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THE WELFARE OF INVESTMENT DEDUCTIBILITY UNDER A FLAT TAX

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The Welfare of Investment Deductibility under a Flat Tax

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Abstract

This paper analyses the welfare effects of investment deductibility in a contest of endogenous growth generated by learning-by-doing and knowledge spillovers. We present a model where a set of revenue neutral fiscal policies, each characterised by different degrees of investment deductibility and different uniform tax rates on income, have been introduced. We show that, given the ratio of public expenditures to national product, partial investment deductibility turns out to be welfare enhancing when the intertemporal elasticity of substitution of consumption is sufficiently small. Our result means that a pure consumption tax —although ensuring more saving and faster growth— is not always preferable to a revenue neutral tax system in which both consumption and investment are taxed.

Key words: Investment deductibility, Flat Tax, Welfare, Consumption tax, Endogenous Growth.

JEL classification: E62, H21, O41.

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1   Introduction

The current debate on tax reform has been fueled by almost universal tax reforms in the 1980s. Since Diamond and Mirrlees (1971)' seminal paper the theoretical analysis of tax reforms in static economies has been developed by several works. More recently, a number of papers have extended this analysis to endogenous growth economies.[1] The concern of these papers is to examine the effects of tax reforms on the private sector, the size of the public sector, the saving behavior, and the rate of economic growth. A common result to all these studies is that an increase in marginal tax rates on physical and human capital lowers the growth rate.

In this framework, among the current tax reform proposals, Hall and Rabushka's (1995, 1996) flat tax has received a great deal of attention. The basic idea is to replace current tax systems with a single tax rate applied to labor income above a given threshold and all capital income after full investment deductibility.[2]

A key feature of a flat tax is the definition of taxable income inspired to the principle that "individuals should be taxed on what they take out of the economy (consumption), and not what they put in (saving or investment)" [Cassou and Lansing, 1996]. This principle could be satisfied by allowing households to fully deduct investment expenditures in calculating taxable income. In this respect, the flat tax would amount to a pure consumption tax.

The aim of this paper is to examine the effects on growth, employment and household welfare of this key feature of the flat tax proposal. In particular, we do not discuss the consequences of switching from a system with several tax rates, each applied to a different income bracket, to a system with a single tax rate,[3] but we focus our attention on the effects of changing the degree of investment deductibility within a single tax rate system.

Our analysis builds on the standard endogenous growth model with production externalities generated by learning-by-doing and knowledge spillovers [Barro and Sala-i-Martin, 1992, 1995]. To this framework we add explicit preferences for leisure and a government which has access to a set of revenue neutral fiscal policies, each characterized by different degrees of investment deductibility and different uniform tax rates on income.

To summarize the main result at the outset, we find that, given the ratio of public expenditures to national product, partial investment deductibility turns out to be welfare enhancing if the intertemporal elasticity of substitution of consumption is sufficiently small. In other words, although a pure consumption tax ensures more saving and faster growth, it is not always preferable to a revenue neutral tax system in which both consumption and investment are taxed. Our

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[1] King and Rebelo (1990), Lucas (1990), Rebelo (1991), Pecorino (1993, 1994), Jones, Manuelli, and Rossi (1993), Devereux and Love (1994), Glomm and Ravikumar (1998), Milesi-Ferretti and Roubini (1998), Ortigueira (1998), Gruner and Heer, (2000), among others.

[2] Stokey and Rebelo (1995), McClure and Zodrow (1996), Altig et al. (1997), Weidenbaum (1997), Ventura (1999), Judd (1999), Cassou and Lansing (1996, 2000,2001), Gruner and Heer (2000).

[3] Cassou and Lansing (1996,2000) provide an analysis of this kind (with quantitative implications) in an endogenous growth model similar to the one we use in this paper.

result, which holds in spite of the positive externalities associated with the investment activities, can be given an intuitive interpretation. A revenue neutral switch to a pure consumption tax generates future benefits due to the higher growth rate but also implies present costs in terms of initial consumption. For sufficiently small intertemporal elasticity of substitution of consumption and positive elasticity of substitution between consumption and leisure, future benefits are not high enough to compensate for present costs.

The rest of the paper is organized as follows. The theoretical framework is presented in the next section, while Section 3 focuses on the global analysis of the equilibrium. Section 4 extends the analysis by considering the set of revenue neutral tax policies. Section 5 concludes.

2 The Model

The economy consists of a continuum of identical, infinite-lived households who earn income by supplying capital and labor services to firms. They choose the levels of consumption, labor time, and capital stock. In so doing, they take account of a flat tax on income after a partial or full deductibility of investment expenditures. In what follows, each of these features of the economy is described in more detail.

2.1 Households

Households' preferences are described by the intertemporal utility

$$U = \sum_{t=1}^{\infty} \beta^t u\left(c_t, l_t\right), \qquad (1)$$

where $c_t \geq 0$ is the consumption flow at time t, $l_t \in [0,1]$ denotes labor hours, and $\beta \in [0,1]$ is the subjective discount factor. The number of households is normalized to one.

Throughout this paper we shall adopt the following standard specification for $u(\cdot)$[4]

$$u\left(c_t, l_t\right) = \left[c_t\left(1 - l_t\right)^\eta\right]^{(1-\theta)}\left(1 - \theta\right)^{-1}, \qquad (2)$$

where θ^{-1} and $[1 - \eta(1-\theta)]^{-1}$ are the intertemporal elasticities of substitution of consumption and leisure respectively. Such a utility function turns out to be concave provided $\eta \geq 0$ and $\theta \geq \eta(1+\eta)^{-1}$.

Households earn income by supplying capital and labor services to firms, taking the market rental rate on capital q_t and the wage rate w_t as given. We assume a flat tax system in which households pay rate $\tau \in [0,1]$ on income after deducting investment expenditures to the extent allowed. Thus, at each t the representative household faces the budget constraint

$$(1-\tau)(q_t k_t + w_t l_t) = c_t + (1 - \mu\tau)\left[k_{t+1} - (1-\delta)k_t\right], \qquad (3)$$

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[4]See, for instance, King, Plosser, Rebelo (1988);Rebelo (1991); Jones, Manuelli, Rossi (1993); Milesi-Ferretti, Roubini (1998).

where k_t is the household's capital stock, $\delta \in [0, 1]$ is the capital depreciation rate, and $\mu \in [0, 1]$ is the fraction of investment expenditure that can be deducted from taxable income. It is convenient to define

$$1 - \tau_y = \frac{1 - \tau}{1 - \mu\tau} \quad \text{and} \quad 1 + \tau_c = \frac{1}{1 - \mu\tau}. \tag{4}$$

Using these definition, the household's budget constraint (3) can be written as

$$(1 - \tau_y)(q_t k_t + w_t l_t) = (1 + \tau_c)c_t + [k_{t+1} - (1 - \delta)k_t] . \tag{5}$$

Eqs. (3) and (5) and definitions (4) show that full investment deductibility ($\mu = 1$) is equivalent to a pure consumption tax system ($\tau_y = 0$ and $\tau_c > 0$), while partial deductibility ($0 < \mu < 1$) corresponds to a mixed consumption-income tax system ($\tau_y > 0$ and $\tau_c > 0$).

Given prices, initial endowments and the tax policy, each household chooses the sequences (c_t, l_t, k_{t+1}) in order to maximize (1) subject to (5). Using standard optimization methods, we obtain the following first order conditions:

$$\frac{\eta c_t}{1 - l_t} = \frac{(1 - \tau_y)w_t}{1 + \tau_c}, \tag{6}$$

$$\frac{1}{\beta}\left(\frac{c_{t+1}}{c_t}\right)^\theta \left(\frac{1 - l_t}{1 - l_{t+1}}\right)^{\eta(1-\theta)} = 1 - \delta + (1 - \tau_y)q_{t+1}. \tag{7}$$

Condition (6) equates the marginal rate of substitution between leisure and consumption to the after-tax wage rate in terms of consumption and (7) is the standard Euler equation which equates the marginal rate of substitution between next period consumption and present consumption to the market discount factor $1/[1 - \delta + (1 - \tau_y)q_{t+1}]$, where $(1 - \tau_y)q_{t+1} - \delta$ is the after-tax interest rate in the next period.

To (6) and (7) we must add the transversality condition

$$\lim_{N \to \infty} R_{N-1} k_N = 0, \tag{8}$$

where

$$R_t = \prod_{s=0}^{t} [1 + (1 - \tau_y)q_s - \delta]^{-1} .$$

Note that (8) is a necessary condition. Moreover, if a sequence (c_t, l_t, k_t) satisfies the first order conditions (6) and (7), the budget constraint (5), and the requirement (8), then it is optimal.

2.2 Firms

There is a continuum of identical competitive firms with the total number normalized to one. Each firm uses capital, K_t, and labor hours, L_t, to produce output, Y_t, according to the constant returns to scale production function

$$Y_t = A K_t^\alpha \left(\overline{k}_t L_t\right)^{1-\alpha}, \tag{9}$$

with $A > 0$, $0 < \alpha < 1$. Here $\bar{k}_t$ is the economy-wide average stock of capital. From a single firm point of view, $\bar{k}_t$ is given and causes positive external effects on production for which firms do not pay any market price [Romer, 1986; Barro and Sala-i-Martin, 1992, 1995].

The returns to scale of private capital and labor hours are constant and private returns of both capital and labor hours are decreasing. Since firms behave symmetrically, at equilibrium, it will be $K_t = \bar{k}_t$. Thus, the aggregate production function becomes

$$\bar{y}_t = A\bar{k}_t \bar{l}_t^{1-\alpha}, \tag{10}$$

where $\bar{y}_t$ and $\bar{l}_t$ are the economy-wide average levels of output and labor hours, respectively. Consequently, social returns to scale are increasing, while those of capital are constant and those of labor hours are decreasing. Indeed, the fact that the social returns of capital are constant will allow the economy to grow endogenously.

The representative firm maximizes profit given by $Y_t - q_t K_t - w_t L_t$. Imposing $K_t = \bar{k}_t$, we can write the first order conditions as

$$q_t = A\alpha L_t^{1-\alpha}, \tag{11}$$

$$w_t = A(1-\alpha)K_t L_t^{-\alpha}. \tag{12}$$

2.3 Government

As shown before, the tax system is described by the parameters τ and μ or, using definitions (4), by τ_y and τ_c. Government uses tax revenue to provide goods and services which do not affect household utility or production possibilities. The government budget is balanced at each period, that is,

$$g_t = \tau(\bar{y}_t - \mu\left[\bar{k}_{t+1} - (1-\delta)\bar{k}_t\right]), \tag{13}$$

where g_t is the per capita level of public expenditures. Using (4) and the aggregate consistency condition $\bar{y}_t = \bar{c}_t + \bar{k}_{t+1} - (1-\delta)\bar{k}_t + g_t$, where $\bar{c}_t$ is per capita consumption, Eq. (13) can be written as

$$g_t = \tau_y \bar{y}_t + \tau_c \bar{c}_t. \tag{14}$$

2.4 Equilibrium

We are now ready to set out our definition of equilibrium.

Definition 1. An equilibrium consists of a set of prices (w_t, q_t), quantities (c_t, l_t, k_t), and fiscal parameters (g_t, τ_y, τ_c) with the following properties:

- given $(q_t, w_t, \tau_y, \tau_c)$, the sequence (c_t, l_t, k_t) maximizes (1) subject to (5);

- given $(w_t, q_t, \bar{k}_t)$, firms maximize profits;

- the aggregate consistency conditions are satisfied, that is,

$$k_t = K_t = \bar{k}_t, \quad l_t = L_t = \bar{l}_t, \quad c_t = \bar{c}_t,$$
$$y_t = Y_t = \bar{y}_t = \bar{c}_t + \bar{k}_{t+1} - (1-\delta)\bar{k}_t + g_t. \tag{15}$$

- the government budget constraint is satisfied.

2.5 The choice of modelling strategies

At this point a comment is in order on the main simplifications of our model, that is the choice of an infinite-lived, representative agent framework in preference to a model with heterogeneous agents, and the assumption of a single capital stock.

The effects of flat tax reforms have been analyzed in a number of papers. Some of these have focused on the distributional consequences of a flat tax reform [Altig et al., 1997; Ventura, 1999]. Heterogeneity among individuals is the key feature of this class of growth models. By contrast, in another class of models welfare results are driven purely by efficiency considerations [Judd, 1999; Coleman, 2000]. Here, the representative agent model is the basic framework, although its inability to dealt with distributional effects should be kept in mind.[5]

Our paper belongs in this latter strand of literature. In particular, our purpose is not to explore the economic aspects of redistribution policy within the context of a flat tax proposal, but to pursue the efficiency properties of total investment deductibility. This exercise can be accomplished most cleanly in a simple infinitely-lived, representative agent model. Although this model seems to be too divorced from reality to be instructive with regard to actual policy decisions, it can yield considerable information. For instance, in our case we will see that, under empirically relevant conditions on preferences, total investment deductibility turns out to be inefficient. This result seems sufficiently strong to cast serious doubts on the desirability of such a policy in the real world.

As far as the second simplification is concerned, following Barro (1990) and Judd (1999) we can interpret k as a single capital stock which can be allocated among alternative uses in each period, that is, among physical capital and human capital.[6] Judd points out that the Hall-Rabushka flat tax proposal does not actually amount to a true consumption tax since it defines "consumption" as the difference between income and investment in physical capital only, allowing few deductions for educational investment. On the other hand, Judd's analysis shows that there is no aggregate efficiency reason for favoring physical capital investment over human capital investment.[7] If in our model k represents both physical and human capital, then the investment deductibility has to be viewed as applying to the investment in physical goods, as well as to the

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[5] Although Hall and Rabushka do not develop a formal model of their proposal, they cite representative analyses as well [Judd, 1999].

[6] Obviously, equilibrium requires that in the two alternative allocations capital earns the same returns. Moreover, in this setting w stands for "raw labor" remuneration.

[7] If human capital does not directly affect household utility, an otpimal tax policy would treat human and physical capital identically [Judd, 1999].

expenses in education. This assumption is clearly unrealistic, but, as will later become clear, it allows us to identify an inefficient solution even when the two kinds of investment are treated equally. In other words, the flat tax proposal can result in inefficiency even when it is structured to take account of Judd's criticisms.

3 Global Dynamics

This section carries out a global analysis of the equilibrium. Using the results found so far, in the first subsection we show that the short-run equilibrium conditions can be condensed in a first order dynamic equation in labor hours. Besides, we state the condition that allows us to select full equilibria. The second subsection is devoted to the equilibrium properties of global dynamics.

3.1 Equilibrium Conditions

The following analysis assumes $\eta > 0$. This assumption will be maintained throughout the paper, with the exception of the end of Subsection 4.3 where we will discuss the case of inelastic labor supply.

Substituting the firm's first order condition (12) into the household's first order condition (6) and using (15), we obtain

$$\frac{c_t}{k_t} = \frac{A(1 - \tau_y)(1 - \alpha)(1 - l_t)}{(1 + \tau_c)\eta l_t^\alpha}. \tag{16}$$

Substituting (11) into the household's first order condition (7) and using (15), we get

$$\frac{c_{t+1}}{c_t} = \beta^{1/\theta} \left[1 + (1 - \tau_y)q(l_{t+1}) - \delta \right]^{1/\theta} \left(\frac{1 - l_{t+1}}{1 - l_t} \right)^{\gamma(1-\theta)/\theta}, \tag{17}$$

where

$$q(l) = A\alpha l^{1-\alpha}. \tag{18}$$

Finally, using (5), (10), (11), (12), (15), and (16), we get the following law of motion for the capital stock:

$$\frac{k_{t+1}}{k_t} = 1 + (1 - \tau_y)f(l_t) - \delta, \tag{19}$$

where

$$f(l) = \frac{A\left[(1 + \eta - \alpha)l - (1 - \alpha) \right]}{\eta l^\alpha}. \tag{20}$$

Since $c_{t+1}/c_t = (c_{t+1}/k_{t+1})(k_{t+1}/k_t)(k_t/c_t)$, using (16), (17) and (19), it follows

$$\frac{\beta^{1/\theta} \left[1 + (1 - \tau_y)q(l_{t+1}) - \delta \right]^{1/\theta} l_{t+1}^\alpha}{(1 - l_{t+1})^\sigma} = \frac{\left[1 + (1 - \tau_y)f(l_t) - \delta \right] l_t^\alpha}{(1 - l_t)^\sigma}, \tag{21}$$

where $\sigma = 1 - [\gamma(1 - \theta)/\theta] \geq 0$.

Eq. (21) is a first-order dynamic equation in labor hours that, in principle, yields the time path of all endogenous variables, as long as the initial values k_0, l_0 are given. Indeed, when the labor dynamics is known, the remaining variables are easily calculated. Obviously, these solutions are in accordance with the nature of Euler equations that are not sufficient to select completely optimal paths. This task is accomplished by the transversality condition (8) in which we can replace q_s with $q(l_s)$.

Since functions $q(l)$, $f(l)$ and $l^\alpha (1-l)^{-\sigma}$ are strictly increasing, both sides of (21) are strictly increasing. Consequently, (21) gives rise to a monotonic first-order dynamics on the interval $0 \leq l < 1$. Clearly, the solutions l^* to the equation

$$1 + (1 - \tau_y)f(l) - \delta = \beta^{1/\theta} \left[1 + (1 - \tau_y)q(l) - \delta \right]^{1/\theta} \qquad (22)$$

lying in $(0,1)$ are fixed points of (21). Notice that the capital growth rate $\gamma_{kt} = (k_{t+1}/k_t) - 1$, the consumption growth rate $\gamma_{ct} = (c_{t+1}/c_t) - 1$, the consumption-capital ratio $c_t/k_t = \chi_t$, and the interest rate $r_t = (1 - \tau_y)q(l_t) - \delta$ remain time-invariant in connection with the solution $l_t = l^*$. More precisely, we have

$$\gamma_{kt} = \gamma_{ct} = (1 - \tau_y)f(l^*) - \delta = \gamma^*, \qquad (23)$$

$$\chi_t = \frac{(1 - \tau_y)Al^{*1-\alpha} - \gamma^* - \delta}{1 + \tau_c} = \chi^*, \qquad (24)$$

$$r_t = (1 - \tau_y)q(l^*) - \delta = r^*. \qquad (25)$$

It is easy to check that these balanced growth path (BGP) solutions satisfy the transversality condition (8) if and only if $\gamma^* < r^*$, that is, using (23), (19) and (20), if and only if

$$l^* < \hat{l} = \frac{1}{1 + \eta} < 1. \qquad (26)$$

3.2 Existence and Uniqueness of Equilibrium

The following proposition characterizes the dynamic behavior of our economy.

Proposition 1 *If*

$$\beta < \hat{\beta} = \left[1 + (1 - \tau_y)q(\hat{l}) - \delta \right]^{\theta-1}, \qquad (27)$$

then the economy has a unique equilibrium which is a BGP solution as determined by Eqs (22), (23), (24) and (25). By contrast, when $\beta \geq \hat{\beta}$ the economy has no equilibrium.

The formal proof of Proposition 1 is relegated in the Appendix Here, with the help of Figures 1 and 2 we give an intuitive explanation of the equilibrium dynamics. Figure 1 shows a BGP equilibrium for $1 + \gamma^*$ and l^* as the intersection of γ_c and γ_k curves which represent the left hand side and the right hand side

of (22), respectively −that is, the γ_c and γ_k curves represent the consumption growth rate and the capital growth rate as functions of l. If $\beta < \hat{\beta}$, to the left of $\hat{l}$ we have one and only one intersection point. By contrast, for $\beta \geq \hat{\beta}$ the γ_c curve lies above the γ_k curve for all $l \leq \hat{l}$. It is worth noting that in a BGP equilibrium the γ_k curve is steeper than γ_c curve. This entails

$$\theta(1 + r^*)f'(l^*) - (1 + \gamma^*)q'(l^*) > 0. \tag{28}$$
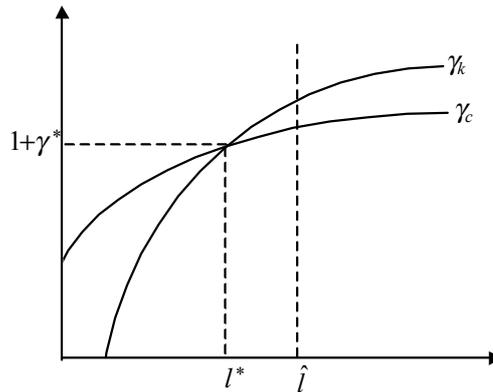
Fig. 1. A BGP solution when $\beta < \hat{\beta}$.

Obviously, this result, obtained in part (i) of the proof, is not sufficient to totally characterize the equilibrium. To complete our analysis, whether the transversality condition at infinity is consistent with some non-stationary solutions to the Euler equations in (21) must be investigated. This is accomplished in part (ii), where we analyze the optimal myopic trajectories (Euler dynamics) when the starting point l_0 differs from l^*. We show that these trajectories either leave the unit interval or tend to 1, as illustrated in Figure 2. This means that they cannot be equilibria, so that there are no transitional dynamics in our

economy.[8]
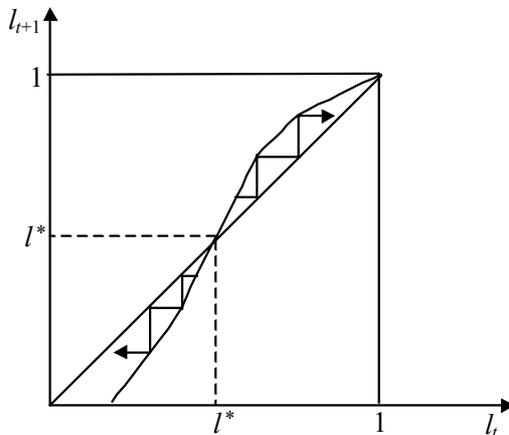
Figure 2. Optimal myopic trajectories (Euler dynamics).

In what follows we assume that condition (27) is satisfied.

4 Fiscal Policy

In this section the model is used to study how revenue neutral changes in the tax parameters τ_y and τ_c affect households' welfare. This requires prior analysis of the effects of such changes on growth, employment and initial consumption.

4.1 Revenue neutrality

In our growth economy, the concept of revenue neutral fiscal policies is necessarily a relative one. Following Cassou and Lansing (1996, 2000), we define as revenue neutral those policies that leave unchanged the ratio of government revenue to national product. In our setting, this implies that the tax parameters τ_y and τ_c are linked by the relation

$$\psi = \tau_y + \tau_c \frac{c_t}{y_t}, \tag{29}$$

where ψ is the constant value of g_t/y_t. Since $c_t/y_t = (c_t/k_t)/(k_t/y_t) = \chi_t/Al_t^{1-\alpha}$, at equilibrium (29) can be written

$$\psi = \tau_y + \tau_c \frac{\chi^*}{Al^{*1-\alpha}}. \tag{30}$$

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[8] This is consistent with known results from the Ak model (Barro and Sala-i-Martin, 1995). Although our model is not exactly an Ak model, it is similar in that there is only one type of capital which is the essential fact needed for no transition dynamics. Cassou and Lansing (2000) study the growth and level effects of adopting a revenue neutral flat tax during the transition to the balanced growth path in a model in which physical capital and human capital are different inputs.

Given definitions (4), the revenue neutral changes are obtained through changes in the degree of investment deductibility μ and in the income tax rate τ. For instance, revenue neutral increases in τ_c and decreases in τ_y are generated by suitable increases in μ and τ.

At this point it is convenient to eliminate τ_c from (24) by using (30). We obtain

$$\chi^* = (1 - \psi)Al^{*1-\alpha} - \gamma^* - \delta. \tag{31}$$

Eqs. (22), (23) and (31) do not contain τ_c. Thus we can study the effects of revenue neutral changes in τ_c and τ_y on growth, employment and consumption by changing τ_y only.

4.2 Growth and Employment Effects

Differentiating (22) and (23), we get

$$\frac{dl^*}{d\tau_y} = \frac{\theta(1 + r^*)f(l^*) - (1 + \gamma^*)q(l^*)}{(1 - \tau_y)\left[\theta(1 + r^*)f'(l^*) - (1 + \gamma^*)q'(l^*)\right]}, \tag{32}$$

$$\frac{d\gamma^*}{d\tau_y} = \frac{(1 + \gamma^*)\left[f(l^*)q'(l^*) - q(l^*)f'(l^*)\right]}{\theta(1 + r^*)f'(l^*) - (1 + \gamma^*)q'(l^*)}. \tag{33}$$

Proposition 2 *In our economy, a revenue neutral reduction in τ_y increases the rate of growth and has ambiguous effects on employment. If*

$$\theta > \theta_0 = \frac{(1 + \gamma^*)q(l^*)}{(1 + r^*)f(l^*)},$$

the level of employment decreases.

Proof. Using (18) and (20), it is easy to see that the difference $f(l^*)q'(l^*) - q(l^*)f'(l^*)$ in (33) is always negative. Thus, by (28), $d\gamma^*/d\tau_y < 0$. On the other hand, (28) and (32) imply that $dl^*/d\tau_y$ has the same sign of $\theta(1 + r^*)f(l^*) - (1 + \gamma^*)q(l^*)$. ∎

It is straightforward to note that a reduction in τ_y shifts both curves in Figure 1 upward and to the left. The shift to the left of the curve γ_c is greater than the shift of the curve γ_k, so that the new intersection point lies above the old one. The relative magnitude of the upward shifts depends on θ. If $\theta > \theta_0$, the upward shift of γ_k is greater than that of γ_c. In this case, the new intersection point lies to the left of the old one (see Figure 3).

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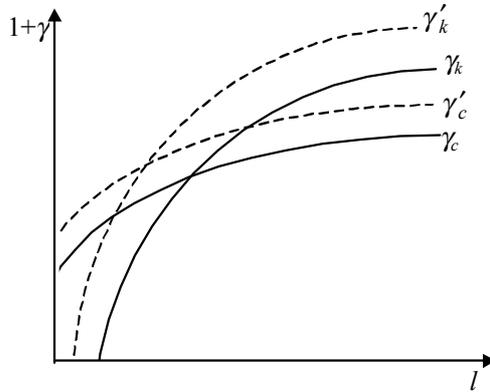
Figure 3. A reduction in τ_y: growth and employment
effects when $\theta > \theta_0$.

By contrast, if $\theta < \theta_0$, the curve γ_c shifts upward more than the γ_k curve (see Figure 4).
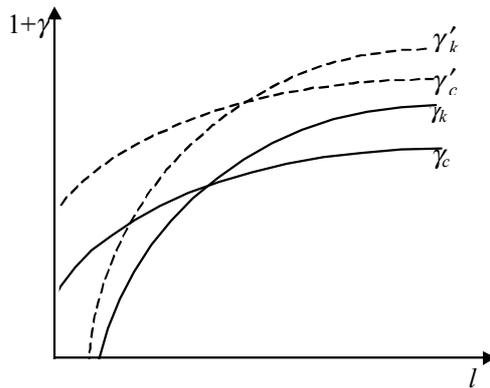
Figure 4. A reduction in τ_y: growth and employment
effects when $\theta < \theta_0$.

Following Milesi-Ferretti and Roubini (1998), we can distinguish between the growth effects of changes in τ_y for given employment levels (*direct effects*) and those operating through the response of labor hours (*indirect effects*). The direct effects are unambiguous: a decrease in τ_y surely increases both the capital growth rate and the consumption growth rate through its impact on the after tax interest rate and the wage, for a given level of employment. But these unambiguous direct effects – represented by the upward shifts of the γ_k and γ_c

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curves – are only part of the story. If the intertemporal elasticity of substitution is low (that is, if θ is high), then the impact of the after tax interest rate change on the consumption growth rate is weak. In particular, as illustrated in Figure 3, if $\theta > \theta_0$ the consumption growth rate increases less than the capital growth rate, for given l. In this case, to restore equilibrium there must be adjustments in the after tax interest rate and wage which require that employment decreases. The opposite obtains when the intertemporal elasticity of substitution is high $(\theta < \theta_0)$.

4.3   Welfare Effects

We now come to the welfare effects. Using the fact that at equilibrium $(c_{t+1}/c_t) - 1 = (k_{t+1}/k_t) - 1 = \gamma^*$ and $l_t = l^*$, we can write the household's utility defined in (1) and (2) as

$$U = \frac{(\chi^* k_0)^{1-\theta} (1 - l^*)^{\eta(1-\theta)}}{(1 - \theta) \left[1 - \beta(1 + \gamma^*)^{1-\theta}\right]}, \tag{34}$$

where k_0 is the given initial capital stock, so that $\chi^* k_0$ is the equilibrium level of initial consumption. Differentiating U with respect to τ_y and taking account of (22) and (23), we get

$$\frac{dU}{d\tau_y} = B_0 \left[(1 - l^*)\frac{d\chi^*}{d\tau_y} - \eta\chi^*\frac{dl^*}{d\tau_y} + \frac{\beta(1 + \gamma^*)^{-\theta}\chi^*(1 - l^*)}{1 - \beta(1 + \gamma^*)^{1-\theta}}\frac{d\gamma^*}{d\tau_y} \right],$$

where B_0 is a strictly positive amount. It is convenient to eliminate χ^*, γ^* and $d\chi^*/d\tau_y$. To this purpose we use (20), (23) and (31). After some tedious algebra, we obtain

$$\frac{dU}{d\tau_y} = B_0 \left(B_1\frac{dl^*}{d\tau_y} + B_2\frac{d\gamma^*}{d\tau_y} \right), \tag{35}$$

where

$$B_1 = (\psi - \tau_y)\eta f(l^*), \tag{36}$$

$$B_2 = \frac{(1 - l^*)q(l^*)\left[(1 - \psi) - \alpha(1 - \tau_y)\right]}{\alpha(1 - \tau_y)\left[q(l^*) - f(l^*)\right]}. \tag{37}$$

Since in a growing economy $f(l^*) > 0$, we have $B_1 \geq 0$ according whether $\psi - \tau_y \geq 0$. The sign of B_2 depends on the differences $q(l^*) - f(l^*)$ and $(1 - \psi) - \alpha(1 - \tau_y)$. The difference $q(l^*) - f(l^*)$ is surely positive due to the transversality condition $\gamma^* < r^*$. On the other hand, the difference $(1 - \psi) - \alpha(1 - \tau_y)$ is surely positive if $\psi < 1 - \alpha$, that is if the ratio of public expenditures to national product is smaller than the share of labor in national product. We can conclude that as a rule B_2 is positive.

The fact that $dl^*/d\tau_y$ can be positive entails that, in turn, $dU/d\tau_y$ in (35) can be positive. The following proposition clarifies the effects of small changes in τ_y when the starting points are at the two extremes $\tau_y = \psi$ (that is, $\mu = 0$ and $\tau_c = 0$) and $\tau_y = 0$ (that is, $\mu = 1$ and $\tau_c = \psi y_t/c_t$). It is one of the main results of the paper.

Proposition 3 *In a growing economy:*
(i) beginning with the highest income tax ($\tau_y = \psi < 1 - \alpha$), a revenue neutral small reduction in τ_y increases household welfare;
(ii) beginning with the lowest income tax ($\tau_y = 0$), a revenue neutral small increase in τ_y has ambiguous effects on household welfare. However, for

$$\theta > \theta_1 = \theta_0 \frac{(1 + \eta - \alpha)l^* - \psi}{(1 + \eta - \alpha)l^* - (1 - \alpha)},$$

household welfare increases.

Proof. (i) Definitions (36) and (37) imply $B_1 = 0$ and $B_2 > 0$ for $\tau_y = \psi$. Thus, since $B_0 > 0$ and $d\gamma^*/d\tau_y < 0$, in (35) $dU/d\tau_y < 0$. (ii) The value θ_1 is obtained by tiresome calcula from Eqs. (18), (20), (32), (33), (36), and (37). It turns out that when $\theta > \theta_1$ the derivative $dU/d\tau_y$ at point $\tau_y = 0$ is positive. ∎

Proposition 3 provides some insight on the welfare effects of a Hall-Rabushka type flat tax. The Hall-Rabushka plan implies total investment deductibility, that is $\tau_y = 0$. If we assume that the government target is the economy's growth rate, undoubtedly total investment deductibility has positive effects (see Proposition 2). However, things are more complex if, as usually assumed, government takes care of the household's welfare. If the intertemporal elasticity of substitution of consumption is sufficiently small (that is, if θ is sufficiently large), then a partial investment deductibility would be better. In fact, beyond certain levels a consumption tax becomes more distortionary than an income tax. Roughly speaking, for sufficiently large values of θ and τ_c the increases in future consumption due to a reduction in τ_y are not enough to compensate for the decrease in initial consumption due to the revenue neutral increase in τ_c. Note that this result obtains in spite of the assumption of positive externalities of investment on aggregate output.

A couple of points are worth noting. First, Proposition 3 implies that for $\theta > \theta_1$ there exists at least one $\tau_y \in [0, \psi]$ for which $dU/d\tau_y = 0$. In turn, this implies that there exists a partial investment deductibility at which household utility is maximized subject to the government budget constraint. Unfortunately, a closed form solution for the optimal level of τ_y is not available. Moreover, the implicit relation between fiscal, technological and preference parameters is too complex to give us additional information beyond that contained in Proposition 3.

Secondly, note that the foregoing analysis has been conducted assuming variable labor hours ($\eta > 0$). Greater intuition as to why, under certain conditions, the consumption tax is not efficient can be developed by considering the case in which labor supply is completely inelastic. In this case, the household's utility defined in (34) reduces to

$$U = \frac{(\chi^* k_0)^{1-\theta}}{(1 - \theta)\left[1 - \beta(1 + \gamma^*)^{1-\theta}\right]}, \tag{38}$$

where, normalizing the exogenously given labor hours to one,

$$1 + \gamma^* = \beta^{1/\theta} \left[1 + (1 - \tau_y)A\alpha - \delta \right]^{1/\theta}, \tag{39}$$

$$\chi^* = (1 - \psi)A - \gamma^* - \delta. \tag{40}$$

Eqs. (39) and (40) correspond to the traditional Ak model. It is easy to see that in this setting $dU/d\tau_y < 0$ for any θ (provided $\psi < 1 - \alpha$). Hence, a revenue neutral increase in the consumption tax τ_c always improves household welfare. It follows that under the flat tax proposal the inefficiency of total investment deductibility is jointly due to distortion of the choice between consumption and leisure time and to a low intertemporal consumption elasticity. In other words, if labor supply is inelastic, then the reduction in initial consumption, triggered by a revenue neutral increase of τ_c, is only due to the increase in the growth rate and is always more than compensated for by the increase in future consumption. By contrast, if labor supply is elastic, then the reduction in initial consumption also depends on the increase in leisure time (which is tax exempt); furthermore, if intertemporal substitution elasticity is low enough, then this reduction is not compensated for by the increase in future consumption.

5 Conclusion

This paper has explored the welfare effects of investment deductibility within a framework of endogenous growth generated by learning-by-doing and knowledge spillovers. A set of revenue neutral fiscal policies, each characterized by different degrees of investment deductibility and different uniform tax rates on income, have been introduced in the Barro and Sala-i-Martin model augmented with variable labor hours. It has been shown that the equilibrium solution, when it exists, is unique and corresponds to a balanced growth solution.

The main finding of the paper is that beyond certain levels a consumption tax may become more distortionary than an income tax. As a consequence partial investment deductibility may be preferable to complete deductibility. The intuition for this result is as follows. If preferences are characterized by a sufficiently low value of the intertemporal elasticity of substitution, then the increases in future consumption due to a reduction in the income tax rate are not enough to compensate for the decrease in initial consumption due to the revenue neutral increase in the consumption tax rate.

One shortcoming of our model is that it assumes that individuals are identical. However, the importance of this assumption is likely to depend on the set of issues to be addressed. The introduction of heterogeneous agents would go a long way towards generalizing the model, but would be unlikely to alter any of the main conclusions drawn above. For, the key objective of this paper has been to analyze the welfare effects of investment deductibility rather than the distributional effects of a flat tax. To that end, the standard endogenous growth model built around an infinitely lived representative individual has proven particularly useful to ensure analytical tractability without loss of generality.

The results described here are a first step that points the way toward further research. An interesting point that we have left out of our analysis is the transitional dynamics towards a balanced growth path. Furthermore, although our result is theoretically significant, the extent to which it is sensitive to the assumptions about the underlying taste and technology parameters of the model is a subject requiring empirical investigation.

Appendix
Proof of Proposition 1. The proof consists of two parts.

(i) *Balanced growth equilibria.* We begin by counting the number of roots of Eq. (22) over the positive axis $l > 0$. Let us write (22) as

$$\Gamma(l) = \beta^{1/\theta} \left[1 + (1 - \tau_y)q(l) - \delta\right]^{1/\theta} - \left[1 + (1 - \tau_y)f(l) - \delta\right] = 0. \qquad (A.1)$$

We shall evaluate the sign of the derivative $\Gamma'(l)$ at points for which $\Gamma(l) = 0$. With some algebra

$$\frac{\theta\left[1 + (1 - \tau_y)q(l) - \delta\right]}{1 - \tau_y}\Gamma'(l) = \beta^{1/\theta}\left[1 + (1 - \tau_y)q(l) - \delta\right]^{1/\theta}q'(l)$$
$$-\theta\left[1 + (1 - \tau_y)q(l) - \delta\right]f'(l).$$

Provided $\Gamma(l) = 0$, the latter leads to

$$sign\left\{\Gamma'(l)\right\} = sign\left\{m(l)\right\},$$

where

$$m(l) = \left[1 + (1 - \tau_y)f(l) - \delta\right]q'(l) - \theta\left[1 + (1 - \tau_y)q(l) - \delta\right]f'(l).$$

In view of (17) and (20), functions $1 + (1 - \tau_y)q(l) - \delta$ and $1 + (1 - \tau_y)f(l) - \delta$ can be represented as

$$\begin{aligned} 1 + (1 - \tau_y)q(l) - \delta &= q_0 + q_1 l^{1-\alpha}, \\ 1 + (1 - \tau_y)f(l) - \delta &= f_0 - f_1 l^{-\alpha} + f_2 l^{1-\alpha}, \end{aligned} \qquad (A.2)$$

where $q_0, q_1, f_0, f_1, f_2 > 0$. Thanks to (A.2), we can easily compute $m(l)$. It turns out that

$$\begin{aligned} l^\alpha m(l) = & (1-\alpha)(f_0 q_1 - \theta f_2 q_0) - \alpha\theta q_0 f_1 l^{-1} \qquad (A.3) \\ & -f_1 q_1 (1 - \alpha + \alpha\theta) l^{-\alpha} + (1-\alpha)(1-\theta)q_1 f_2 l^{1-\alpha}. \end{aligned}$$

If $\theta < 1$, the right-hand side can be regarded as a sum of strictly increasing and concave functions that go to $+\infty$, as $l \to +\infty$. Hence in this case $m(l)$ vanishes as it passes from negative to positive values. Let us examine the opposite case $\theta \geq 1$. It is readily seen that (A.3) can be alternatively written as

$$\begin{aligned} l^{2\alpha-1}m(l) = & (1-\alpha)(f_0 q_1 - \theta f_2 q_0)l^{\alpha-1} - \alpha\theta q_0 f_1 l^{\alpha-2} \qquad (A.4) \\ & -f_1 q_1 (1 - \alpha + \alpha\theta)l^{-1} + (1-\alpha)(1-\theta)q_1 f_2. \end{aligned}$$

Since $f_0 q_1 - \theta f_2 q_0 \leq 0$, the right-hand side of (A.4) can be regarded as sum of increasing and concave functions. At the boundaries, it takes values $-\infty$, as $l \to 0$ and $(1 - \alpha)(1 - \theta) r_1 g_2 \leq 0$, as $l \to +\infty$. We infer $m(l)$ to be always negative over $l > 0$.

Let us now study the behavior of $\Gamma(l)$ at the boundaries. We have $\Gamma(l) \to +\infty$, as $l \to 0^+$, and $\Gamma(l) \to +\infty$, as $l \to +\infty$, for $\theta < 1$, while $\Gamma(l) \to -\infty$, if $\theta \geq 1$. This entails that (A.1) has one root, when $\theta \geq 1$, while it exhibits at most two roots when $\theta < 1$. Now requirement (27) is derived by imposing the condition $\Gamma\left(\hat{l}\right) < 0$. Clearly, given that $\Gamma(0) = +\infty$ and in force of transversality condition (26), it implies the existence of a unique BGP equilibrium. Obviously, $\Gamma\left(\hat{l}\right) < 0$ is equivalent to (27).

The next step consists in studying the sign of the derivative $dl^*/d\beta$. Some algebra yields
$$\frac{dl^*}{d\beta} = -\frac{(1 + r^*)(1 + \gamma^*)}{\beta m(l^*)},$$
that shows how the increasing direction depends chiefly on the sign of $m(l^*)$. On the other hand,

$$sign\left[m\left(\hat{l}\right)\right] = sign\left[q'\left(\hat{l}\right) - \theta f'\left(\hat{l}\right)\right].$$

Consequently, if $q'\left(\hat{l}\right) - \theta f'\left(\hat{l}\right)$ is negative, then the unique root falls outside the interval $\left(0, \hat{l}\right)$ for $\beta > \widehat{\beta}$. On the contrary, if $q'\left(\hat{l}\right) - \theta f'\left(\hat{l}\right)$ is positive, a new root enters the interval $\left(0, \hat{l}\right)$. It is easy to show that requirement $q'\left(\hat{l}\right) - \theta f'\left(\hat{l}\right) \geq 0$, implying $\theta < \alpha\eta/[1 + \eta(1 + \alpha)]$, is inconsistent with the concavity condition $\theta \geq \eta/(1 + \eta)$. Thus, for $\beta \geq \hat{\beta}$ the economy does not have any BGP equilibria.

(ii) *Euler dynamics.* Let us now study the non-stationary solutions to (21). As the functions $q(l)$, $f(l)$ and $l^\alpha/(1 - l)^\sigma$ are increasing, both sides of (21) are strictly increasing and, consequently, (21) gives rise to an explicit monotonic first-order dynamics
$$l_{t+1} = \Lambda(l_t)$$
on the interval $0 \leq l < 1$, with Λ strictly increasing. These dynamics are easily understood with the help of the following simple observation. If l_t is such that $\Gamma(l_t) > 0$, then $l_{t+1} = \Lambda(l_t) < l_t$. While if $\Gamma(l_t) < 0$, then $l_{t+1} > l_t$. In fact, $\Gamma(l_t) > 0$ amounts to

$$\beta^{1/\theta}\left[1 + (1 - \tau_y)q(l_t) - \delta\right]^{1/\theta} > 1 + (1 - \tau_y)f(l_t) - \delta,$$

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that implies

$$\frac{\beta^{1/\theta}\left[1+(1-\tau_y)q\left(l_t\right)-\delta\right]^{1/\theta}l_t^\alpha}{\left(1-l_t\right)^\eta} \quad > \quad \frac{\left[1+(1-\tau_y)f\left(l_t\right)-\delta\right]l_t^\alpha}{\left(1-l_t\right)^\eta} =$$

$$= \frac{\beta^{1/\theta}\left[1+(1-\tau_y)q\left(l_{t+1}\right)-\delta\right]^{1/\theta}l_{t+1}^\alpha}{\left(1-l_{t+1}\right)^\eta}.$$

and, in turn, $l_{t+1} < l_t$. Note further that $\Lambda\left(l\right) \to 1$ when $l \to 1^-$. Moreover, $\Lambda\left(l\right) < 0$ for l small enough. This entails that all the trajectories that are not a BGP monotonically approach $l = 1$ or leave the interval $(0,1)$ after finitely many iterations. Furthermore, the unique root is a repelling point.

To conclude, let us check the optimality property for a trajectory approaching $l = 1$ by calculating $R_{N-1}k_N$ along it. We can write

$$R_{N-1}k_N = k_0\frac{k_1/k_0}{1+r_0} \cdot \frac{k_2/k_1}{1+r_1} \cdot \ldots\ldots \cdot \frac{k_N/k_{N-1}}{1+r_{N-1}}.$$

But

$$\frac{k_N/k_{N-1}}{1+r_{N-1}} = \frac{1+f\left(l_{N-1}\right)-\delta}{1+q\left(l_{N-1}\right)-\delta},$$

so that, for $l \to 1$,

$$\frac{k_N/k_{N-1}}{1+r_{N-1}} \to \frac{1+f(1)-\delta}{1+q(1)-\delta} > 1.$$

Consequently, $R_{N-1}k_N \longrightarrow \infty$ and this path is not an equilibrium due to transversality condition 8.

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