ. THE REGRESSION LINE (AA) SUGGESTS A NEGATIVE RELATIONSHIP WITH GROWTH. IN PANEL B EACH ECONOMY HAS OVERSIZED LEVELS OF ϕ, REGRESSION LINE (BB) WHICH SUGGESTS A POSITIVE RELATIONSHIP WITH GROWTH.

In Panel A positions 1, 2 and 3 represent values of ϕ that maximize the growth rate for each economy. In Panel B, positions 1', 2' and 3' correspond to "too large" shares of investment in public capital of type 1. However, applying a linear regression of growth rates on the share of investments in K_{G1} results in a negative relationship in Panel A and a positive one in Panel B.

This suggests that even when the effect of a single component of the public budget (say, infrastructure) is found strongly positive, it is necessary to check for the effect of other public expenditure on growth before deciding to expand investment in infrastructure. Only after checking all components of public spending ought one decide how to re-allocate public resources.

Apart from the peculiarities of the examples given above, the general conclusion of this work is that in randomly taken observations a linear regression is very unlikely to identify the real relationship between τ, ϕ and economic growth. Misleading results, which derive from the mis-specification of the model, are thus to be expected. Inclusion of both positive and negative aspects of public spending in empirical investigations would certainly be of great help.

CONCLUDING REMARKS

This paper analyses the optimal size of government and the composition of public spending that maximise growth. We show that it is possible to optimise growth during the transition path to the steady state by controlling the size of the government and, also, the composition of government expenditure.

The model considers two different categories of government spending. It allows public capital productivity to differ and assumes that all government investment positively affects the productivity of private factors. For a given structure of public spending the aim is to find the optimal spending level for maximising growth, reallocating resources between private and public capital according to their relative elasticity.

In the same way, for a given level of public expenditure (which can be easily considered fixed in the short-medium term) the aim of the model is to find the optimal composition of public spending. Changes in the spending structure lead to different growth rates, depending on their relative elasticity and share. This should induce governments to redistribute budgets between less and more productive public capital to achieve the optimum balance, thereby yielding stronger positive transitional growth effects than would otherwise be obtained.

The economy in the long term is in the steady state where growth only depends on exogenous factors. However, this does not imply that fiscal policy is not important for long term economic performance. Fiscal policy has considerable influence on the levels of capital and output. In addition a transitional period of increased growth resulting from an optimal public spending can be rather long. As Barro e Sala–i–Martin (1995) suggest, at least five years are necessary to reach half of the transition, and if a broad concept of capital is used, this becomes 27 years. This highlights the need for short-medium term analysis such as that in our work.

Finally, the model has an important empirical implication which comes from the hypothesis of non-linearity between public spending and growth and from the effects of the composition of government spending. Studies on optimal tax rates should take into account all the effects that public capital has on the economy. To be more precise, an increase in public capital at the expense of private capital is likely to accelerate or brake the economic growth rate. The latter effect typically depends on the marginal product of public and private capital respectively. Studies on fiscal policy which postulate a monotonic relationship (either positive or negative) and merely add an *ad hoc* government variable may well suffer from mis-specification and linear regression analysis will be missleading.

References

ARROW, K.J., AND KURZ, M. (1969). "Optimal public investment policy and controllability with fixed private savings ratio," *Journal of Economic Theory*, vol. 1, pp. 141-177.

ARROW, K.J. (1962). "The economic implications of learning by doing," *Review of Economic Studies*, vol. 29, pp. 155-173.

ASCHAUER, D.A. (1989). "Is public expenditure productive?," *Journal of Monetary Economics*, vol. 23, pp. 177-200.

BAFFES, J., AND SHAH, A. (1998). "Productivity of public spending, sectoral allocation choices, and economic growth," *Economic Development and Cultural Change*, vol. 46, pp. 291-303.

BARRO, R.J. (1990). "Government spending in a simple model of endogenous growth," *Journal of Political Economy*, vol. 98, pp. S103-S125.

BARRO, R.J. (1997). *Determinants of Economic Growth: A Cross-Country Empirical Study*. MIT Press, Cambridge, MA.

BARRO, R.J., AND SALA-I-MARTIN, X. (1995). *Economic Growth*. McGraw Hill, New York.

CASHIN, P.,(1995). "Government Spending, Taxes, and Economic Growth", *IMF Staff Papers*, vol.42, pp. 237-269.

CHEN, B. (2006). "Economic growth with an optimal public spending composition," *Oxford Economic Papers*, vol. 58, pp. 123-136.

CORSETTI, G., AND ROUBINI, N. (1996). "Optimal government spending and taxation in endogenous growth models," NBER Working Papers 5851.

DEVARAJAN, S., SWAROOP, V. AND ZOU, H.. (1996). "The composition of public expenditure and economic growth," *Journal of Monetary Economics*, vol. 37, pp. 313–344.

FISHER, W.H., AND TURNOVSKY, S.J. (1998). "Public investment, congestion, and private capital accumulation," *Economic Journal*, vol. 108, pp. 399-412.

GLAESER, E.L., LA PORTA, R. AND LOPEZ-DE-SILANES, F. (2004). "Do institutions cause growth?," *Journal of Economic Growth*, vol. 9, pp. 271-303.

GLOMM, G. AND RAVIKUMAR, B. (1997). "Productive government expenditures and long-run growth," *Journal of Economic Dynamics and Control*, vol. 21, pp. 183-204.

ISLAM, N. (2003). "What have we learnt from the convergence debate?," *Journal of Economic Surveys*, vol. 17, pp. 309-362.

KING, R.G., AND REBELO, S. (1990). "Public policy and economic growth: developing neoclassical implications," *Journal of Political Economy*, vol. 98, pp. S126-S150.

KNELLER, R., BLEANEY, M.F., AND GEMMELL, N. (1999). "Fiscal policy and growth: evidence from OECD countries," *Journal of Public Economics*, vol. 74, pp. 171-190.

LEE, J. 81992). "Optimal size and composition of government spending," *Journal of the Japanese and International Economies*, vol. 6, pp. 423-439.

LEVINE, R., AND RENELT, D. (1992). "A sensitivity analysis of cross-country growth regressions," *American Economic Review*, vol. 82, pp. 942-963.

LUCAS, R.E. (1988). "On the mechanics of economic development," *Journal of Monetary Economics*, vol. 22, pp. 3-42.

MANKIW, N.G., ROMER, D., AND WEIL, D.N. (1992). "A contribution to the empirics of economic growth," *Quarterly Journal of Economics*, vol. 107, pp. 407- 437.

MILESI-FERRETTI, G. M., AND ROUBINI, N. (1998). "On the taxation of human and physical capital in models of endogenous growth." *Journal of Public Economics*, vol. 70, pp. 237-254.

MITTNIK, S., AND NEUMANN, T. (2003). "Time-series evidence on the nonlinearity hypothesis for public spending," *Economic Inquiry*, vol. 41, pp. 565-573.

MORRISON, C.J., AND SCHWARTZ, A.E. (1996). "State infrastructure and productive performance," *American Economic Review*, vol. 86, pp. 1095-1111.

NIJKAMP, P., AND POOT, J. (2004). "Meta-analysis of the effect of fiscal policies on long-run growth," *European Journal of Political Economy*, vol. 20, pp. 91-124.

NONNEMAN W, AND VANHOUDT, P. (1996). "A further augmentation of the Solow model and the empirics of economic growth for OECD countries," *Quarterly Journal of Economics*, vol. 111, pp. 943-953.

RAM, R. (1986). "Government size and economic growth: a new framework and some evidence from cross-section and time-series data," *American Economic Review*, vol. 76, pp. 191-203.

ROMER, P.M. (1986). "Increasing returns and long-run growth," *Journal of Political Economy*, vol. 94, pp. 1002-1037.

ROMER, P.M. (1994). "The origins of endogenous grwoth," *Journal of Economic Perspectives*, vol. 8, pp. 3-22.

SLEMROD, J. (1995). "What do cross-country studies teach about government involvement, prosperity, and economic growth?," *Brookings Papers on Economic Activity*, vol. 1995, pp. 373-415.

SOLOW, R.M. (1956). "A contribution to the theory of economic growth," *Quarterly Journal of Economics*, vol. 70, pp. 65-94.

SOLOW, R.M. (1994). "Perspectives on growth theory," *Journal of Economic Perspectives*, vol. 8, pp. 45-54.

SWAN, T.W. (1956) "Economic growth and capital accumulation," *Economic Record*, vol. 32, pp. 334-61.

TEMPLE, J., AND JOHNSON, P.A. (1998). "Social capability and economic growth," *Quarterly Journal of Economics*, vol. 113, pp. 965-990.

TURNOVSKY, S.J., AND FISHER, W.H. (1995). "The composition of government expenditure and its consequences for macroeconomic performance," *Journal of Economic Dynamics and Control*, vol. 19, pp. 747-786.

Ultimi Contributi di Ricerca CRENoS

I Paper sono disponibili in: http://www.crenos.it

06/17 *Susana Iranzo, Fabiano Schivardi, Elisa Tosetti* "Skill dispersion and firm productivity: an analysis with employer-employee matched data"

06/16 *Luigi Guiso, Fabiano Schivardi,* "What determines entrepreneurial clusters?"

06/15 *Vittorio Pelligra,* "Trust Responsiveness: On the Dynamics of Fiduciary Interactions"

06/14 *Rinaldo Brau, Alessandro Lanza, Francesco Pigliaru,* "How fast are small tourist countries growing? The 1980-2003 evidence"

06/13 *Emanuela Marrocu, Raffaele Paci,* "The effects of public capital on the productivity of the Italian regions"

06/12 *Raffaele Paci, Stefano Usai,* "Agglomeration economies and growth-the case of italian local labour systems, 1991-2001"

06/11 *Fabrizio Ariani, Luca G. Deidda,* "The Monopolist's Blues"

06/10 *Bianca Biagi, Dionysia Lambiri, Vicente Royuela,* "Quality of life in the economic and urban economic literature"

06/09 *Manuela Pulina, Bianca Biagi,* "Tourism, environmental quality and economic growth: empirical evidence and policy implications"

06/08 *Gianfranco E. Atzeni, Oliviero A. Carboni,* "Regional disparity in ict adoption: an empirical evaluation of the effects of subsidies in Italy"

06/07 *Isabel Cortés-Jiménez*, "Tourism and economic growth at regional level: the cases of Spain and Italy"

06/06 *Maria Gabriela Ladu*, "Total Factor Productivity Estimates: some evidence from European Regions"

06/05 *Gerardo Marletto*, "La politica dei trasporti come politica per l'innovazione: spunti da un approccio evolutivo"

06/04 *Elisabetta Strazzera,* "Application of the ML Hausman approach to the demand of water for residential use: heterogeneity vs two-error specification"

06/03 *Silvia Loddo,* "Structural Funds and Regional Convergence in Italy"

06/02 *Fabio Cerina,* "Tourism specialization and environmental sustainability in a dynamic economy"

06/01 *Emanuela Marrocu, Raffaele Paci e Francesco Pigliaru,* "Gli effetti del capitale pubblico sulla produttività delle regioni italiane"

05/14 *Rinaldo Brau and Davide Cao,* "Uncovering the macrostructure of tourists' preferences. A choice experiment analysis of tourism demand to Sardinia"

05/13 *Barbara Dettori, Raffaele Paci and Stefano Usai,* "Technological activity in European regions"

05/12 *Rosina Moreno, Raffaele Paci and Stefano Usai,* "Innovation clusters in European regions"

05/11 *Luca Deidda and Bassam Fattouh,* "Bank, financial markets and growth"

05/10 *Fabio Cerina and Francesco Pigliaru,* "Agglomeration and growth in NEG: a critical assessment"

05/09 *Maurice Kugler and Rossella Oppes,* "Collateral and risk-sharing in group lending: evidence from an urban microcredit program"

05/08 *Adriana Di Liberto,* "Convergence and divergence in neoclassical growth models with human capital"

05/07 *Maria Gabriela Ladu,* "Growth and employment: a survey on the demand side of the labour market"

05/06 *Maria Gabriela Ladu,* "Total factor productivity growth and employment: a simultaneous equations model estimate"

05/05 *Silvia Balia,* "Health and economic behaviour: a critical survey of the literature"

05/04 *Gianna Boero, Tiziana Laureti and Robin Naylor,* "An econometric analysis of student withdrawal and progression in post-reform Italian universities"

05/03 *Vittorio Pellagra,* "Banking with sentiments. A model of fiduciari interactions in micro-credit programs"

05/02 *Margarita Genius and Elisabetta Strazzera,* "Modelinf elicitation effects in contingent valuation studies: a Monte Carlo analysis of the bivariate approach"

05/01 *Fabio Cerina,* "Marshall's *ceteris paribus* in a dynamic frame"

04/20 *Rinaldo Brau and Carlo Carraio,* "The economic analysis of voluntary approaches to environmental protection. A survey"

04/19 *Cristina Murroni,* "ICT and local development: a case study of the metropolitan area of Cagliari"

04/18 *Adriana Di Liberto,* "Convergence clubs and the role of human capital in Spanish regional growth"

04/17 *Stefano Usai and Marco Vannini,* "Banking structure and regional economic growth: lessons from Italy"

04/16 *Silvia Balia and Andrew M. Jones,* "Mortality, lifestyle and socio-economic status"

04/15 *Rosina Moreno, Raffaele Paci and Stefano Usai,* "Geographical and sectoral clusters of innovation in Europe"

04/14 *Gianfranco Atzeni and Oliviero Carboni,* "ICT productivity and firm propensity to innovative investment: learining effects evidence from Italian micro data"

04/13 *Fabrizio Ariani and Luca G. Deidda,* "Few bad apples or plenty of lemons: which makes it harder to market plums?"

04/12 *Giovanni B. Concu,* "A choice modelling approach to investigate biases in individual and aggregated benefit estimates due to omission of distance"

04/11 *Giovanni B. Concu,* "Effects of distance aon non-use values"

04/10 *Antonio Sassu and Sergio Lodde,* "Le tecnologie dell'informazione e della comunicazione nelle piccole imprese dei settori maturi"

04/09 *Riccardo Marselli e Marco Vannini,* "L'efficienza tecnica dei distretti di Corte d'Appello italiani: aspetti metodologici, benchmarking e arretrato smaltibile"

04/08 *Rinaldo Brau, Matteo Lippi Bruni and Anna Maria Pinna,* "Public vz private demand for covering long term care expenditures"

04/07 *Matteo Bellinzas,* "Dinamiche demografiche, agglomerazione e determinanti economiche. Il caso italiano"

04/06 *Giuseppe Medda, Claudio Piga,* "R&S e spillover industriali: un'analisi sulle imprese italiane"

04/05 *Adriana Di Liberto, Roberto Mura, Francesco Pigliaru,* "How to measure the unobservable: a panel technique for the analysis of TFP convergence"

04/04 *Vittorio Pelligra,* "How to incentive Who? Intr-personal and inter-personal mechanisms"

04/03 *Domenica Giovanna Dettori, Antonello Paba, Manuela Pulina,* "European rural Tourism: agrotouristic firms in Sardina and their life cycle"

04/02 *Giovanni Sulis,* "Wage dispersion and Equilibrium search models: some evidence from Italy"

04/01 *Silvia Loddo,* "Old and new intervention policy: A survey of empirical studies for the Mezzogiorno"

03/13 *Raffaele Paci, Ernesto Batteta,* "Innovation Networks and Knowledge Flows across the European Regions"

03/12 *Antonio Sassu, Sergio Lodde,* "Piccole imprese e tecnologie della comunicazione: un'indagine empirica"

03/11 *Antonio Sassu, Sergio Lodde,* "Tradizione e innovazione nel settore vinicolo in Sardegna"

03/10 *Rosina Moreno-Serrano, Raffaele Paci, Stefano Usai,* "Spatial distribution of innovation activity. The case of European Regions"

03/09 *Rinaldo Brau, Alessandro Lanza, Francesco Pigliaru,* "How fast are the tourism countries growing? The cross-countries evidence"

03/08 *Margarita Genius, Elisabetta Strazzera,* "The copula approach to sample selection modelling: an application to the recreational value of forests"

03/07 *Guido Ascari, Emanuela Marrocu,* "Forecasting inflation: a comparison of linear Phillips curve models and nonlinear time series models"

03/06 *Alessandro Lanza, Matteo Manera, Massimo Giovannini,* "Oil and product price dynamics in international petroleum markets"

03/05 *Rinaldo Brau, Gianluca Fiorentini, Matteo Lippi Bruni, Anna Maria Pinna,* "La disponibilità a pagare per la copertura del rischio di non autosufficienza: analisi econometrica e valutazioni di policy"

03/04 *Gianfeanco Atzeni, Claudio Piga,* " Credit Rationing in High-Tech Firms and Sample Selection"

03/03 *Manuela Pulina,* "Quantitative forecasting for tourism: OLS and ARIMAX approaches"

03/02 *Gianna Boero, Riccardo Pinna,* "Durata degli studi e voto di laurea: un'indagine econometrica su alcune facoltà dell'Università di Cagliari"

03/01 *Anna Maria Pinna, Miriam Manchin,* "Border Effects in the Enlarged EU Area. Evidence from Imports to Applicant Countries"

02/12 *Gianna Boero, Riccardo Pinna,* "La performance esterna dell'Università di Cagliari: il caso delle facoltà del polo giuridico-economico"

02/11 *Sergio Lodde,* "Patti territoriali e specializzazione produttiva nel Mezzogiorno"

02/10 *Maria Grazia Curreli, Sergio Lodde,* "Saperi tradizionali e sviluppo locale: il comparto della produzione del miele in Sardegna"

02/09 *Gianna Boero, Jeremy Smith, Kenneth F. Wallis,* "The properties of some goodness-of-fits tests"

02/08 *Gianna Boero, Emanuela Marrocu,* "The performance of SETAR models: a regime conditional evaluation of point, interval and density forecasts"

02/07 *Anna Maria Pinna, Carla Fancello,* "How far do we trade intermediate inputs?"

02/06 *Sonia Deidda, Raffaele Paci, Stefano Usai,* "Spatial Externalities and Local Economic Growth" www.crenos.it