FISCAL POLICY AND GROWTH: A SURVEY

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Introduction

The lack of convergence of growth rates among the world economies is probably one of the most debated topics in the last few years in theoretical and empirical research. In this period we have observed a strong resurgence of the debate about long-run growth, starting from the initial contributions by Paul Romer (1986) and Robert Lucas (1988) who opened the so called "Endogenous Growth Theory" or "New Growth Theory". The reason of this resurgence of interest lies in two important aspects left unsolved by the theoretical attempts of the 60s and 70s: first, the need to explain long-run growth determinants and secondly, to provide a careful explanation to the lack of convergence of growth rates among world economies footnote . The biggest achievement of the Endogenous Growth Theory is represented by the reconciliation of the diminishing returns hypothesis with the typical finding of empirical analyses, i.e. a growth rate continuously increasing.

There are many explanations of the lack of convergence of growth rates. Among the empirical studies on convergence we consider Barro and Sala-i-Martin (1992) who analyzed the different definition of convergence expressed as *absolute* and *relative*, according to the emphasis given to the initial endowments and the saving rate footnote . However, probably, one of the most important explanations for the divergence of growth rates lies in the heterogeneity of fiscal policies adopted by different countries. The present paper tries to explain the lack of convergence by invoking differences in fiscal policies, as explained by the more recent literature.

Differently from the growth theory of 60s and 70s, the endogenous growth theory shows many interesting features to the link between fiscal policies and growth. When growth is endogenous, policy actions affecting the saving rate (fiscal policy can be though as a typical example of such a policy), have *growth* effects and not only *level* effects. This means that fiscal policy affects the steady state growth rate on a Balanced Growth Path (BGP, thereafter) and not only during the transition from one steady state to the other.

Fiscal policy in growth models can be analyzed within a wide range of contexts: (i) representative agents models with infinite horizon; (ii) overlapping generations models; (iii) redistributive models with electoral competition about the level of fiscal pressure. Given the enormous degree of development reached in each of the above fields, the present survey will concentrate mostly on representative agent models with infinite horizon, with a special emphasis on two-sector models with human capital footnote . The reason of this choice has to do with the goal of analyzing the growth effect of flat rate taxes and how various assumptions on the production function for physical and human capital, will interact to assess the magnitude of fiscal policy. The models under point (ii)-(iii) focus more on the redistributional effects of fiscal policy, and they take as given the effect of fiscal policy on growth.

A very important point concerns the endogeneity of public expenditure in endogenous growth models: unfortunately, not much work has been done in the infinite horizon framework apart the initial contribution by Barro (1990), Barro and Sala-i-Martin (1992) and the literature on redistributional issues. In this survey I will present both the aforementioned contributions and some extensions to the two-sector framework by Corsetti and Roubini (1996).

In what follows the focus will be only on deterministic models, without exploring the implications of the stochastic growth models with fiscal policy. The goal of stochastic growth models is different: they take as given the existence of a BGP to explain the origins and causes of economic fluctuations originating around it. To do so, they try to replicate the observed behavior of time series of income, consumption, investment and other relevant macroeconomic variables, by adding to the model shocks - technological or fiscal - which could generate such fluctuations. The model is evalued according to its ability to replicate the observed behavior of time series. Those models are in the tradition of Real Business Cycles (RBC) literature. The difference with the RBC typical assumption is that a fiscal policy shock - together with a pure technological shock - is assumed to be the origin of economic fluctuations footnote around a BGP exogenously given. In the case of pure deterministic growth models, instead, we keep fluctuations as exogenous to the model and the goal is to explain the existence of an unceasing growth.

I will not touch empirical aspects of the relationship between fiscal policy and growth. For a survey of the empirical results on fiscal policy and growth I address the reader to other surveys, like, fore example, Easterly et al. (1992), Engen and Skinner (1992), Levine and Renelt (1992).

The remainder of this paper is organized as follows. Section 2 introduces the reader to the analytical context employed in the subsequent sections, by surveying the basic mechanisms underlying endogenous growth mechanisms. Section 3 analyzes endogenous growth models driven by human capital accumulation, while the role of the innovative activity as engine of growth is discussed in section 4. Income taxation is discussed in section 5 under the usual two formulation of an income tax and a tax on private inputs. In section 6 there is an extensive discussion on endogenous fiscal policy. In this context,. models without and with human capital are analyzed in order to evaluate different distorsive effects of taxation. Section 7 studies a growth model with monopolistic competition and differentiated goods. The effect of endogenous labor supply under various specifications is discussed in section 8. The effect of consumption and investment taxation is discussed respectively in section 9 and 10. Section 11 provides a brief discussion on optimal taxation issues. Concluding Remarks close the paper.

Endogenous growth: an introduction

The fundamental question to which endogenous growth theory deals with is: why can long-run growth be kept constant and unceasing over time ?

From the exogenous growth models we know that if the production function respects the Inada conditions, the law of diminishing returns makes the long run growth rate equal to zero. In fact, the traditional literature on growth stopped in the early 70s because of its inability to explain the continuously increasing growth rate empirically observed for all developed economies. During past years, this problem has been brilliantly solved by Paul Romer and Robert Lucas who offered two alternative explanations to the long-run growth. On the one hand, the proposed solution hinges on the role played by externalities in the production function of final goods. The presence of externalities has a countervailing effect on the law of diminishing returns, as stressed by Romer (1986). On the other hand, there is the two-sector growth model by Lucas (1988) which is built on the previous work by Uzawa (1964), where the growth engine is represented by human capital accumulation.

As discussed by Barro and Sala-i-Martin (1995), quite all the models of endogenous growth can be represented along the lines discussed by these models. To introduce the analytical framework employed throughout the paper, in what follows I will sketch the two classes of models just mentioned.

Let us start by considering a Cobb-Douglas production function such as:

$$Y_t = A_t K_t^{\alpha} Z_t^{1-\alpha} \qquad \#$$

where $0 < \alpha \leq 1$. In (ref: uno) K_t indicates physical capital and Z_t is a whatsoever input having a countervailing effect on the decreasing returns to scale associated with K_t for which an appropriate qualification will be offered later on. A_t is a scale parameter. In a one good model like this, the aggregate final product can be either invested or consumed. The capital accumulation is governed by the following equation:

$$\dot{K}_t = Y_t - C_t - \delta_K K_t \qquad \#$$

where δ_K is the depreciation rate on physical capital.

With competitive markets for the productive inputs, the real interest rate must equate the marginal product of capital:

$$r_t = \alpha A_t \left(\frac{}{} \right)^{\alpha - 1} \qquad \#$$

From (ref: tre) we observe that Z_t should operate in such a way that real interest rate never declines over time when K_t increases. The countervailing effect will be complete if $\alpha = 1$.

The preference structure in this context is subsumed by the following utility function of CRRA-type (Constant Relative Risk Aversion) with constant relative risk aversion coefficient σ:

$$U_t = \int_0^\infty e^{-\rho t} \frac{C_t^{1-\sigma} - 1}{1-\sigma} dt \quad \#$$

where $\rho > 0$ is the discount rate. The representative agent chooses the optimal quantity of consumption C_t and investment by maximizing (ref: quat) subjected to (ref: due). After rearranging the first order conditions, we obtain the following expression for the growth rate of consumption:

$$\gamma = \frac{\dot{C}_t}{C_t} = \frac{r_t - \rho - \delta_K}{\sigma} \quad \#$$

Moreover, $\gamma \geq 0$ *if and only if* $r_t \geq \rho + \delta_K$. It is also easy to verify that when $\alpha = 1$ the growth rate γ will be strictly positive if and only if $A > \rho + \delta_K$.

The above mechanism is a schematic description of the basic features of the endogenous growth models: the growth rate is always positive because of the presence of some mechanism able to contrast the effects of the law of diminishing returns.

Growth driven by Human Capital

The simplest way to represent the role of human capital is to imagine an aggregate production function like $y = Ak$ where k can be interpreted as aggregate capital in a broad sense. The definition of k encompasses both physical and human capital. In this context, it is just the assumption that human and physical capital are included in one term that gives the production function having the property of constant returns to scale. In this case, the marginal product of aggregate physical capital is constant as well, making the growth rate constant and positive.

An explicit treatment of human capital requires the analysis of a two-sector growth model with separate accumulation and production processes for physical and human capital.

Therefore, let us assume in (ref: uno) that $Z = H$, where H is the level of human capital. The accumulation constraint for human capital:

$$\dot{H}_t = I_H - \delta_H H_t \quad \#$$

where I_H is the amount of *new* human capital produced net of depreciation $\delta_H H_t$, with δ_H being the human capital depreciation rate. In order to get tractable closed-form solutions, assume that the production function of new human capital I_H is:

$$I_H = B_t (v_{2t} K_t)^\beta (z_{2t} H_t)^{1-\beta} \quad \#$$

with $0 < \beta \leq 1$ and with $B_t = B \quad \forall\ t$ on a BGP. Also, (ref: uno) can be rewritten as footnote :

$$Y_t = A_t (v_{1t} K_t)^\alpha (z_{1t} H_t)^{1-\alpha} \quad \#$$

with $0 < \alpha \leq 1$ and with $A_t = A \quad \forall\ t$ on a BGP.

In (ref: sette) and (ref: otto) v_{1t} (v_{2t}) indicates the fraction of physical capital employed in the production of final goods (human capital), while z_{1t} (z_{2t}) represents the fraction of human capital employed in the production of final goods (human capital). This model is generalization of Lucas (1988) model and Rebelo (1991). In particular, Lucas (1988) assumes that the production function of human capital is linearly homogeneous in H_t: this means that with $\beta = 0$ the only argument of the human capital production function is human capital itself, because $I_H = B_t z_{2t} H_t$. To obtain a closed-form solution, I assume that the depreciation rate for both physical and human capital are the same, i.e. $\delta_K = \delta_H = \delta$. Given the utility function (ref: quat) we obtain an expression for the growth rate still given by (ref: cinque) but with the following expression for the interest rate r:

$$r = \left[(\alpha A)^\beta ((1-\beta)B)^{1-\alpha} \left(\frac{\alpha}{1-\alpha} \frac{1-\beta}{\beta} \right)^\beta \right]^{\frac{1}{1-\alpha+\beta}} \quad \#$$

From (ref: nove) we observe that interest rate r is a function of all the technological parameters of the model which are assumed to be constant on a BGP. Therefore, the growth rate of this economy will be constant as well and positive if $r > \rho + \delta$. The expression for the interest rate in the Lucas (1988) model can be obtained as particular case of the model considered here, after imposing $\beta = 0$ in (ref: nove) to get $r = B$.

The two-sector model has a transitional dynamics which has been carefully studied by Mulligan and Sala-i-Martin (1992) using the *time elimination method*. Without entering into the details of the model, it is possible to say that if there are not adjustment costs for physical and human capital, all the inputs are totally free to move from one sector to another and there does not exist any transitional dynamics at all. Therefore, without adjustment costs, the two-sector model has the same qualitative behavior of the '*Ak* model', as discussed by Barro and Sala-i-Martin (1995) footnote .

Growth driven by innovative activity

In this class of models the engine of growth is represented by the activity of technological innovation conducted at level of each single firm, having the goal of obtaining a monopoly profit from selling new goods on the market, as originally pointed out by Schumpeter and Kaldor. Aggregate knowledge derived from investment in R&D is considered as an externality and has the characteristics of public good nonrival and partially excludable. After that new goods entered into the market, the innovative component of those goods becomes a fraction of aggregate knowledge available to all other firms that can imitate these goods and erode the initial monopoly power of the firm who started first. Those issues can be treated in two class of models. The first assumes the presence of externality connected to the accumulation of a particular good, like knowledge, which are external to the firm but internal to the industrial sector or a market. This allows to keep together the structure of a perfectly competitive market, and the profit motivation for accumulating knowledge is implicit in the model. The second class of models, instead, explicitly considers the profit motivation leading to the innovative activity in a model with monopolistic competition in the final goods sector.

In the first class of models, according to Romer (1986), Z_t in (ref: uno) represents the aggregate level of knowledge available to a given economy. Z_t is a public good non-rival and non-excludable: knowledge is freely available to every agent of the society at no. The diffusion of knowledge is realized in two ways: through specialized journals, reviews and newspapers and, most importantly, through the sales of final goods produced by using investment in R&D realized at the level of each single firm. Given n the number of producer-consumers of an economy footnote , Z can be defined as $Z = nk$. The interest rate is by $r = \alpha A$ which, evidently, is independent from k, and is therefore constant. The consequence of this will be a growth rate continuously increasing over time. On the other hand, if $\alpha < 1$ the BGP just obtained is suboptimal because of the presence of the externality deriving from Z, which is not taken into account by a single-profit maximizing firm. A social planner will choose the optimal accumulation path by taking into account the externality effects: in this case interest rate would be $r = A$.

The second class of models can be analyzed along the lines of Romer (1990) where the production function for final goods is $Y_t = A(H_t - \overline{H}_R)^\alpha \left(\int_0^{N_t} z(i)di\right)^{1-\alpha}$ where A is a scale parameter (constant), and the Z_t factor is given by $Z_t = \int_0^{N_t} z(i)di$. Z_t can now be interpreted as the sum of all the i-th capital goods $z(i)$ produced by using the i-th project. $\overline{H}_R$ is the amount of human capital employed in the production of new designs, while N_t indicates the total amount of designs of the economy. In this model the growth engine is entirely represented by the production of new projects which is assumed to be a linear function of N_t:

$$\dot{N}_t = D\overline{H}_R N_t \qquad \#$$

where D is a scale parameter.. Equation (ref: dod) describes the growth rate of new designs: the amount of new projects N_t depends linearly on the existing level of projects footnote . The level of scientific knowledge represents the basis for further development of new projects. It is precisely in this sense that the existing amount of projects represents a positive externality. The growth rate of the economy is then given by (ref: dod), and it is constant because $\overline{H}_R$ is assumed to be constant on a BGP. The mechanism just described and the relationship expressed by

(ref: dod) offsets the decreasing returns to scale, keeping bounded away from zero the growth rate of this economy footnote .

Income Taxation

In this section, I start with the analysis of the role of fiscal policy in endogenous growth models. This section considers the effects of fiscal policy created by income taxation under two qualifications: a pure income tax and a set of differentiated taxes on the returns on productive inputs.

The income tax

Consider now the introduction of a flat tax rate τ on the aggregate income Y_t produced by using a Cobb-Douglas production function (ref: uno). The income net-of-taxes is:

$$Y_t = (1-\tau)A_t K_t^{\alpha} Z_t^{1-\alpha} \qquad \#$$

Clearly, from (ref: tred) the rate of return on the invested capital will be:

$$r_t = (1-\tau)\alpha A_t \left(\frac{K_t}{Z_t}\right)^{\alpha-1} \qquad \#$$

After a quick inspection of (ref: tred)-(ref: quatdici) we note that the income tax reduces the real return on invested capital and inhibits the incentives to capital accumulation. As an example, consider now the *Ak* model. Given the utility function (ref: quat), the growth rate for the *Ak* model with a tax rate on income is:

$$\gamma = \frac{(1-\tau)A - \delta - \rho}{\sigma} \qquad \#$$

In the model with knowledge spillover, as in Romer (1986,1989), the growth rate is:

$$\gamma = \frac{(1-\tau)\alpha A - \delta - \rho}{\sigma} \qquad \#$$

In the two-sector model with human capital accumulation *à la* Rebelo (1991), the growth rate after tax will be:

$$\gamma = \frac{1}{\sigma}\left\{[(1-\tau)^{\beta} Q]^{\frac{1}{1-\alpha+\beta}} - \delta - \rho\right\} \qquad \#$$

where $Q = (\alpha A)^{\beta}((1-\beta)B)^{1-\alpha}\left(\frac{\alpha}{1-\alpha}\frac{1-\beta}{\beta}\right)^{\beta}$.

In the model with capital accumulation *à la* Lucas (1988) with $I_H = B_t z_{2t} H_t$ inserted in (ref: sei), the growth rate will be:

$$\gamma = \frac{B - \delta - \rho}{\sigma} \qquad \#$$

Finally, in the technological innovation model, we have:

$$\gamma = \frac{\alpha D - \rho}{\sigma + \alpha} \qquad \#$$

From (ref: quind)-(ref: dicia9) we can conclude that only for three cases out of five the growth effect of income tax rates is negative. In fact, this happens only for (ref: quind)-(ref: dicias7): in all the other cases, fiscal policy does not have any effect at all on growth rate. There is a simple explanation of this result: in the models by Lucas (1988) and Romer (1990), the growth rate is entirely determined by the growth rate of human capital and that of accumulated projects. Therefore, since those activities are produced in non-taxed sector, the growth rate will not be affected by the fiscal structure introduced on the final goods sector. Thus, in a two-sector model where human capital production is not taxed at all, growth rate is not affected by tax rates applied on the production of final goods.

Moreover, it is easy to verify from (ref: quind)-(ref: sed) that it does not exist any level of τ such that the growth rate turns out to be maximized footnote .

To highlight the mechanism behind this result we need to distinguish between *direct* and *indirect* effects of tax rates. Consider first *direct* effects: the introduction of a tax rate lowers the rate of return on capital and, through the investment channel, produces a negative impact on the long-run growth rate. For the *indirect* effects, it is clear that in the *Ak* model they do not exist at all (see (ref: quind)). However, the assumptions on the technology producing human capital are crucial in the determination of the effects of fiscal policy on the growth rate. In fact, from the growth rate given by (ref: dicias7), if the production of human capital is not taxed, when income tax rate raises there will be the incentive to shift resources from the taxed sector to the untaxed one, by lowering the steady state ratio physical/human capital (thereafter K/H). Moreover, if the production of human capital is realized without physical capital - as in Lucas (1988) - the decline of the ratio K/H increases the real interest rate and this completely offsets the negative (*direct*) effect created by taxation.

Instead, if human capital sector employes physical capital, as in (ref: sette), then the offsetting mechanism is only partial and the net effect on growth rate is negative.

This discrepancy between Lucas (1988) and Rebelo (1991) model, is a consequence of the fact that the production of human capital is indirectly taxed when physical capital is a necessary input, because the production of physical capital (final goods) is taxed. In fact, the taxation effects go from the sector producing final goods (physical capital) to the sector producing human capital, making impossible a perfect offsetting of fiscal distortions through movements in K/H.

In Romer (1986), the global effects of taxation are somehow ambiguous. It was stressed before that this model produces a suboptimal equilibrium, since if $\alpha < 1$ the growth rate of this model is lower than what it could be obtained by a Social Planner. This non-optimality represents the main reason for the public intervention in this model. To restore Pareto optimality, it would useful to subsidize production through the revenue from a *lump sum* tax or from a proportional tax on income.

The taxation on private inputs

The analytical context previously developed can be extended to the two-sector growth models of endogenous growth *à la* Lucas (1988) and Rebelo (1991), where income taxation is considered as taxation on the real returns of private inputs. If human capital is a non-market good, only the real returns on factors employed in the production of final goods will be taxed. The accumulation constraint for human capital sector is still given by (ref: sei). Also, the production functions for the final goods sector and human capital are given, respectively, by (ref: otto) and (ref: sette). The real returns on K and H, are given, respectively by r_t^k and r_t^h:

$$r_t^k = \alpha A\left(\frac{v_{1t}K_t}{z_{1t}H_t}\right)^{\alpha-1} \quad \#$$

$$r_t^h = (1-\alpha)A\left(\frac{v_{1t}K_t}{z_{1t}H_t}\right)^{\alpha} \quad \#$$

Moreover, I consider the same the same depreciation rate for both physical and human capital, i.e. $\delta_K = \delta_H = \delta$. The accumulation constraint for the final goods sector is becomes footnote :

$$\dot{K}_t = r_t^k v_1 K_t + r_t^h z_1 H_t - C_t - \delta K_t - G_t \quad \#$$

where G_t is public expenditure. The government budget constraint for this economy is:

$$\dot{B}_t = r_t B_t + G_t - T_t \quad \#$$

where B_t represents the total amount of public debt issued at time t. The fiscal revenue T_t is defined as $T_t \equiv \tau_t^k r_t^k v_1 K_t + \tau_t^h r_t^h z_1 H_t$. Therefore, considering (ref: venti2), (ref: venti3) and the definition of fiscal revenue T_t the accumulation constraint for the final goods sector can be rewritten as:

$$\dot{B}_t + \dot{K}_t = r_t B_t + (1-\tau_t^k) r_t^k v_1 K_t + (1-\tau_t^h) r_t^h z_1 H_t - C_t - \delta K_t \quad \#$$

To simplify matters, I consider the existence of no public debt, i.e. $\dot{B}_t = 0$. In this case, the government budget is continuously balanced at each instant t, i.e. $G_t = T_t$. Although in a model with distortionary taxation public debt is not neutral, the growth rate effects of taxation do not change when government issues public debt.

As discussed previously, the impact effect of taxation on growth depends upon the characteristics of human capital production function. In fact, if we consider the same analytical specification assumed by Lucas (1988), the growth rate is still given by (ref: dici8), which establishes that any form of fiscal restraint imposed on the production of final goods does not have growth effects. As it was said before, this is due to the countervailing effect between resources employed in the two sectors: physical and human will tend to shift to the untaxed sector and the reduction of the ratio K/H will be compensated by an analogous offsetting of the real returns of both K and H.

If human capital is produced with physical capital as essential input, according to equation (ref: sette) the growth rate will be affected by both tax rates τ^k, τ^h:

$$\gamma = \frac{1}{\sigma}\left\{\left[Q(1-\tau^k)^{\alpha\beta}(1-\tau^h)^{\beta(1-\alpha)}\right]^{\frac{1}{1-\alpha+\beta}} - \delta - \rho\right\} \qquad \#$$

with $Q = (\alpha A)^{\beta}((1-\beta)B)^{1-\alpha}\left(\frac{1-\alpha}{\alpha}\frac{\beta}{1-\beta}\right)^{\beta(1-\alpha)}$.

From (ref: venti5) it is immediate to verify that both tax rates on physical and human capital have a negative impact on growth rate in a multiplicative manner. The magnitude of these effects depends upon technological parameters α, β, A, B, and the index of relative risk aversion σ. Moreover, if the technology employed in the production of physical capital and human capital is the same, i.e. if $\alpha = \beta$ and $A = B$, the steady state growth rate will be:

$$\gamma = \frac{1}{\sigma}\left\{A[\alpha(1-\tau^k)^{\alpha}]^{\alpha}[(1-\alpha)(1-\tau^h)^{\alpha}]^{1-\alpha} - \delta - \rho\right\} \qquad \#$$

From (ref: venti6) it is still true that taxation produces distorsive effects, whose magnitude is directly related to the magnitude of α. Furthermore, if the level of fiscal pressure on both sectors is equal and production functions are the same, after setting $\tau^k = \tau^h = \tau$, equation (ref: venti6) will be modified as follows:

$$\gamma = \frac{1}{\sigma}\left\{\alpha^{\alpha}(1-\alpha)^{1-\alpha}A(1-\tau)^{\alpha} - \delta - \rho\right\} \qquad \#$$

On the other hand, when technologies are different but $\tau^k = \tau^h = \tau$, the growth rate expression given by (ref: dicias7) is still valid here.

Comparing equations (ref: venti5)-(ref: venti7) we can recognize the crucial role played by the parameters in the determination of the impact effect of taxes on growth rate. However, the cross substitution effects among factors induced by taxation will imply that an economy characterized by growth rate (ref: venti5) will grow at a slower growth rate than an economy characterized by (ref: venti6) or (ref: venti7).

It is worth to stressing that one crucial assumption of the above model is that human capital is not a market good. By relaxing this assumption, it will be possible to extend to the production of human capital the same kind of tax structure on inputs above considered only for the sector producing physical capital, as in Stockey and Rebelo (1995) and Pecorino (1993). It is not difficult to justify the production of human capital as a market activity. In fact, in many advanced economies it is possible to observe that human capital formation and educational activities can be activities market oriented, not dissimilarly from the production of physical capital. In this case, those activities become subjected to taxation as well. Since human capital enters directly into the production of final goods, as in (ref: otto), we may interpret human capital as an intermediate good produced by a separate sector not integrated with the production of final goods. Thus, when the real returns of inputs employed in the production of final goods and human capital are taxed, we will end up with an expression of the growth rate depending upon all fiscal parameters of the model, showing up the problem of the double taxation of productive factors.

In terms of the convergence issue two economies will exhibit the same growth rate and the same convergence rate not only if they are similar with respect to their technological parameters, but also if their fiscal structure will be equal. Those issues are crucial especially if we consider how many parameters enter into the definition of the growth rate.

When in the production function for final goods (ref: otto), we insert a non-reproducible factor, like for example land, indicated by X, whose return is taxed at a rate different from what employed in the other inputs, we have that the tax rate on X will not affect at all the real interest rate and the growth rate, as proved by Rebelo (1991). In other words, growth rate is not affected by the tax rates imposed on non-reproducible factors inserted as inputs in the production of final goods.

Endogenous Fiscal Policy

The models described so far did consider neither the problem of an optimal degree of public expenditure (and consequently, of taxation) nor the problem of the determinant of public expenditure and its effect on growth and distribution. Indeed, this is quite a broad topic since it involves several issues, like optimal public expenditure and political equilibria based on the size of public expenditure. In what follows I distinguish between models without an explicit treatment of human capital and models where human capital plays a significant role together with other production inputs.

Models without human capital

One possible way to endogenize public expenditure is to remove the assumption which makes public expenditure completely useless inside the model by opening a role for it as a productive input in the final goods sector, along the lines of Barro (1990) and Barro and Sala-i-Martin (1992b). The main results of those papers are based on a different definition of the input Z_t in (ref: uno), which now can be interpreted as a pure public good. In other words: $Z_t = G_t$, where G_t indicates the total level of public expenditure in period t entirely invested in the production of a public good. A possible interpretation considers G_t as the total amount of public infrastructures and facilities provided by the Government to the private sector. Following Barro and Sala-i-Martin (1992b),it is possible to consider three different definitions of G_t:

(i) public goods, as publicly provided good, but rival and excludable (like a private good);
(ii) pure public goods, non-rival and non-excludable (like, f.e., defense expenditure);
(iii) public goods subjected to congestion phenomena (like, for example, highways, streets, green areas, etc.).

In cases (i)-(iii) it is assumed that the production of public goods is realized through a technology similar to what is employed by private sector to produce market goods footnote .

In (i) G_t is the total quantity of public services allocated to each producer. In fact, given N the total number of entrepreneurs of a given economy, we have that $g = G/N$, and in (ref: uno) $Z_t = g_t$. The private real return on investment is:

$$r_t = \alpha A\left(\frac{}{}\right)^{1-\alpha} \qquad \#$$

where k is the per capita stock employed by each single firm. Even in this case, as in Romer (1986), the private real return on capital is non-optimal and the growth rate will be lower than what we could obtain under a Social Planning solution. To finance public expenditure, the Government imposes a proportional tax rate τ on aggregate income. From the balance budget condition we have that $\tau y = g$ for all t. Therefore, on a BGP the steady-state growth rate is:

$$\gamma = \frac{1}{\sigma}\left\{(1-\tau)\tau^{\frac{1-\alpha}{\alpha}}\alpha A^{1/\alpha} - \delta - \rho\right\} \qquad \#$$

The growth rate for a Social Planner economy is:

$$\gamma^{SP} = \frac{1}{\sigma}\left\{(1-\tau)\tau^{\frac{1-\alpha}{\alpha}} A^{1/\alpha} - \delta - \rho\right\} \qquad \#$$

By comparison of (ref: venti9) and (ref: trenta), we get that $\gamma < \gamma^{SP}$, since $\alpha < 1$. It is also easy to show that the growth maximizing tax rate τ^* is:

$$\tau^* = 1 - \alpha \qquad \#$$

Note that $\tau^* = 0$ if and only if $\alpha = 1$, i.e. public expenditure becomes useless when physical capital has enough constant returns by itself.

In case (ii) G represents a pure public good in the sense of Samuelson. The budget balance condition implies that for each instant t $G = \tau y$. Now the growth rate will be footnote :

$$\gamma = \frac{1}{\sigma}\left\{(1-\tau)\tau^{\frac{1-\alpha}{\alpha}}\alpha A^{1/\alpha}N^{\frac{1-\alpha}{\alpha}} - \delta - \rho\right\} \qquad \#$$

In this case too, the growth maximizing tax rate will be given by (ref: trenta1). It is worthwhile to note that (ref: trenta2) depends upon N which is the total number of firms operating in this economy. This suggests that the growth rate depends on the size of the economy. This aspect has a difficult interpretation because empirical regularities show that large countries are slow growers relatively to small countries, as discussed, for example, by Levine and Renelt (1992). This undesirable effect can be by-passed when we abstract from the concept of nation and we consider the economic region as replacing the idea of State-nation. Under this interpretation, γ is the growth rate of an economic region which can encompass areas belonging to several nations but sharing similar characteristics with respect to the economic conditions.

Consider now model (iii) with public goods congestion. The production function is given by:

$$y_t = AK_t\left(\frac{G_t}{K_t}\right)^{1-\alpha} \qquad \#$$

When income is high we have a sort of crowding out effect on G that reduce its positive externality effects in the productive process. In this case, the growth rate here is:

$$\gamma = \frac{1}{\sigma}\left\{(1-\tau)\tau^{\frac{1-\alpha}{\alpha}}A^{1/\alpha} - \delta - \rho\right\} \qquad \#$$

with a growth maximizing tax rate still equal to (ref: trenta1).

From the growth rate expressions (ref: venti9), (ref: trenta2) and (ref: trenta4) and their respective social planning solutions, we observe a non-linear effect of fiscal policy and public expenditure on growth. The overall effect depends whether τ is lower or bigger than the optimal τ^*. In other words, if we indicate with γ^* the growth rate corresponding to the optimal tax rate τ^* we have:

$$\gamma \geq \gamma^* \Leftrightarrow \tau \leq \tau^*$$

$$\gamma < \gamma^* \Leftrightarrow \tau > \tau^*$$

This results shows that the growth effect of a proportional tax rate is not necessarily negative and the function $\gamma = f(\tau)$ assumes a behavior of an inverted **U**. Therefore, if $\tau = G/Y$ the growth maximizing tax rate is exactly equal to the share of public expenditure (or total expenditure on investment goods) on aggregate income. Before the optimal tax rate (the optimal ratio G/Y) is reached, the advantage of an higher taxation good is higher than costs, because the fiscal revenue is invested in investment good. The opposite happens when the tax rate is higher than its socially optimal level: the positive effects of having a higher level of public goods are more than compensated by the cost of an higher level of taxation.

However, it should be recognized that the optimal level of the tax rate τ represents a Second Best solution, due to the distortions caused by a proportional income taxation. Barro and Sala-i-Martin (1992b) showed that the First best solution with the highest growth rate can be achieved through *lump-sum* taxation footnote . The case with public goods subjected to congestion represents probably the most favorable framework to restore Pareto-optimality. In fact, in this case the distortions are originated by an excessive use of the public good by private agents: the introduction of a tax rate reports the economy on the optimal path.

Another possible way to endogenize public expenditure is to insert the public expenditure as an argument of the utility function, as in Barro (1990). In this case, given G as the amount of public expenditure the utility function can be represented by:

$$U = \int_0^\infty e^{-\rho t}[u(C_t) + \phi(G_t)] \qquad \#$$

with $u'(\bullet) > 0$, $\phi'(\bullet) > 0$, $u''(\bullet) < 0$, $\phi''(\bullet) < 0$. If we specify a Cobb-Douglas utility function for (ref: extra), we still obtain the same class of results considered before for the production case, i.e., an inverted-**U** relationship between taxes and the growth rate.

The analytical context introduced by Barro (1990) and Barro and Sala-i-Martin (1992b) can be easily extended to more complex models. One example is represented by Cashin (1995) where government spending on physical capital and transfers are inputs of the production function of private goods. We have two state variables: the stock of private physical capital and the stock of public physical capital. Basically, public expenditure can be divided into two components: the stock of public physical capital and the transfers. Per capita aggregate product is:

$$y_t = Ak_t\left[\frac{G_t}{K_t}\right]^{\alpha}\left[\frac{T_t}{K_t}\right]^{\beta} \qquad \#$$

where G_t/K_t is the ratio of public aggregate capital stock G_t to the aggregate capital stock K_t, and T_t/K_t is the ratio of aggregate public transfer payments T_t to the aggregate private capital stock. As in Romer (1986), we assume that the aggregate level of capital stock is defined as: $K_t = Nk_t$ where N is the number (constant) of private firms operating in this economy and k_t is the capital-labor ratio for each firm. Equation (ref: trenta5) is linear in k_t for given G_t/K_t and T_t/K_t, and exhibits increasing returns to scale with respect to all the inputs considered together. The rationale behind the presence of G_t/K_t is the same as for the public goods with congestion described above. To justify the presence of transfers T_t/K_t Cashin (1995) argues that public transfers represent a way to raise the after-tax private return to capital through the reduction of inefficiencies and excess burden derived from a poor protection of property rights. In general, we can distinguish between intergenarational and intragenerational transfers: Sala-i-Martin (1992) provides a rationale justification for intragenerational transfers which would enforce private property rights and reduce the aggregate distortions. A better enforcement of property rights would incentivate people to accumulate capital and it would have a positive effect on the growth rate footnote . The resource constraints for this economy are:

$$\dot{k}_t = (1-\tau_1-\tau_2)Ak_t\left[\frac{G_t}{K_t}\right]^{\alpha}\left[\frac{T_t}{K_t}\right]^{\beta} - c_t \qquad \#$$

$$\dot{G}_t = \tau_1 ANk_t\left[\frac{G_t}{K_t}\right]^{\alpha}\left[\frac{T_t}{K_t}\right]^{\beta} \qquad \#$$

$$T_t = \tau_2 ANk_t\left[\frac{G_t}{K_t}\right]^{\alpha}\left[\frac{T_t}{K_t}\right]^{\beta} \qquad \#$$

where $\dot{k}_t$, $\dot{G}_t$ are, respectively, the investment in private and public capital. T_t is total fiscal revenue while τ_1, τ_2 are the marginal tax rate used to finance the production of public physical capital (as in (ref: trenta7)) and transfers (as in (ref: trenta8)). There is not public debt and each sector of the whole public activity cannot be financed by borrowing from another sector. After some algebra along the lines described by Cashin (1995), it is possible to obtain an implicit function relating the growth rate of the economy to tax rates τ_1, τ_2. Given that the growth maximizing tax rates are $\tau_1^* = \alpha$, $\tau_2^* = \beta$, it its easy to show that the model presents the same nonlinear effect of taxes on growth as described before in the simple one-sector model *á la* Barro (1990). In fact:

$$\frac{\partial\gamma}{\partial\tau_1} > (<)0 \Leftrightarrow \tau_1 < (>)\alpha$$

$$\frac{\partial\gamma}{\partial\tau_2} > (<)0 \Leftrightarrow \tau_2 < (>)\beta$$

Once again, the relationship between fiscal variables and growth is an **U**-inverted curve: the effect of tax rate on growth will be positive if the size of government is lower than optimal. Even if this model lacks of a more precise definition of Government Expenditure, it represents a good starting point in highlighting the growth diminishing effect of distortionary taxes and the growth enhancing effect caused by the public provision of public goods and transfers.

Models with human capital

An interesting question is to see what are the growth effects of taxes employed to finance a public expenditure which is used as exclusive input in the production of human capital or, alternatively, in the production of final goods. This line of research has been put foreword by Corsetti and Roubini (1996). In this section I will briefly discuss the model by Corsetti and Roubini (1996), later on I will treat the problem of optimal taxation involved with it. The main result of this paper is not too dissimilar from the seminal contribution by Barro (1990). The difference is that there are now two sector, one producing final goods and the other producing human capital, and two tax rates, one on physical capital and the other on human capital. The negative effects on input taxation can be enhanced by a productive Government expenditure, whose effect is to reduce the distorsive effect of taxation. Intuitively: the inclusion of Government expenditure in the production function generates rents which can be appropriated either by human or by physical capital, according to the modelling structure. The role of the tax rate is to extract these rents. With this respect, the model shows a positive effect of taxes on growth under a certain range of tax rates. The production function for final goods is:

$$Y_t = A(v_{1t}K_t)^{\alpha\varepsilon}(z_{1t}H_t)^{1-\alpha}(G_t)^{\alpha(1-\varepsilon)} \qquad \#$$

In (ref: trenta9) the variables have the usual meaning, apart from ε which represents the productivity of public expenditure G_t in the final goods sector. When $\varepsilon = 1$, then public expenditure is not a required input in the production of final goods. The production of human capital is realized through the following production function:

$$I_{Ht} = B(v_{2t}K_t)^{\beta\omega}(z_{2t}H_t)^{1-\beta}(G_t)^{\beta(1-\omega)} \qquad \#$$

In (ref: quaranta) ω indicates the productivity of public expenditure in the human capital sector. The model is general enough to provide a wide taxonomy of cases according to different assumptions on ε and ω.

To get the rental rate of capital R_t^{1k} and the wage rate R_t^{1h} we need to make assumptions on which factor in what sector appropriates rents deriving from G_t. As a matter of example, assume that public expenditure is a productive input only in sector one and that $\omega = 0$. Therefore, physical capital is the factor which appropriates rents coming from public expenditure. Define now the rental rate on physical capital in sector 1 net of rents deriving from public expenditure as r_t^{1k}. Finally, let r_t^{1G} be the marginal productivity of G in sector 1. The rental rate of capital R_t^{1k} will be: $R_t^{1k} = r_t^{1k} + r_t^{1G}$. So, by using (ref: trenta9) and by dropping time dependence for v_{it}, $i = 1,2$ and z_{it}, $i = 1,2$, we have:

$$r_t^{1k} = \alpha\varepsilon A(v_1K_t)^{\alpha\varepsilon-1}(z_1H_t)^{1-\alpha}(G_t)^{\alpha(1-\varepsilon)}$$
$$r_t^{1G} = \alpha(1-\varepsilon)A(v_1K_t)^{\alpha\varepsilon}(z_1H_t)^{1-\alpha}(G_t)^{\alpha(1-\varepsilon)-1}$$

and:

$$R_t^{1k} = \alpha A\left(\frac{v_1K_t}{z_1H_t}\right)^{\alpha-1}\left(\frac{G_t}{v_1K_t}\right)^{\alpha(1-\varepsilon)} \qquad \#$$

The wage rate is:

$$R_t^{1h} = (1-\alpha)A\left(\frac{v_1K_t}{z_1H_t}\right)^{\alpha}\left(\frac{G_t}{v_1K_t}\right)^{\alpha(1-\varepsilon)} \qquad \#$$

At the same time, in sector 2 we have: $R_t^{2k} = \beta B\left(\frac{v_2K_t}{z_2H_t}\right)^{\beta-1}$, $R_t^{2h} = (1-\beta)B\left(\frac{v_2K_t}{z_2H_t}\right)^{\beta}$.

The following table collects all the possibilities arising from different assumptions on the parameters of the model, without reporting the entire set of algebraic expressions that can be recovered along the guidelines discussed before:

	Parameters	Factor appropriating rents from G
Model 1	$\varepsilon > 0, \omega = 1$	K
Model 2	$\varepsilon > 0, \omega = 1$	H
Model 3	$\varepsilon = 1, \omega > 0$	K
Model 4	$\varepsilon = 1, \omega > 0$	H

Table 1

From table 1 we observe that Model 3 and 4 both consider the production of human capital as subjected to externalities deriving from *G* while the production of final goods is realized in sector 1 without *G*. If we assume that only inputs employed in the production of final goods are taxed, the accumulation constraint is given by (ref: venti4). The accumulation constraint for human capital is still described by (ref: sei). We assume also that the government budget constraint is instantaneously satisfied without issuing public debt. The total fiscal revenue is still given by $T_t \equiv \tau_t^k R_t^{1k} v_1 K_t + \tau_t^h R_t^{1h} z_1 H_t$, with $G_t = T_t$. For expository reasons, I consider here a simple model without the endogenous choice between labor and leisure, by assuming that the utility function of the representative agent is given by (ref: quat). The resulting expression for the growth rate is:

$$\gamma = \frac{1}{\sigma}\left[\Lambda_i \Gamma_i (1-\tau_t^k)^{\alpha\beta}(1-\tau_t^h)^{(1-\alpha)\beta} - \delta - \rho\right] \qquad \#$$

where Λ_i, Γ_i $i = 1,2,3,4$ are constant terms including the constant parameters (both fiscal and non-fiscal) of each model considered in the table. In the particular case considered in the example (Model 1), we would have:

$$A_1 = \left(\frac{\alpha}{1-\alpha}\frac{1-\beta}{\beta}\right)^{\beta(\alpha-1)} \frac{(\alpha A)^{\beta}}{[(1-\beta)B]^{\alpha-1}}$$

$$\Gamma_1 = \left(\frac{G}{v_1 K}\right)^{\alpha\beta(1-\varepsilon)}$$

The growth rate of this model is higher than in the case without productive government expenditure. Therefore, even if taxation has a negative effect on growth, we have that growth rate is higher for each level of taxation. Moreover, as in Barro (1990), it is possible to get the same kind of nonlinear effect due to taxation such that for low level of government expenditure and taxation (assuming continuous balanced budget) the positive effects of an higher public expenditure are higher than the distortions induced by taxation, in such a way that the overall effect on growth rate is positive. Through this way, it is always possible to define a trigger level of taxation beyond that we have a negative effect on growth rate.

The message of this model is twofold: in one sense, it represents the extension to the two-sector case of the Barro (1990) model discussed in the previous section. At the same time, it allows a better discussion of the usage of public expenditure and public investment, by including the opportunity for investment in human capital. Another advantage of the analytical framework adopted by Corsetti and Roubini (1996) hinges on its high reliability which allows to distinguish between several particular cases within a unique general framework.

Imperfectly Competitive Markets

The inclusion of imperfect competition in the production of final goods or in the production of human capital makes all the results on taxation above described enriched by another degree of freedom. The study of monopolistic competition in growth models is primarily due to Grossman and Helpman (1991), and Romer (1990). The explicit study of the links between monopolistic competition and taxation in growth models is due to Judd (1997). This line of research shows that fiscal policy represents an additional distortion to the existing one represented by the presence of monopolistic competition assumed in the production of final goods. In this way, monopolistically competitive markets amplify the distortions created by fiscal policy. Judd (1997) focuses on optimal taxation: in a world with monopolistic competition in the final good sector, the optimal tax rate on capital is negative (i.e. it becomes a subsidy). This is because the government acts in order to compensate firms from the loss to be in an imperfectly competitive market.

In this section, I will describe a simple model useful to address these issues. The model here presented is similar to Judd (1997), but I will not consider the endogenous choice between labor and leisure on the side of the representative agent.

In this economy we have a continuum of individuals indexed by j on $[0,1]$. We also have two types of goods: a consumption good and a capital good entering as input in the production function. There is a continuum of differentiated consumption and capital goods, each indexed by i. An index of consumption goods which are in the set of possible choices for agent j is:

$$C_t^j \equiv \left[\int_0^1 c_t^j(i)^{\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}} \qquad \#$$

with $\theta > 1$. It is clear from (ref: quaranta4) that all the differentiated consumption goods are indexed on $[0,1]$ For each agent j the accumulation constraint for capital good i is:

$$\dot{K}_{it}^{j} = (1-\tau_t^i)R_{it}^j K_{it}^j - \delta K_{it}^j + \pi_{it}^j + w_t^j L_t^j - \int_0^1 p_t(i)c_t^j(i)di \qquad \#$$

In (ref: quaranta5) R_{it}^j indicates the real rate of return on capital good i for agent j, τ_t^i is the tax rate on the real return R_{it}^j, assumed equal across all individual j; w_t^j is the wage rate for agent j, while L_t^j is its labor supply; π_{it}^j is the profit of the consumer-entrepreneur j coming from the firm producing good i. The implicit assumption on (ref: quaranta5) is that we have no public debt. Therefore, $G_t = T_t = \int_0^1\int_0^1 \tau_t^i R_{it}^j K_{it}^j didj$ for all t,and we do not have any particular assumption on the usage of public expenditure G.

This economy has a decentralized equilibrium where the decisions of firms and consumers are totally separated. Firms and consumers meet on the market only when their supplies and demands are equated. Each representative consumer j faces two kind of problem: an intra-temporal allocation problem given by the choice of consumption goods $c_t(i)$ among the infinite varieties $i \in [0,1]$ available on the market. However, there is also an intertemporal condition which is the consumption/saving choice. The utility function of the representative agent is:

$$U_t^j = \int_0^\infty e^{-\rho t}\frac{\left(C_t^j\right)^{1-\sigma} - 1}{1-\sigma}dt \qquad \#$$

Let us consider now the intratemporal condition. Define E_t^j as the total expenditure on consumption goods for the single agent j. Each agent j optimally chooses $c_t^j(i)$ in (ref: quaranta4) subjected to:

$$\int_0^1 p_t(i)c_t^j(i)di = E_t^j \qquad \#$$

The solution for the intratemporal allocation problem is given by the following couple of equations:

$$\left[\frac{c_t^j(i)}{C_t^j}\right]^{-\frac{1}{\theta}} = \frac{p_t(i)}{P_t} \qquad \#$$

$$P_t = \left[\int_0^1 p_t(i)^{1-\theta}di\right]^{\frac{1}{1-\theta}} \qquad \#$$

Equation (ref: quaranta8) is the demand equation for good i expressed from agent j, and θ is the demand elasticity. Equation (ref: quaranta9) is the aggregate price index over good i. Define by $y_t(j)$ as the aggregate demand over all good expressed by agent j and obtained through:

$y_t(j) = \int_0^1 c_t^j(i)di$. Let Y_t be the aggregate demand over all goods and agents expressed as: $Y_t = \int_0^1 y_t(j)dj$. According to these considerations, we can rewrite (ref: quaranta8) as:

$$\left[\frac{y_t(i)}{Y_t} \right]^{-\frac{1}{\theta}} = \frac{p_t(i)}{P_t} \qquad \#$$

Consider now the problem for the representative firm. The production function for the i-th firm producing the i-th differentiated good is:

$$y_t(i) = A_{it} X_{it}^{\alpha} L_{it}^{1-\alpha} \qquad \#$$

where X_{it} is the amount of differentiated good employed in the production of the i-th good. Define the capital aggregate X_{jt} as:

$$X_{jt} = X_t(j) \equiv \left[\int_0^1 K_t^j(i)^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}} \qquad \#$$

where $K_t^j(i)$ indicates the capital stock of good j employed in the production of good i. In (ref: 52) I assume the same elasticity of demand for final goods, $\theta > 1$. Therefore, each firm i producing good i owned by agent j maximizes its profit $\pi_t^j(i)$ defined as:

$$\pi_t^j(i) = p_t(i) y_t(i) - R_t^j(i) K_t^j(i) - W_t(i) L_t(i) \qquad \#$$

In each instant firm i chooses the optimal amount of $K_t^j(i)$ and $L_t^j(i)$ in order to maximize its profit given by (ref: 53) subjected to (ref: cinquanta)-(ref: 52). From the profit maximization condition we obtain the following expressions for the Rate of return on the productive factors $K_t^j(i)$ and $L_t^j(i)$:

$$R_t^j(i) = \left(1 - \frac{1}{\theta}\right) \alpha A_{it} X_{it}^{\alpha-1} L_{it}^{j1-\alpha} \left[\frac{K_t^j(i)}{X_t(i)} \right]^{-\frac{1}{\theta}} \left[\frac{y_t(i)}{Y_t} \right]^{-\frac{1}{\theta}} \qquad \#$$

$$W_t^j(i) = \left(1 - \frac{1}{\theta}\right)(1-\alpha) A_{it} X_{it}^{\alpha} L_{it}^{j-\alpha} \left[\frac{y_t(i)}{Y_t} \right]^{-\frac{1}{\theta}} \qquad \#$$

From (ref: 54)-(ref: 55) we observe that the assumption of monopolistic competitive market makes factor remuneration different from what should be in a perfectly competitive market. In fact, if $\theta = 1$ then (ref: 54)-(ref: 55) will be the same as in a perfect competitive market for final goods. In this formulation the mark-up over marginal cost is defined as $\mu \equiv \left(1 - \frac{1}{\theta}\right)$

θ (the demand elasticity of final goods), higher will be the market power of the representative firm and higher will be the margin over costs. On the other hand, since θ is always strictly bigger than one (by assumption), then from (ref: 54)-(ref: 55) we have that factor remuneration are lower than in perfectly competitive markets.

To get the equilibrium representation of the economy above described, I normalize (ref: quaranta5) with respect to the aggregate price index which for simplicity is set equal to one, i.e. $P_t = 1$. Moreover, I assume the existence of a symmetric equilibrium across goods and agents, by supposing that all agents and firms are the same and that everybody makes the same choices among the differentiated goods to be consumed and invested. In order to aggregate over all agent, let $V_t^j(i)$ be the total demand of good i expressed by agent j, then the total demand for good i expressed by all agents is $V_t(i) = \int_0^1 V_t^j(i)dj$. Therefore, under symmetry, we have: $K_t(i) = K_t, X_t(i) = X_{it} = X_t, R_t(i) = R_t, W_t(i) = W_t, L_t(i) = L_{it} = L_t$ for all $i \in [0,1]$. Moreover, we have that $\int_0^1 p_t(i) c_t(i) di = C_t$ which is the total consumption expressed by each agent i. The aggregate accumulation constraint (ref: quaranta5) will be:

$$\dot{K}_t = (1-\tau) R_t K_t - \delta K_t + \pi_t + W_t L_t - C_t \qquad \#$$

To make easier all the comparisons with the previous models, define with r_t the rate or return on capital in a perfectly competitive market (with $\theta = 0$ in the above model), i.e. $r_t = \alpha A K_t^{\alpha-1} L_t^{1-\alpha}$. Therefore, the rate of return in an economy with monopolistic competition is given by:

$R_t = \left(1 - \frac{1}{\theta}\right) r_t.$

$$\gamma = \frac{\dot{C}_t}{C_t} = \frac{1}{\sigma}\left\{(1-\tau)\left(1 - \frac{1}{\theta}\right) r_t - \delta - \rho\right\} \qquad \#$$

From (ref: 57) we note that the presence of monopolistic competition adds an additional distortion to the growth rate which has a multiplicative effect with respect to the distorsive taxation. In other words: the distorsive effect of taxation is magnified by the presence of imperfectly competitive markets. The background just discussed represents a good starting point for the optimal taxation analysis as in Judd (1997), where it is shown that in presence of monopolistic competition, the optimal taxation on capital must be negative in order to compensate for the distortion coming from an imperfect good market.

The model just presented is highly stylized. The same kind of framework can be easily generalized to all the models previously discussed, without changing the main result.

Endogenous Labor Supply

One of the typical assumptions of the neoclassical growth model is that agents adjust instantaneously their labor supply in response to whatsoever shock either on the production side or on the demand side. Recently, however, we have several models trying to analyze the growth effects of flat-rate taxes when an endogenous choice between labor and leisure is introduced in the model. Among the more representative papers in this area we have Jones, Manuelli and Rossi (1993), Roubini and Milesi-Ferretti (1994a,b), Milesi-Ferretti and Roubini (1995), Devereux and Love (1994, 1995). It does not exist neither a unique way to define “leisure” nor a unique, standard way to endogenize the choice between labor and leisure, as witnessed by the literature on Real Business Cycles (RBC). Among RBC studies, it is worth mentioning here Benhabib, Rogerson and Wright (1991), and Greenwood and Hercowitz (1991), who follow the definition of leisure as *homework production*, as in Becker (1965). With endogenous labor supply, the utility function (ref: quat) can be generalized as follows:

$$u(C_t, \ell_t) = \frac{\left[C_t^{\theta} b(\ell_t)^{1-\theta}\right]^{1-\sigma}}{1-\sigma} \qquad \#$$

where ℓ_t represents leisure in raw form and b is a function such that $b : [0,1] \to \Re^+$, with $b' > 0$, $b'' < 0$. Finally, θ represents the fraction of utility allocated to each argument, interpreted also as the elasticity of intra-temporal substitution between consumption and leisure. The leisure in raw form ℓ is defined as the total amount of time remaining to the single agent, after the fraction of time devolved to human capital accumulation and to the final goods production. One particular function for b is a simple linear case as $b(\ell_t) = \ell_t$. The model can be completed by considering together with (ref: 58) a two-sector model as described by equation (ref: sei)-(ref: otto): in this case, ℓ_t is defined as $\ell_t = 1 - z_{1t} - z_{2t}$ (when we normalize to 1 the endowment of time disposable to the single agent).

The extension considered by (ref: 58) will add to the model another state variable ℓ and one more first order condition that will make the set of first order conditions no more block-recursive. As a consequence, in the expression of the growth rate we would have a term depending upon z_1 and z_2. To be more explicit, in a two-sector economy let Φ be a constant term formed by all the parameters of the model, and let $\widetilde{b}(\ell)$ be a function of z_1 and z_2 representing the fraction of human capital employed in the production of final goods (or physical capital) and human capital, whose sum can vary as response to fiscal policy shocks. The growth rate of this economy can be expressed as:

$$\gamma = \frac{1}{\sigma}\left[\Phi \widetilde{b}(\ell) - \delta - \rho\right] \qquad \#$$

Devereux and Love (1994, 1995) showed that fiscal policy has always a distorsive effect on growth rate when leisure is considered in a raw form, independently upon the assumptions on the production function of final goods and human capital.

Under alternative definitions of leisure we obtain different results. One possibility is to replace in (ref: 58) $b(\ell_t)$ with $b(\ell_t)H_t$. In this case, leisure in raw form is adjusted by the level of human capital H_t: this extension defines the *Quality time* model of endogenous labor supply. In this case leisure is represented by a production function whose unique input is human capital and the output is interpretable as the result of a working activity which uses a fraction of labor different from what is supplied in the market or in the accumulation of human capital.

In a broader sense, it is possible to extend the *Quality time* model to a more complex production function whose inputs are now physical and human capital. Let Y_N be the final output obtained by using $Y_N = f[(1 - v_1 - v_2)K, (1 - z_1 - z_2)H]$. The utility function (ref: 58) can be extended to be:

$$u(C_t, \ell_t) = \frac{[C_t^{\theta} Y_{Nt}^{1-\theta}]^{1-\sigma} \ell_t^{\pi(1-\sigma)}}{1 - \sigma} \qquad \#$$

Basically, the introduction of the production Y_N is like to insert a third sector into a model producing a non-market good. In this context, fiscal policy will affect the choice between consumption and non-market activities (homework production function) and the intersectoral factor allocation. In fact, a fiscal shock in the market oriented sectors will inhibit the supply of inputs to be employed in market sector by distracting resources in favor of the homework activities. In this sense, the production Y_N can be interpreted as a complex set of activities out of control of fiscal authorities: under this interpretation it represents a potential source of tax evasion. In fact, if non-market activities are produced with the same technology as market goods, then a fiscal policy shock will shift the production from the “legal” sector to the “illegal” one, whose income is unobservable and therefore non taxable. Moreover, an high level of fiscal pressure on the “legal” sector will shift resources in favor of the “illegal” one, making even worse the problem of fiscal revenue collection, given the reduction of the tax base following from a reallocation of productive resources.

Finally, in a two-sector model the functional specification of the non-market activities does not affect at all the analytical expressions of the growth rate, which is still given by (ref: venti5)-(ref: venti7), according to the various assumptions on the model.

The Consumption Tax

In the public finance literature consumption taxation has always played an important role. John Stuart Mill and more recently Fischer (1937) and Kaldor (1955) have offered arguments in favor of consumption taxes rather than income taxes. The traditional debate focused on both efficiency and equity arguments footnote . In particular, the Mill’s concern is mainly related with an efficiency argument and is about the principle of double taxation of savings as a consequence of an income tax, but not of a consumption tax. In fact, taxing income distorts the consumption-saving decision, while a consumption tax uniform over time imposes the same burden on current and future consumption. On the other hand, the relative optimality of consumption versus income taxation can be expressed as a question on the optimality of tax rates over current and future consumption. In fact, consumption tax introduces a distortion into the work-leisure choice. Therefore, the final judgement has to do with the relative substitutability of consumption and leisure at different point in time. According to standard optimal taxation principles, given that leisure is untaxed, we should tax more heavily goods that are more complementary and/or substitutable with consumption. Moreover, in a world where labor supply is exogenous, a uniform consumption tax is equivalent to a wage tax when there is no leisure. Thus, in this last case, we are back to the traditional debate on relative optimality. between a wage (or consumption) tax rate and a capital tax rate. By following the same kind of argument about efficiency, it is also possible to reach different conclusions according to the particular specification adopted in the model. A general presumption, however, implies that a uniform consumption tax will be superior to income taxation if the utility function is separable between consumption and leisure and preferences are homothetic over consumption at different dates.

Equity arguments are manly based on the view that it is fairer to tax people on what they consume rather than on what they produce, as stressed by Kaldor (1955).

In the endogenous growth context, Devereux and Love (1994, 1995) showed in a two-sector model that consumption tax affects negatively growth rate only if leisure is modelled in a raw form. In fact, for a model similar to that described by (ref: 58) and (ref: 59) with $b(\ell_t) = \ell_t$, we have that growth rate depends on the total amount of time spent in the market sector and in the human capital accumulation activity through the function $b(\ell_t) = \ell_t$. Therefore, a consumption tax affects the choice on labor supply in both productive sectors through the usual mechanisms of income and substitution effects footnote .

If leisure is modelled according to the homework production or *Quality Time* approach, then the consumption tax does not produce any effect at all on the growth rate. In fact, the mechanism at work here is exactly the same as we have seen in the discussion on taxation of the non-reproducible factors. There are no links between the homework activities and the aggregate consumption, given the fact that in the expression for the growth rate there is any variable describing the leisure allocation.

The Investment Tax

Following Rebelo (1991), assume that the production of new investment goods uses a proportion $1 - \psi_t$, $0 < \psi_t \leq 1$, of the entire amount of capital in a model where the production function is of the *Ak* type. The accumulation constraint is: $\dot{K}_t = I_t = A(1 - \psi_t)K_t$ where I_t indicates the gross investment, and the other variable have the usual meaning. Suppose also that the production of consumption good C_t requires a proportion ψ_t of the aggregate capital stock with a Cobb-Douglas production function:

$$C_t = B(\psi_t K_t)^\alpha T_t^{1-\alpha} \qquad \#$$

with $0 < \alpha \leq 1$. In (ref: 60) T_t is a fixed non-reproducible factor and B is a constant productivity parameter. Let p_t be the relative price of investment goods in term of consumption goods and Y_t be the aggregate income. The resource constraint for this economy is $Y_t = C_t + p_t I_t$.

Suppose now that between the interest rate for loans denominated in consumption-goods term r_c and the real return to capital r_k holds the following arbitrage relation:

$$r_{ct} = r_{kt} + \frac{\dot{p}_t}{p_t} \qquad \#$$

where $\dot{p}_t / p_t$ indicates the rate of variation of the investment goods price expressed in terms of consumption good. It is just the non-constancy of p_t which makes r_{ct} and r_{kt} different. From the profit maximization condition for each single firm we obtain the usual condition of equality of the marginal product in both sectors (consumption and investment):

$$p_t(1 - \psi_t)A = \alpha B(\psi_t K_t)^{\alpha-1} \qquad \#$$

Therefore, if ψ_t is constant over time, we will have that $\dot{p}_t / p_t = (\alpha - 1)\gamma_k$ where γ_k is the growth rate of physical capital. In other words: the price of capital good decreases with a rate which is proportional to the growth rate of physical capital itself. The equilibrium on the aggregate capital markets requires that for a given tax rate on physical capital τ^k the rate of return r_k will be:

$$r_k = (1 - \psi)(1 - \tau^k)A - \delta \qquad \#$$

Finally, from the arbitrage condition (ref: 61) we have:

$$r_c = (1 - \psi)(1 - \tau^k)A - \delta + (\alpha - 1)\gamma_k \qquad \#$$

Therefore, with an isoelastic utility function having a constant degree of relative risk aversion like (ref: quat), the consumption growth rate γ_c can be expressed as: $\gamma_c = (r_c - \rho)/\sigma$. By inserting (ref: 64) into the expression for γ_c and using from (ref: 60) the fact that $\gamma_c = \alpha\gamma_k$ we get:

$$\gamma_k = \frac{(1 - \psi)(1 - \tau^k)A - \delta - \rho}{1 - (1 - \alpha)\sigma} \qquad \#$$

$$\gamma_c = \alpha \frac{(1-\psi)(1-\tau^k)A - \delta - \rho}{1-(1-\alpha)\sigma} \qquad \#$$

From (ref: 65)-(ref: 66) we have that taxation on investment is somehow similar to capital taxation and has negative consequences on the growth rate, as it appears from the fact that $\partial\gamma_c/\partial\tau^k < 0$. Moreover, the tax rate on physical capital which maximizes the consumption growth rate is equal to zero and corresponds to the optimal long-run tax rate on capital.

The model just described is extremely stylized and does not consider a set of complex interactions deriving, for example, from the degree of substitution between factors in the production function of the two goods. However, even in a more complex model the results will be similar to what has been showed here: the investment tax is interpretable as a tax on new capital and it affects growth and accumulation exactly in the same fashion as we have described in the previous sections.

Optimal taxation

The problem of optimal taxation has been implicitly treated in many cases considered in the previous sections. One of these examples is certainly represented by the Barro (1990) model where the growth maximizing tax rate is the same of the tax rate which maximizes the welfare of the representative agent, with a CRRA utility function. Probably, the more interesting case is the two-sector model where income taxation assumes the form of taxation of real returns of the productive inputs.

The optimal taxation analysis can be thought as a part of the well known “Ramsey Problem” where the choices of the social planner on the optimal tax are constrained by the conditions describing the optimizing behavior of the representative agent. We can generally distinguish between two approaches: the first is adopted by Chamley (1985, 1986) and Judd (1987) in a growth model with exogenous technical progress. This approach finds the optimal tax structure as the result of the maximization of the indirect utility function of the representative agent subjected to the first order conditions derived as result of the optimal choice of the consumption plan. The second approach, mainly followed by Lucas (1990), Chari, Christiano and Kehoe (1991), Bull (1993a), Jones, Manuelli and Rossi (1993), Roubini and Milesi-Ferretti (1994a,b), Milesi-Ferretti and Roubini (1995), Corsetti and Roubini (1996), leaves directly to the social planner the task of finding the optimal quantities of consumption, production and investment plans subjected to the intertemporal budget constraint and the resource constraint. This method will deliver functional forms linking the optimal quantities to the tax rates. The comparison between the first order condition of the choice problem of the social planner and the first order of the representative agent will show the optimal tax structure.

The optimal taxation analysis in exogenous growth models reveals that the optimal tax on capital should be zero, while the tax on labor should be positive. However, in endogenous growth models we obtain a multiplicity of results depending upon the particular assumptions considered in the model. In particular, if public expenditure is endogenous as, for example, in Barro (1990), Barro and Sala-i-Martin (1992), Jones, Manuelli and Rossi (1993), Judd (1990), Zhu (1992), then the optimal long-run tax on capital must be equal to zero. On the other hand, if public expenditure is endogenous and generates externalities in a two-sector model along the same lines of Corsetti and Roubini (1996), then the optimal tax on physical and human capital strictly depends upon which factor appropriates the rents generated by public expenditure. For example, if physical capital is the factor appropriating rents from public expenditure, then the optimal tax on it will be positive and zero the tax on human capital (the reverse is true when human capital is the factor appropriating rents).

On the other hand, if the externalities in the production function are generated by other factors and not by public expenditure, as in Romer (1987, 1990) and Lucas (1988), the optimal taxation plan considers subsidies for the activities with generating positive externalities footnote .

When we consider some upper limits to tax rates on certain inputs, like for example human capital, the long run optimal tax rate on capital is positive again, as showed by Jones, Manuelli and Rossi (1993b).

A discussion on the optimal structure of indirect taxation is conducted by Bull (1993a,b) and by Jones, Manuelli and Rossi (1993a). Moreover, the issue of an optimal consumption tax rate is discussed by Milesi-Ferretti and Roubini (1995).

In an open economy context, the same type of analysis is conducted by Rebelo (1992), and Razin and Yuen (1992a,b).

In the literature above cited it is generally showed that the results on the zero-tax rate on capital can be maintained even in the endogenous growth context, unless some particular assumptions are inserted in the model. Moreover, for a whatsoever functional form assumed for the *homework activities* in a model with human capital accumulation, if there are not limits to human capital taxation, the optimal long-run tax rates on both human and physical capital should be zero. In particular, if labor supply is exogenously given and human capital formation does not require physical capital as necessary input, the optimal long run tax rate on physical capital is zero, while on human capital is positive. However, this is the unique case the two-sector model of endogenous growth without endogenous public expenditure where we have an asymmetry between long run optimal taxes on physical and human capital. In general, we have symmetric optimal tax rates on physical and human capital: both they are either positive or zero. Moreover, the positive optimal tax rate is obtained when there are rents to be appropriated or when there are some upper limits on taxation of some inputs footnote (in these cases we could also get asymmetry, as previously discussed). In exogenous growth models, instead, the asymmetry between the two tax rates is the usual result.

Probably, one of the more striking result coming from the endogenous growth literature is the symmetric results on the fiscal tax rates on productive inputs, and its ability in discerning several particular cases where the asymmetric result cannot be obtained. It is worthwhile to stress that the symmetric result is almost a natural consequence, given the fact that with an asymmetric long run optimal tax structure the representative agent will have the incentive in misreporting the source of its income, in order to avoid fiscal pressure.

Concluding Remarks

This paper surveys some of the more important and recent results on the literature on fiscal policy and growth, in the endogenous growth context. Given the enormous amount of literature, this survey concentrated on infinite-horizon representative agent models with one and two productive sector, considering also the case of imperfectly competitive markets. It has been shown that the heterogeneity of results and point of views present in the literature strictly depends upon the particular assumption of the underlying model. This is also reflected on the optimal taxation analysis.

Given the number of contributions in this area and the various different framework analyzed, probably it is not hazardous to define the state of this literature as mature. New areas of research are offered by a more careful analysis of fiscal policy issues in growth models with imperfect competition, and by quantitative research and sensitivity analysis on all the other models of the literature.

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