JOURNAL OF PUBLIC ECONOMIC THEORY
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Submission Number:JPET-08-00048

Taxes, tuition fees and education for pleasure

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Abstract

The fact that education provides both a productive and a consumptive (non-productive) return has important and, in some cases, dramatic implications for optimal taxes and tuition fees. Using a simple model, we show that when the consumption share in education is endogenous and tuition fees are unconstrained, the optimal tax/fee system involves regressive income taxes and high tuition fees. A progressive labour income tax system may, on the other hand, be a second-best response to politically constrained, low tuition fees. Finally, the existence of individuals with different abilities will also move the optimal income tax system towards progressivity.

We wish to thank two referees, an associate editor and John Conley for very constructive comments and guidance.
Citation: Nikolaj Malchow-Møller and Søren Bo Nielsen and Jan Rose Skaksen, (2011) "Taxes, tuition fees and education for pleasure", *Journal of Public Economic Theory*, Vol. 10 no.2 pp. 72-100.
Submitted: Mar 24 2008. **Published:** August 08, 2011.

1. Introduction

It is widely accepted by economists as well as politicians that education is one of the most important components of national wealth. However, it also seems to be the case that different types of education are not equally valuable. Thus, the estimated private and social returns to a given *level* of higher education vary considerably across different *degree subjects*, see, *e.g.*, Chevalier *et al.* (2002), who review the UK evidence, or Arcidiacono (2004), who cites evidence for the US. These papers find a general pattern of rates of return which are much lower within humanities than within social science and natural science.

One possible explanation for these findings is that education comes with two kinds of return. First, it raises labour productivity, which is reflected in higher wages. Second, it yields a consumption value such as the value of being more knowledgeable, having a higher social status, or finding a more interesting job; see, *e.g.*, Becker (1964), Heckman (1976), and Lazear (1977). The relative importance of these returns is likely to vary across different types of education and hence becomes subject to individual control. It may even vary within a given type of education, as students decide individually on how to allocate their time and effort between different activities, such as participation in lectures, social activities, and student organisations.

In this paper, we assume that both types of return influence the choice of education. One implication of this is that financing higher education by taxing the income of educated people at a high rate may induce students to choose more untaxed consumption value and less taxed production value in their education. The Scandinavian countries are examples of countries characterised by having free education but high marginal tax rates, and in a recent study by Trostel *et al.* (2002) it is also found that social rates of return to education in the Scandinavian countries are only between one half and one fourth of the social rates of return in the US, UK and Australia – even when controlling for the differences in the human capital levels of these countries.

Since the estimated social rates of return only measure the production value of education, these results may to some extent reflect that students in Scandinavian countries choose more consumption value and less production value in their education. This raises the question of what an optimal tax system should look like when it is acknowledged that education comes with these two types of return. Accordingly, the main purpose of our paper is to demonstrate that an endogenous choice of type of education can have important implications for the optimal choice of taxes and tuition fees. Thereby, we add a significant dimension to the existing literature.

We consider an overlapping generations model and, in a first simple version, we assume a representative individual of each generation. Under these circumstances we find that the first-best allocation requires regressive labour income taxes and high tuition fees.[1] The intuition is that progressive taxes distort the choice of type of education towards untaxed consumption value, whereas tuition fees do not distort this choice as they work as an implicit tax on both types of return from education.

When assuming a representative individual of each generation, we preclude investigation of intra-generational equity or any equity-efficiency trade-off. We therefore extend the model to allow for two groups of individuals in each generation, one more able than the other. The individual control over the type of education still tends to make the optimal tax system regressive, but the existence of multiple ability groups is shown to draw the otherwise unrestricted optimal tax/fee system towards progressive income taxation.

A number of papers are related to our work, in the sense that they consider the interaction between taxation and educational choice. In Trostel (1993), it is found that a proportional income tax significantly reduces investments in education. One reason for this is that individuals' cost of education is not tax-deductible; see also Nerlove *et al.* (1993). A second reason is that income taxes reduce labour supply, which decreases the degree of utilisation of human capital and hence the return to human capital; see also Lucas (1990).

Nielsen and Sørensen (1997) argue that a proportional tax on labour income is not in itself distortionary with respect to investments in education if the cost of investment is the time spent in school rather than a pecuniary cost. With a tax on capital income, a proportional labour income tax will in fact lead to overinvestment in education, since investments in human capital will then be taxed more lightly than financial investments. This in turn justifies a progressive labour income tax.

Alstadsæter (2003a) extends the model of Nielsen and Sørensen (1997) by arguing that education also has a consumption value which is untaxed. In her model, the consumption value of education is exogenous, and this serves to strengthen the case for a progressive income tax in order to prevent over-education.[2]

In Alstadsæter *et al.* (2008) the choice of consumption value in education is assumed to be endogenous. In this case, it is illustrated how a propo-

[1] We use the term "progressive (regressive) income tax" to indicate an increasing (decreasing) marginal tax rate.

[2] In a subsequent paper, Alstadsæter (2003b), the consumption share in education is made endogenous as in our model, but the implications for the tax system are not considered.

tional income tax induces individuals to choose education types with more consumption value and less production value. However, as they assume a single proportional tax rate, they do not consider how different taxes should be determined in an optimal tax system.

Bovenberg and Jacobs (2005) show that education subsidies may alleviate the tax-induced distortions on learning resulting from redistributive policies. They also illustrate that optimal subsidies depend on the presence of non-pecuniary costs or benefits. However, as in Alstadsæter (2003a), these costs or benefits are exogenous. This is also the case in Dur and Glazer (2008), who argue that rich people tend to attend college at a higher rate than poor people, because of the consumption content of education. To make sure that colleges attract the most able students and not only the richest, it is, therefore, optimal that colleges charge higher tuition fees from rich students. Moreover, it is optimal for the government to give out grants which are means-tested.

While these studies consider taxation and educational choice, none of them considers how different tax rates should be determined in an optimal tax system if education gives rise to consumption value as well as production value. This, however, is the main focus of our paper.

The paper is organised as follows. The model is presented in Section 2. Section 3 looks at individuals' choice of the extent and type of education, while Section 4 derives the optimal tax/fee policy in the case of a representative individual in each generation. For comparison, Section 5 looks at taxes and tuition fees in the case of multiple ability classes. Section 6 concludes.

2. The Model

Following Nielsen and Sørensen (1997) and Alstadsæter (2003a), we set up a two-period overlapping-generations model of a small open economy with perfect international mobility of capital and an internationally immobile labour force. For simplicity, we disregard productivity growth, and we assume that the population size is fixed, such that each generation is of size unity and lives for two periods. Hence, an old and a young generation are alive at each point in time.

In both periods of life, leisure is demanded inelastically by the representative agent. In her first period of life, the agent divides her non-leisure time between labour supply and education, whereas in the second period, she spends all her non-leisure time on the job. Education in period 1 raises the effective labour supply in period 2 and provides a direct utility gain – a so-called *consumption value*. Furthermore, the agent can transfer resources between periods by saving or borrowing at the international interest rate.

We consider a system of dual income taxation where tax rates on capital income and labour income are set separately. Moreover, in order to focus on labour income taxation, we follow Nielsen and Sørensen (1997) in assuming that the tax on capital income is exogenously given. Furthermore, capital income is taxed according to the residence principle, implying that all savings by residents are taxed at the same rate. With respect to labour income, we assume one tax rate applying to income up to the income level of an uneducated individual, and another rate for income above this level. Hence, the latter becomes a tax on the productive return to education.

Government (non-interest) expenditures are taken as exogenous. Further, in the event of reform, the public debt level will be adjusted to keep the utility of the current old generation unaffected (see below).

2.1 Individuals

The representative agent of each generation lives for two periods with lifetime utility given by:

$$U = U\left(C, hE\right), \quad U_1, U_2 > 0 \quad and \quad U_{11}, U_{22} < 0 \tag{1}$$

where C is consumption in period 2, E is the time spent on education in period 1, and h is the share of E having consumption value, *i.e.*, a direct utility effect. Correspondingly, $1 - h$ is the share of E having production value, *i.e.*, it raises the effective labour supply of the agent in period 2. For simplicity, and without loss of generality, we assume that all consumption takes place in period 2.[3] Furthermore, we assume that both C and hE are normal goods.

We can think of E as the level of education, and h as the type. We assume h to be a continuous variable, $h \in [0, 1]$, implying that the representative agent is able to choose any mix of production and consumption value.

The agent is endowed with one unit of time in both periods. With demand for leisure being inelastic and normalised to zero, the time budgets are given by:

$$L_1 + E = 1 \qquad and \qquad L_2 = 1 \tag{2}$$

where L_1 and L_2 are the labour supplies in the two periods.

The private pecuniary cost of education in period 1 is ωE, where ω is the cost per time unit of education. We will refer to ω as a "tuition fee".[4]

[3] Although households need to finance education in the first period, their savings may nevertheless be negative in the first period.

[4] We assume throughout that ω does not depend on h. The tuition fee is not deductible from taxes. Altering this assumption has no qualitative effects on our results.

Education raises the effective labour supply in period 2 to $g\left(\left(1-h\right)E\right)$, where $g\left(0\right)=1$, $g'>0$ and $g''<0$. Thus, effective labour supply is increasing in productive education, but at a decreasing rate.

Since all consumption takes place in period 2, savings in period 1 are given by:

$$S=\left(1-t_l\right)W\left(1-E\right)-\omega E \tag{3}$$

where W is the wage rate, and t_l is the low-income tax rate that applies to all income up to W. Labour income above W is taxed at the rate t_h. Hence, consumption in period 2 is given by the following budget constraint:

$$C=\left[1+\left(1-\tau\right)r\right]S+\left(1-t_l\right)W+\left(1-t_h\right)W\left[g\left(\left(1-h\right)E\right)-1\right], \tag{4}$$

where r is the rate of interest and τ is the tax on capital income. Using the expression for S in (3) and the time constraints in (2), the budget constraint can be rewritten as:

$$C=\frac{\left(1-t_l\right)W\left(1+p-E\right)-\omega E}{p}+\left(1-t_h\right)W\left[g\left(\left(1-h\right)E\right)-1\right] \tag{5}$$

where

$$p=\frac{1}{1+r\left(1-\tau\right)}. \tag{6}$$

2.2 The Business Sector

The domestic business sector produces a good which is a perfect substitute for foreign goods. The price of this good is normalised to one. We assume that production is given by a standard neoclassical production function with constant returns to scale:

$$Y=F\left(K,N\right) \tag{7}$$

where Y is production, K is the input of capital, and N is the input of effective labour. The assumption of constant returns to scale allows us to work with the production function in intensive form:

$$y=f\left(k\right) \tag{8}$$

where $y=\frac{Y}{N}$ and $k=\frac{K}{N}$.

Maximising profits implies that:

$$f'\left(k\right)=r \qquad \text{and} \qquad f\left(k\right)-rk=W \tag{9}$$

Since k is solely determined by the rate of interest at international capital markets, r, it follows that the before-tax wage rate, W, is also determined by r and is independent of domestic tax rates.

2.3 The Government

Education is publicly provided, but must – together with other public expenditures, G, which are assumed to be exogenous – be financed through tax revenues, including tuition fees. When considering the optimal tax and tuition fee reforms in Section 4, we assume that the objective of the government is to maximise the utility of the current young generation and all future generations without reducing the utility of the current old generation. This is achieved by keeping the taxes on the old generation unchanged in the event of a reform, and instead adjusting the level of public debt, D. In other words, the reform is assumed only to apply to the current young and the future generations. In this way, we ensure that the government achieves a strict Pareto improvement.[5]

The budget constraint of the government in the reform period is formally given by:

$$\begin{aligned} D &= G + (\theta - \omega) E - t_l W (1 - E) \\ &\qquad - t_l^0 W - t_h^0 W \left[g \left(E^0 \left(1 - h^0 \right) \right) - 1 \right] - \tau r S^0 \end{aligned} \quad (10)$$

where D is government debt at the end of the reform period, and θ is the government's cost per time unit of education. Government debt at the beginning of the reform period is assumed to be zero. The government's net cost for education is $\theta - \omega$. The superscript "0" in (10) indicates that these variables are predetermined for the current old generation and therefore not influenced by the tax reform. New tax rates apply exclusively to the current young and all future generations. Thus, the term $t_l W (1 - E)$ is the tax revenue from the young generation, whereas the last three terms in (10) all represent tax revenue from the current old generation.

If debt and tax rates must be kept constant in all periods following the tax reform, the public budget constraint for each of these periods will be given by:

$$\begin{aligned} & t_l W (2 - E) + t_h W [g (E (1 - h)) - 1] + \tau r [(1 - t_l) W (1 - E) - \omega E] \\ &\qquad - G - r D - (\theta - \omega) E = 0 \end{aligned} \quad (11)$$

since the steady state will be reached already in the period following the reform. The reason is that in essence all possible sources of non-degenerate dynamics are shut off. Policy instruments remain constant after the reform, and there are no bequests linking generations. Further, in the small open

[5] A similar approach is used by Nielsen and Sørensen (1997) and Alstadsæter (2003a).

economy, the link between savings and investment is cut, and the capital stock will be determined solely by the fixed international interest rate. This precludes any reaction in the capital stock and in the wage per efficiency unit of labor. As a consequence, the present young and all future generations will face identical prices and taxes, and as soon as the current old generation has disappeared, all periods will be identical.

Consolidating the constraints in (10) and (11) by eliminating D yields:

$$\begin{aligned} & rR + (1+r)\, t_l W (1-E) + t_l W + t_h W \left[g\left(E(1-h)\right) - 1 \right] \\ & \quad + \tau r \left[(1-t_l) W (1-E) - \omega E \right] - (1+r) G - (1+r)(\theta - \omega) E = 0 \end{aligned} \tag{12}$$

where:

$$R = t_l^0 W + t_h^0 W \left[g^0 \left(E^0 \left(1 - h^0 \right) \right) - 1 \right] + \tau r S^0 \tag{13}$$

is an exogenous constant.

This completes the model. We next look at individual decisions and then at the optimal financing of education and other government outlays.

3. The Individual Education Choice

The representative agent maximises the utility function in (1) with respect to C, E, and h, subject to the budget constraint in (5).

Now, define non-productive education as $E_1 = hE$ and productive education as $E_2 = (1-h)E$, such that $E = E_1 + E_2$.[6] It turns out to be convenient to rewrite the agent's optimisation problem in the following equivalent way:

$$\begin{aligned} \max_{C, E_1, E_2} \quad & U(C, E_1) \\ s.t. \quad & C = \frac{(1-t_l) W (1 + p - E_1 - E_2) - \omega (E_1 + E_2)}{p} + \\ & (1-t_h) W \left[g(E_2) - 1 \right] \end{aligned} \tag{14}$$

with the following first-order conditions for E_1 and E_2:[7]

$$U_1 \cdot \frac{1}{p} \left\{ -(1-t_l) W - \omega \right\} + U_2 \;=\; 0 \tag{15}$$

$$U_1 \cdot \left\{ \frac{1}{p} \left[-(1-t_l) W - \omega \right] + (1-t_h) W g' \right\} \;=\; 0 \tag{16}$$

Equation (15) in essence characterises the optimal allocation of comprehensive consumption between the two consumption components, C and E_1.

[6] Then h can be retrieved as $h = E_1/(E_1+E_2)$.

[7] Throughout the paper, we assume that the parameter values ensure an interior solution, *i.e.*, $E_1, E_2 > 0$ and $E_1 + E_2 < 1$.

Equation (16), on the other hand, portrays optimal investment in productive education, E_2.

The condition in (15) can be rewritten as:

$$\frac{U_1}{U_2} = \frac{1}{[(1-t_l)\,W + \omega]/p} \tag{17}$$

This is a standard optimality condition saying that the marginal rate of substitution between the two consumption goods, C and E_1 (the left-hand side), must be equal to the relative price of these goods (the right-hand side).

The condition in (16) directly determines the optimal value of E_2:

$$p\,(1-t_h)\,Wg'\,(E_2) = (1-t_l)\,W + \omega \tag{18}$$

The optimal amount of productive education, E_2, is found where the marginal cost of E_2, *i.e.*, the tuition fee plus the opportunity cost of time invested (the right-hand side), equals the marginal return, which is the present value of higher period-2 income (the left-hand side).

4. Optimal Taxes and Tuition Fees

We are now ready to solve for the optimal financing of government expenditures via taxes and tuition fees. Government expenditures here comprise both residual government expenditures, G, and the costs of education, θE. In this exercise, we shall assume that a non-negative capital tax, τ, is exogenously given. For this given level of τ, we derive the optimal combination of labour income taxes and tuition fee, *i.e.*, t_l, t_h, and ω, so as to maximise the individual indirect utility function of the current young and all future generations, $V\,(t_l, t_h, \omega; p)$, subject to the consolidated public budget constraint.

To begin with, t_l, t_h and ω can all be freely chosen by the government. In reality, there might be (political) constraints on the choice of tuition fees. Hence, in the second part of this section, we consider the case where ω is fixed, and only t_l and t_h can be adjusted, implying that only a second-best allocation can be reached. Finally, in the next section, we study optimal taxes and tuition fees in the case with individual heterogeneity (mutiple ability types).

4.1 Unbounded Tuition Fees

When the government can optimally set all three tax instruments, the first-best outcome is achieved. Formally, the government's policy maximisation problem is:

$$\begin{aligned}
\max_{t_l,t_h,\omega} \quad & V\left(t_l,t_h,\omega;p\right) && (19)\\
s.t. \quad & (1+r)\,t_lW\,(1-E)+t_lW+t_hW\left[g\left(E\,(1-h)\right)-1\right]+ \\
& \tau r\left[(1-t_l)\,W\,(1-E)-\omega E\right]-(1+r)\,G-(1+r)\,(\theta-\omega)\,E+ \\
& rR=0
\end{aligned}$$

The maximisation, of course, should further recognise individual optimality conditions.

The government needs to finance its expenditures in addition to securing an appropriate private choice of education volume and type. It has three instruments at its disposal, which can be freely set. Thus, reaching the first best should be possible; in fact, this is achieved using only two of the three instruments. In the appendix, it is shown that the optimal taxes and tuition fees (for a given level of the tax on capital income) are given by:

$$t_h = 0 \qquad (20)$$

$$t_l = \frac{(1+r)\,G-rR-\tau rW}{(2+r-\tau r)\,W} \qquad (21)$$

$$\omega = \frac{(1+r)}{(1+r-r\tau)}\,(\theta+W)-(1-t_l)\,W \qquad (22)$$

The optimal marginal tax rate, t_h, equals zero. The reason is that a tax on the wage return to education, $t_h > 0$, would distort the educational choice as the tax falls on productive education, E_2, only, leaving non-productive education, E_1, untaxed.

As long as public expenditures are not too small, $G > r\,(R+\tau W)\,/\,(1+r)$, the basic tax rate t_l will be positive. Thus, sufficiently large revenue needs will cause optimal income taxes to become regressive, $t_l > t_h = 0$. In this situation, it follows from (22) that the optimal tuition fee will be higher than the government's cost of education, $\omega > \theta$ (a positive tax, τ, on capital income will reinforce the inequality). With regressive taxes on labour income, education will have to be taxed by other means in order to prevent over-education. As opposed to t_h, a tuition fee can function as a symmetric "tax" on the two types of education. Hence, the optimal tuition fee, ω, will exceed the government's cost of education, θ, in this situation.

To gain further intuition for this configuration of taxes and fees, consider the implications for individual choices. This is easiest in the case where the tax on capital income is zero, $\tau = 0$. Here, ω degenerates to $\omega = \theta + t_lW$. The interpretation is that the tuition fee should cover the direct cost of education paid by the government, θ, and also offset the implicit tax deduction caused by the time being set aside for education rather than work (remember that the gains from education are not taxed). The individual first-order conditions thereafter become especially simple, resulting in:

$$\frac{U_1}{U_2} = \frac{1}{(1+r)(\theta + W)} = \frac{1}{Wg'(E_2)} \tag{23}$$

The marginal rate of substitution between consumptive education and other consumption should equal the opportunity cost of education, $(1+r)(\theta+W)$, and the same should hold for the marginal return to productive education in the second period.

It is interesting to note that exactly the same conditions would obtain in an economy without a public sector in which education was provided privately at the cost of θ per unit. The individual would recognize the two components of the opportunity cost of education – foregone wages and the payment to the provider – and would make sure that the utility value of the consumption part of education and the income value of the productive part would measure up to the opportunity cost. The reason for this equivalence between the economy with publicly provided education and the public sector-less economy is that the basic tax, t_l, appropriately backed up by the tuition fee, ω, in reality works as a lump-sum tax, given that there is no labour-leisure choice in the model. Government revenue needs can hence costlessly be covered by the basic tax, implying that the other instruments can be used to ensure an appropriate education choice.

Things change a bit when capital income is taxed, $\tau > 0$. A capital income tax implies that the discount rates on the part of individuals and the government (society) become different. Thus, the tuition fee – and the basic income tax – will have to adjust for this. The individual's discount rate falls with capital income taxation, so that the gains from education in the form of higher wage income when old appear greater when the individual makes her education decision as a young person. Therefore, she has an incentive to increase education. To counteract this, the tuition fee is raised, essentially implying greater implicit taxation of the gains from education, *cf.* equation (22).[8] Plugging in the values of optimal taxes and tuition fees in the individual maximisation problem, the first-order conditions in (23) reappear. From society's viewpoint it is *a fortiori* important that individuals register a second-period value of the opportunity cost of education equal to $(1+r)(\theta+W)$, regardless of whether extra education is chosen for pleasure or for higher period-2 income.

[8] In Nielsen and Sørensen (1997), a similar argument leads to progressive labour income taxation when the capital income tax is positive.

Altogether, the optimal tuition fee will reflect possible distortions in financial capital accumulation introduced by the capital income tax, in addition to the direct cost of education and the existence of the basic income tax. But the optimal tax on high labour income, t_h, will remain zero, with or without capital income taxation.

We summarise the above results in Proposition 1:

Proposition 1 *When the consumption share of education, h, is endogenous, and the tuition fee, ω, is adjustable, the first-best allocation can be achieved with values of t_l, t_h and ω given by (21)-(22) for a given value of τ. As a consequence, if government expenditures are not too small, $G > r(R + \tau W)/(1+r)$, optimal labour income taxes will be regressive, and the tuition fee will exceed the government's cost of education:*

$$t_l > t_h = 0 \quad \textit{and} \quad \omega > \theta$$

4.2 Fixed Tuition Fees

The assumption that the government can set the tuition fee at any rate may strike one as rather unrealistic. After all, a tuition fee in the order of the sum of the direct cost of education and the implicit tax deduction for time set aside for education is much higher than seen in any country. We shall therefore also consider the case where ω is exogenous at $\bar{\omega}$, perhaps at a significantly lower level than in the preceding analysis. If so, the government no longer has sufficient instruments to ensure the achievement of the first-best allocation, and the tax on high incomes, t_h, receives a distinct role in the tax/fee system. The question is whether the income tax will become progressive rather than regressive in this case.

The government now solves the same maximisation problem as in the previous section, with the exception that ω is taken as given. After some manipulations of first-order conditions (see appendix for details), the following condition for optimal t_l and t_h ensues:

$$\begin{aligned}
&\left[-(1+r)t_lW + t_hWg' - \tau r\left[(1-t_l)W + \bar{\omega}\right] - (1+r)(\theta - \bar{\omega})\right] \cdot \\
&\left\{W(1+p-E)\frac{\partial E}{\partial t_h} - pW\left[g(E_2) - 1\right]\frac{\partial E}{\partial t_l}\right\} + \\
&\left[-t_hWg'\right] \cdot \\
&\left\{W(1+p-E)\frac{\partial E_1}{\partial t_h} - pW\left[g(E_2) - 1\right]\frac{\partial E_1}{\partial t_l}\right\} = 0
\end{aligned} \tag{24}$$

From (24), one cannot determine unambiguously, whether the optimal tax system is progressive or regressive. However, it can be shown that if:

$$\bar{\omega} < \theta\frac{(1+r)(1-t_h)}{1+r-r\tau} \tag{25}$$

i.e., if $\bar{\omega}$ is sufficiently small compared to θ, then:

$$\left(\frac{t_h - t_l}{1 - t_h} - \frac{\tau r}{1 + r - r\tau}\right) > 0 \tag{26}$$

implying $t_h > t_l$. Hence, if the young pay low enough tuition fees, the optimal tax system becomes progressive. The intuition for this result is that with low tuition fees, education must be taxed on the output side in order to prevent over-education induced both by low tuition fees and the implicit tax deduction caused by the low-income tax – despite the fact that this creates a distortion in the type of education chosen. Proposition 2 summarises the findings in this case:

Proposition 2 *When the consumption share of education, h, is endogenous, and the tuition fee, ω, is fixed, only a second-best solution can be achieved. In this case, a sufficient condition for optimal labour income taxes to be progressive is that tuition fees, ω, satisfy (25).*

5. Individual Heterogeneity

This section widens the perspective on optimal taxation of labour income and tuition fees on education by including equity considerations.

The previous section did encompass different individuals, but individuals only differed in so far as they belonged to different generations. Now we introduce several classes of individuals within the same generation, of which some are more able than others. A government which is sensitive to differences in standards of living across types within the same generation will then wish to redistribute consumption possibilities from those better off to those not so well off.[9] How does this redistributive motive interfere with the considerations behind the optimal setting of labour income taxes and tuition fees which we uncovered in the previous section?

To investigate this, we postulate two types within each generation, while maintaining the basic structure of the tax and tuition fee system. Type A corresponds to the individuals we already defined above. Type B is a less productive and less able type. Lower labour productivity from birth implies that an individual of type B can earn a wage of only ηW per unit of time, with $\eta < 1$. The same relative improvement of labour productivity through education as for type A implies that if a B individual dedicates E_2^B units of time to productive education, gross income increases to $g(E_2^B)\eta W$

[9] This concerns the young and future generations. We still aim at keeping all members of the current old generation unaffected by any policy reform.

in the second period (we use superscripts to indicate type). Finally, there is the question of type B's ability to extract utility from time dedicated to education with a consumption content, E_1^B. We choose to assume that type-B individuals are also less able to enjoy education for pleasure, implying that their utility can be described by the utility function $U(C^B, \eta E_1^B)$. In this way, type-B individuals are both less productive to begin with and less able to derive benefits from either type of education. In each generation, a fraction a of individuals will be of type A and the remaining fraction $(1-a)$ are of type B.

We moreover assume that type-B individuals are sufficiently less productive, *i.e.*, η is small enough that second period wage income on the part of these individuals does not exceed the level W, even though they do choose their optimal level and composition of education in the first period. Hence, the top-income tax rate, t_h, will not be relevant to type B; only to type A.[10] It is also essential that the government is supposed not to be able to observe or verify each individual's type *ex ante*. Furthermore, it cannot exploit observations on individuals' income or education choices for separate treatment of the two types in regard to tax or tuition fee rates. The only instruments available to the government are, *a fortiori*, the tuition fee, ω, per unit of education (regardless of who gets it), the low-income tax rate, t_l, and the high-income tax rate, t_h. Later in this section, we introduce an additional instrument: a lump-sum tax.

With this specification of the two types of individuals we now look at individual optimisation of consumption and education, as well as the government's policy problem. The full-scale optimum tax-cum-tuition fee problem is very complex, which is why we opt for an intuitive approach to explain the direction in which taxes and tuition fees will be modified, relative to Section 4, when a second type is accounted for. Subsequently, we back up the intuitive approach by simulation analysis.

5.1 Type-B Individual Optimisation

A type-B individual chooses education, savings and consumption in much the same way as a type-A individual (see Section 3), the only differences having to do with lower ability (η) and with t_l as the relevant marginal tax in the second period. Ultimately, the choice of level of productive education, E_2^B, will be determined by the rule:

$$p\left(1-t_l\right)\eta W g'\left(E_2^B\right) = \left(1-t_l\right)\eta W + \omega \tag{27}$$

[10] In this way, redistribution becomes both more pressing and easier to carry out.

while the composition of consumption will be dictated by:

$$\frac{U_1}{U_2} = \frac{\eta}{[(1-t_l)\,\eta W + \omega]/p} \tag{28}$$

Everything else being equal, the B individual will choose less E_2^B but more E_1^B, if the low-income tax rate, t_l, is increased. A higher tuition fee, ω, will depress education of either form.

5.2 Optimal Policy Programme

From the information above on individual utility optimisation we can derive indirect utility functions, $V^A(t_l, t_h, \omega; p)$ and $V^B(t_l, t_h, \omega; p)$, for the two types. Given this, the optimum tax and tuition fee programme on the part of the government becomes:

$$\begin{aligned}
\max_{t_l, t_h, \omega} \quad & aV^A\,(t_l, t_h, \omega; p) + (1-a)V^B\,(t_l, t_h, \omega; p) \qquad (29)\\
s.t. \quad & (1+r)\,t_l W[a\left(1-E^A\right) + (1-a)(1-E^B)\eta] \\
& + t_l W[a + (1-a)\eta g(E_2^B)] + t_h W\left[a(g\left(E_2^A\right) - 1)\right] \\
& + \tau r\left[(1-t_l)\,W(a\left(1-E^A\right) + (1-a)\eta(1-E^B) - \omega(aE^A + (1-a)E^B)\right] \\
& - (1+r)\,G - (1+r)\,(\theta-\omega)\,[aE^A + (1-a)E^B] + rR' = 0
\end{aligned}$$

in which:

$$R' = t_l^0 W[a + (1-a)\eta g(E_2^{0B})] + t_h^0 W\left[a(g^0\left(E_2^{0A}\right) - 1)\right] + \tau r(aS^{0A} + (1-a)S^{0B})$$

is an exogenous variable, summarising the tax payments of the current old generation.

In general, the optimality conditions for this problem give few clues as to the character of the optimal setting of tax rates and the tuition fee. The reason is that while there are altogether three policy instruments available, the government effectively wishes to control four variables, namely the choice of both types of education (productive and consumptive) on the part of both types of agents. Obviously, the result would be a second-best allocation, even if the government had no interest in redistributing consumption possibilities across the two types. Considering also the government's interest in redistribution, the policy instrument setting will become a true compromise between limiting inefficiencies and limiting differences in consumption possibilities, while maintaining fiscal balance.

5.3 An Intuitive Explanation

We find that the best way to grasp the eventual setting of policy instruments, t_l, t_h and ω, is a small thought experiment: we choose a particular setting of policy instruments and ask how the instruments could be modified to improve conditions along the following dimensions: (i) type A's choices of productive and consumptive education; (ii) type B's similar choices; and (iii) equity between the two types.

The particular initial setting of instruments is the set which was found to be optimal in Section 4.1. With only type-A individuals, the optimal values of t_l, t_h, and ω were:

$$t_h = 0 \quad (30)$$

$$t_l = \frac{(1+r)\,G - rR - \tau r W}{(2+r-\tau r)\,W} \quad (31)$$

$$\omega = \frac{(1+r)}{(1+r-r\tau)}\,(\theta + W) - (1-t_l)\,W \quad (32)$$

These instrument values (to be termed 'A values') permitted the first-best situation to be obtained with only A types in the model. With these values, the choices of E_1^A and E_2^A will be undistorted; *i.e.*, no inefficiency along margins (i). Now we wish to start with the 'A values' and examine the direction in which they should be modified in order to encompass the existence of also group B.

Inserting the 'A values' into individual optimality conditions (27) and (28) above, we can establish that both E_1^B and E_2^B will be inefficiently small. Consider first E_1^B: for the type-A individuals, the positive level of t_l compensates for the high tuition fee, $\omega > \theta$, to ensure the first-best outcome. For type-B individuals, the value of the tax discount caused by t_l is smaller as their wage is lower. For this reason, type-B individuals acquire too little education for pleasure, E_1^B, relative to consumption, C. Their choice of E_2^B is plagued by the same distortion but, in addition, the productive return for type-B individuals is taxed at a positive rate, $t_l > t_h = 0$, causing them to reduce their choice of E_2^B even further. We state these results as a lemma (the formal details can be found in the appendix):

Lemma 3 *With t_l, t_h and θ given by (30)-(32), the values of E_1^B and E_2^B will be inefficiently small.*

Finally, with the 'A values', there will be no redistribution of consumption possibilities from type A to type B. Type A will earn a higher income and will pay a somewhat higher tax on the share of their income which lies below

W. However, the share of their second period income which lies above W, they will pay zero tax, meaning that their average tax rate is actually lower than for type-B individuals.

All in all, the initial situation with the 'A-values' has (i) undistorted A education; (ii) too little education of both forms for type B; and (iii) perverse income redistribution.

The fact that t_h is set at zero means that this potential redistribution instrument is completely dormant. Furthermore, it can be activated at zero marginal dead-weight loss as it only affects the choices of type A, which equal the first-best outcomes initially, whereas the other policy instruments are already burdened by distortions. Hence, the optimal solution must have a positive high-income tax rate. An increase in t_h causes limited distortions: it only affects type A's choice of productive education, whereas it does not distort their relative consumption of C^A and E_1^A, nor does it affect the choices of type-B individuals.

A higher tuition fee, ω, depresses both forms of education for both types. Conversely, lowering the fee can reduce the inefficiency in type-B individuals' education, while at the same time counteracting the downward pressure on E_2^A created by a positive t_h. Even though a lower fee does lead to an inefficiency in E_1^A – too much education for pleasure for type-A individuals – the optimal policy package should feature a more modest tuition fee.

If we ignore any income effects, the low-income tax, t_l, stimulates education of both forms for type A since it reduces the (time) cost of education without affecting marginal benefits. The same holds for type-B individuals' choice of education for pleasure. However, the benefits from type B's productive education are hit by the tax, whereas only part of the cost is alleviated by it (given that $\omega > 0$), so that the tax actually depresses E_2^B.

Against this background it is quite hard to figure out how the low-income tax rate will be altered relative to its 'A value'. The initial inefficiencies in type B's education decisions send conflicting signals: To raise E_1^B, an increase in t_l is desirable, but to raise E_2^B, a fall in t_l is warranted. Also from the inefficiencies now introduced in type A's education decisions (too high E_1^A and too low E_2^A), conflicting recommendations as to t_l may well ensue.

To all this we must add that as type-B individuals are introduced, the average ability to pay taxes in the economy falls. Coupled with a fixed government revenue requirement, there will be a common force acting to raise all three policy instruments to secure sustainability of government finances. We therefore state our conjecture in the following way:

Introducing a second group of less able individuals into the economy gives rise to an equity-efficiency trade-off. The top marginal income tax, t_h, will be positive, partly to redistribute income and partly to bear a share of overall inefficiencies in the economy. The tuition fee, ω, will be relatively modest. The size of the low marginal income tax, t_l, will be determined by the size of the government revenue need and the realisation that it distorts productive education for the B types. Depending on the circumstances, the income tax system could in principle display progressivity, but it is not a given.

5.4 Simulation Results

To illustrate the equity-efficiency trade-off, we have set up a simulation version of our model. Briefly explained, preferences are specified as log(Cobb-Douglas) with a 20 *per cent* weight attached to education for pleasure, $U(C, E_1) = \ln\left(C^{0.8} \cdot (\eta E_1)^{0.2}\right)$, and with the ability parameter, η, set to 0.6 for type-B individuals. The gains-to-education function is iso-elastic, $g(E_2) - 1 = \kappa E_2^{\beta}$, with elasticity, β, at 0.7, and $\kappa = 2$. The production structure is Cobb-Douglas, $F(K, N) = K^{\alpha} L^{1-\alpha}$, with $\alpha = 0.3$. The implicit length of the two periods is 20 years, and the real interest rate per year is 2 *per cent*, implying that $r = 1.02^{20} - 1$ and $W \approx 0.57$. Public expenditure, G, is 0.4; the cost of education is $\theta = 0.2$; and initial tax rates are $\tau = 0.25$, $t_l^0 = t_h^0 = 0.4$, and $\omega^0 = 0.2$.

The baseline simulation with the population equally divided between A and B types ($a = 0.5$) produces the results for optimal taxes and tuition fee, t_l, t_h and ω, displayed in line 1 of Table I.

TABLE I: NUMERICAL SIMULATIONS[11]

	a	G	β	$\bar{h}$	t_l	t_h	ω
(1)	0.5	0.4	0.7	–	0.372	0.358	0.228
(2)	1	0.4	0.7	–	0.245	0	0.407
(3)	0	0.4	0.7	–	0.585	–	0.186
(4)	0.25	0.4	0.7	–	0.462	0.448	0.210
(5)	0.75	0.4	0.7	–	0.299	0.243	0.269
(6)	0.5	0.3	0.7	–	0.234	0.287	0.214
(7)	0.5	0.5	0.7	–	0.505	0.410	0.258
(8)	0.5	0.4	0.6	–	0.343	0.372	0.223
(9)	0.5	0.4	0.7	0.557	0.327	0.801	0.182
(10)	1	0.4	0.7	0.404	0.153	0.715	0
(11)	1	0.4	0.7	0.404	0.227	0	0.407

[11] See text for functional forms and values of the other parameters.

With these baseline values, the tuition fee is slightly above the direct time-cost of education, θ, and the optimal tax system is close to linear, with the low-income tax rate being a bit higher than the top marginal rate.

Lines 2 and 3 in the table compare the baseline simulation to the two extreme situations of $a = 1$, *i.e.*, only type-A individuals, and $a = 0$, *i.e.*, only type-B individuals in the economy. With only A types (line 2), the top marginal tax rate is selected to zero, while the tuition fee becomes relatively high in order to offset the implicit subsidy to education stemming from the low-income tax rate. Comparing lines 2 and 1 we confirm our intuition as laid out in section 5.3: Introducing the B types gives rise to higher tax rates, but dampens the tuition fee. With only B types present (line 3), the given revenue need necessitates a relatively high income tax, while the tuition fee becomes smaller than the cost of education, θ, so as to counteract the inefficiency introduced in the choice of productive education via the income tax. The high-income tax rate is irrelevant in this case.

Lines 4 and 5, corresponding to values of a at 0.25 and 0.75, feature optimal tax rates at intermediate values. None of these two cases displays a progressive income tax system since the low marginal tax is a bit higher than the top rate.

Lines 6 and 7 in the table demonstrate, however, that it is possible to achieve a progressive optimum tax/fee system with our model, as we vary the size of the government revenue need away from the baseline value of 0.4. A smaller value of 0.3 implies less need of revenue from the main revenue generator, the low-income tax, whence it can dip below the high marginal tax. Conversely, with government expenditure at 0.5 instead (line 7), the distance between the low- and the high-income tax rates is widened; the former just has to increase, whereas the latter creates so large distortions in A individuals' choice of productive education that it cannot follow suit.

Finally, line 8 contains a simulation with a lower elasticity in the gains-to-education function, $g(.)$. The baseline value is 0.7, and line 8 features a slightly lower value of 0.6. This leads the two tax rates to flip, so that the high-income tax rate becomes the larger one. Progressivity of the income tax system is thus possible with modest values of the elasticity. A possible interpretation is that the lower elasticity increases productive education and the gains from education – also for the B types. This reduces the need for taxation and makes the distortion caused by the high-income tax relatively less important.

The main point of this article is that the fact that individuals can compose their education as they wish will have significant implications for tax policy. Our final simulations in lines 9-11 support our insight by describing a situation in which education comes in fixed proportions. We look at both the case of $a = 0.5$ (our baseline case) in line 9, and the case of $a = 1$ (only type-A individuals) in lines 10-11; to be compared with lines 1 and 2, respectively. The simulations are performed with an exogenous share, $\bar{h}$, of consumptive education in total education, where $\bar{h}$ is set equal to the average (endogenous) values in the corresponding economies with an endogenous consumption share.

In the baseline case (line 9), we find that making the consumption content exogenous turns the optimal taxes into a highly progressive system. The reason is that in this case the consumptive content can be taxed at both the input and the output side. Hence, the redistributive motives that favour a high t_h no longer create a distortion in the choice of consumptive *vs.* productive education.

The point that the consumption content can be taxed on the output side in the case of an exogenous h is further stressed in lines 10 and 11, which contain two simulations with only A individuals. In this case, the first best can be achieved with only two instruments (as there are only two choices to be made by the individuals: E and C). Hence, in line 10, we fix ω at 0, which results in a high value of t_h, whereas in line 11, we fix ω at its endogenous value from line 3, which results in a low value of t_h.[12] This illustrates how ω and t_h are largely substitutable instruments in this case.[13]

5.5 A Lump-Sum Tax

Although a pure lump-sum tax is rarely seen in practice, some elements of tax systems have lump-sum features, such as a fixed deduction in the taxable income. In our framework, nothing precludes enriching the policy instrument set by a lump-sum tax (or transfer). Accordingly, we next analyze the implications of such a lump-sum tax in the model with individual heterogeneity. As we shall see, our insights are robust to this model extension.

It is straightforward to allow for an extra instrument in the government optimisation problem in (29). With four instruments available, the optimality conditions are, however, still rather complicated as there are four variables to control (the four educational choices) in addition to the redistribution motive and the requirement of a sustainable budget.

Intuitively, a lump-sum tax can be used to generate tax revenue in a non-distortive manner. In that sense, it can be expected to lift some of the

[12] The small difference in outcomes for t_l in lines 3 and 11 is entirely due to the difference in R' in the two cases (the exogenous tax payments of the current old generation).

[13] One can easily more formally demonstrate the substitutability between tuition fees and high marginal taxes in the case of exogenous composition of education. This is done in our working paper version (available upon request), but omitted here for brevity.

pressure from t_l as the main generator of tax revenue. However, a positive lump-sum tax also has negative distributional consequences as it will be relatively harmful for low-ability individuals. *A priori*, we would thus expect the lump-sum tax to balance these considerations. With a strong need for revenue generation, the former motive might dominate, resulting in a positive value of the optimal lump-sum tax, while for a weak revenue need we might expect the optimal lump-sum tax to be negative.

This intuition is confirmed by the simulation results presented in Table II, where we have extended the simulations above to allow for a lump-sum tax, T, of the same size for either type of agent. Specifically, we have assumed that the lump-sum tax is paid in the second period of an agent's life and that the initial lump-sum tax (applying to the current old generation) is zero. Otherwise, we have used the same parameter values as in the baseline simulation above.

TABLE II: NUMERICAL SIMULATIONS WITH A LUMP-SUM TAX[14]

	a	G	β	t_l	t_h	ω	T
(1)	0.5	0.4	0.7	0.378	0.359	0.230	−0.007
(2)	0.5	0.5	0.7	0.451	0.415	0.224	0.060
(3)	0.5	0.3	0.7	0.320	0.314	0.235	−0.091

With baseline parameter values, the optimal lump-sum tax is very close to zero and, as a consequence, the optimal values of the other taxes are hardly affected as compared to the case without a lump-sum tax. Raising other public expenditures to $G = 0.5$ strengthens the revenue generation motive; as a consequence the optimal lump-sum tax becomes positive. This allows for a reduction in t_l compared to the case without a lump-sum tax, *cf.* line 7 in Table I. Still, less than 10% of the total tax revenue is raised through the lump-sum tax, whereas t_l accounts for more than 60% of the total revenue. The values of t_h and ω are much less affected by the introduction of a lump-sum tax, although ω decreases a bit to counteract the effect of a lower t_l on the educational choices.

If we instead reduce the revenue need by lowering G to 0.3, the redistributional motive will dominate in the optimal choice of the lump-sum tax. This can be inferred from the last line of Table II. As a consequence, in particular the low-income tax must be raised compared to the situation without a lump-sum tax (*cf.* line 6 in Table I) to ensure sufficient tax revenue. (Thereby, the

[14] See the text above for functional forms and values of the other parameters.

income tax turns slightly regressive; progressivity will reappear for smaller values of G, though.)

In sum, the results and insights of the previous subsections are only moderately affected by the introduction of a lump-sum component in the tax system. It should be noted, however, that in a setting with endogenous labour supply, the attractiveness of using a (negative) lump-sum tax for redistributive purposes would probably decline, as financing the transfer would negatively affect labour supply. Hence, in such a setting, the optimal lump-sum tax is likely to be larger.

6. Concluding Remarks

While existing studies of education and optimal taxation concentrate on the *level* of education as the variable of interest, we argue that the *type* of education should also be considered, as different types of education come with different productive returns and different consumption content. We model the type of education as the "consumption share" in education, *i.e.* as the non-productive share of total education. In other words, different degree subjects are characterised by different relative amounts of consumptive and productive returns. Alternatively, individuals control the consumptive content even within education types through their allocation of time and effort across different activities.

When the type of education is exogenous, so that productive and consumptive components of education come in fixed proportions, tuition fees and high marginal income taxes are close substitutes in the government's toolbox. In essence, education can equally be taxed at the input side or on the output side. However, if the type of education is endogenous, this result changes dramatically. In our base model, a regressive income tax system with high tuition fees is the optimal choice in this situation. A low (zero) top marginal labour income tax is needed to avoid a distortion between productive and non-productive education. Furthermore, since the basic labour income tax tends to induce over-investment in education, as spending time on education constitutes a way to avoid the income tax, tuition fees in excess of the direct costs of education are required. Contrary to marginal labour income taxes, tuition fees do not distort the choice of type of education as they tax the two types of education symmetrically. Hence, an endogenous choice of educational type results in a preference for taxing education on the input side rather than the output side.

Our base model assumed free setting of taxes and tuition fees and homogeneous individuals. We demonstrated that a fixed (perhaps politically constrained) tuition fee may in the end result in progressive income taxation.

Similarly, extending the model to incorporate multiple ability classes will also tilt the optimal tax/fee system towards progressivity. However, limiting the distortion to choice of type of education will remain a consideration in policy setting.

Throughout the paper we have assumed that the governments cannot make tuition fees contingent on the type of education (consumptive or productive). If the government could observe the consumption content within different types of education, it could in principle tie the size of the tuition fee to this information, thereby gaining an extra instrument. However, this would require the government to know the consumption content of different types of education, and even if this information could be obtained and verified, the feasibility of this policy must be questioned. Furthermore, as the consumption content may also vary within degree subjects – depending on how a given individual decides on how to allocate his/her time – the assumption that tuition fees cannot differ across productive and consumptive education seems reasonable.

Our model was deliberately set up in order to push the insight as to the implications of education for pleasure in the starkest possible way. In the process, we have obviously ignored a host of factors which in the real world complicate the setting of labour income taxes and tuition fees. First on the list is the labour-leisure choice for individuals which has the consequence that the basic labour income tax in our model (backed by the tuition fee) no longer will be a costless tax, not even with only one group present. With a labour-leisure choice, taxing labour income instead becomes distortionary, so that authorities will wish to limit the use of the tax and look for other sources of revenue. Accordingly, other financing instruments might be used more heavily, meaning that also top labour income (the productive gains from education) would become subject to tax. Such taxation would introduce a distortion in the choice of education type and in particular a preference for education which primarily delivers consumption pleasure rather than higher future income. At the same time, the tax on high incomes might induce (old) individuals to choose more leisure. Also the use of tuition fees would become less desirable, as an additional alternative for the young to education – apart from work – would be leisure. However, as long as the type of education to some extent would be determined by individual choice, a preference for taxing education on the input side may remain.[15]

[15] Note that the tax on high incomes might be perceived to primarily affect the choice of leisure for the old generation, whereas the tuition fee might be thought to primarily influence leisure for the young generation. Thus, the introduction of leisure would result in an additional difference between taxing the input side of education and taxing its output side.

An often-voiced concern is that in deciding on education, the young face borrowing or liquidity constraints. Carneiro and Heckman (2002) argue, though, that liquidity constraints are only of minor importance empirically. Nevertheless, if the recognition of the endogeneity of the consumption content of education were to lead to a preference for more ex-ante taxation of education (by means of tuition fees) rather than ex-post taxation (by means of progressive taxation), then such liquidity constraints could become more important.

A more precise treatment of these and other themes must be relegated to future work, however.

Appendix

Appendices A.1 and A.2 present detailed derivations of the optimal taxes from Propositions 1 and 2 in Sections 4.1 and 4.2, while Appendix A.3 provides a derivation of the results in Lemma 3 from Section 5.3.

Endogenous h and Unbounded ω

In this case, optimal taxes, t_l, t_h, and ω, can be found by solving the optimisation problem in (19). However, with three instruments, the government is able to achieve the first-best outcome. Thus, an alternative way of finding optimal taxes is therefore to first determine the first-best outcome of the economy, and then find the values of t_l, t_h, and ω that ensure this outcome.

The first-best allocation is achieved when $\omega = \theta$ and remaining government expenditures are covered through a lump-sum tax, denoted by M, on the young generation. To keep a constant value of government debt, D, as in (12) requires:

$$M = G - \frac{r}{1+r} R$$

where R is given by (13). In this case, the individual optimisation problem of the current young and all future generations becomes:

$$\begin{aligned} \max_{C, E_1, E_2} \quad & U(C, E_1) \\ s.t. \quad & C = (1+r)\left[W(1-E) - \theta E - M\right] + W + W\left[g(E_2) - 1\right] \end{aligned}$$

with associated first-order conditions for E_1 and E_2 given by:

$$(1+r)[W+\theta] = \frac{U_2}{U_1} \tag{33}$$

$$(1+r)[W+\theta] = Wg' \tag{34}$$

which together with the budget constraint define the first-best allocation.

In order to achieve the first-best allocation using only tuition fees and labour income taxes (and in the presence of a capital income tax), these should be set such that the optimal choices of E_1 and E_2 implied by (17) and (18) are the same as the first-best choices of E_1 and E_2 implied by (33) and (34), and such that the public budget constraint in (12) is satisfied.[16]

[16] C will then also be the same in the two situations since the government budget constraint is satisfied in both cases.

Combining (17) with (33), and (18) with (34), we obtain the following conditions for the optimal taxes:

$$(1+r)\left[W+\theta\right]=\frac{1}{p}\left\{\left(1-t_l\right)W+\omega\right\}$$

and:

$$(1+r)\left[W+\theta\right]=\frac{1}{p}\left[\frac{\left(1-t_l\right)W+\omega}{1-t_h}\right]$$

Since the left-hand sides are identical, it immediately follows that $t_h=0$. Furthermore, rewriting the first condition results in:

$$\omega=\frac{(1+r)}{(1+r-r\tau)}\left(\theta+W\right)-\left(1-t_l\right)W$$

which gives the optimal relationship between t_l and ω. To obtain the optimal absolute levels of t_l and ω, this condition must be combined with the consolidated public budget from (12) to yield:

$$t_l=\frac{(1+r)\,G-rR-\tau rW}{(2+r-\tau r)\,W}$$

Endogenous h and Fixed ω

Assuming that ω is fixed at $\bar{\omega}$, the government solves the following maximisation problem:

$$\begin{aligned}
\max_{t_l,t_h}\quad & V\left(t_l,t_h;\bar{\omega},p\right) && (35)\\
s.t.\quad & (1+r)\,t_lW\left(1-E\right)+t_lW+t_hW\left[g\left(E\left(1-h\right)\right)-1\right]+\\
& \tau r\left[\left(1-t_l\right)W\left(1-E\right)-\bar{\omega}E\right]-(1+r)\,G-(1+r)\left(\theta-\bar{\omega}\right)E-\\
& rR=0
\end{aligned}$$

which yields the following first-order conditions:

$$\frac{\partial V}{\partial t_l}+\mu\left\{(1+r)\,W\left(1-E\right)+W-\tau rW\left(1-E\right)-t_hWg'\frac{\partial E_1}{\partial t_l}+\right.$$
$$\left.\left[-\left(1+r\right)t_lW+t_hWg'-\tau r\left[\left(1-t_l\right)W+\bar{\omega}\right]-(1+r)\left(\theta-\bar{\omega}\right)\right]\frac{\partial E}{\partial t_l}\right\}=0$$

and:

$$\frac{\partial V}{\partial t_h}+\mu\left\{W\left(g-1\right)-t_hWg'\frac{\partial E_1}{\partial t_h}+\right.$$
$$\left.\left[-\left(1+r\right)t_lW+t_hWg'-\tau r\left[\left(1-t_l\right)W+\bar{\omega}\right]-(1+r)\left(\theta-\bar{\omega}\right)\right]\frac{\partial E}{\partial t_h}\right\}=0$$

where μ is the Lagrange multiplier associated with the constraint in (35), and it has been used that:

$$\frac{\partial E_2}{\partial t_i} = \frac{\partial E}{\partial t_i} - \frac{\partial E_1}{\partial t_i}, \quad i = l, h$$

By application of the envelope theorem, the derivatives of individual indirect utility function, V, with respect to t_l and t_h are easily obtained from the individual budget constraint in (14):

$$\begin{aligned} \frac{\partial V}{\partial t_l} &= \lambda W (1 + p - E) \\ \frac{\partial V}{\partial t_h} &= \lambda p W [g - 1] \end{aligned}$$

where λ is the marginal utility of income in the first period of life. Combining the two first-order conditions above to eliminate μ, and using the expressions for $\frac{\partial V}{\partial t_l}$ and $\frac{\partial V}{\partial t_h}$ results in:

$$\begin{aligned} & W (1 + p - E) \Big\{ W (g - 1) - t_h W g' \frac{\partial E_1}{\partial t_h} + \\ & [- (1 + r) t_l W + t_h W g' - \tau r [(1 - t_l) W + \bar{\omega}] - (1 + r) (\theta - \bar{\omega})] \frac{\partial E}{\partial t_h} \Big\} - \\ & p W [g - 1] \Big\{ (1 + r) W (1 - E) + W - \tau r W (1 - E) - t_h W g' \frac{\partial E_1}{\partial t_l} + \\ & [- (1 + r) t_l W + t_h W g' - \tau r [(1 - t_l) W + \bar{\omega}] - (1 + r) (\theta - \bar{\omega})] \frac{\partial E}{\partial t_l} \Big\} = 0 \end{aligned}$$

Now using that:

$$\begin{aligned} & W (1 + p - E) W (g - 1) - \\ & \qquad p W (g - 1) [(1 + r) W (1 - E) + W - \tau r W (1 - E)] = 0 \end{aligned}$$

the above expression can be rewritten as:

$$\begin{aligned} & \{- (1 + r) t_l W + t_h W g' - \tau r [(1 - t_l) W + \bar{\omega}] - (1 + r) (\theta - \bar{\omega})\} \cdot \\ & \left\{ W (1 + p - E) \frac{\partial E}{\partial t_h} - p W [g - 1] \frac{\partial E}{\partial t_l} \right\} + \\ & \{- t_h W g'\} \cdot \\ & \left\{ W (1 + p - E) \frac{\partial E_1}{\partial t_h} - p W [g - 1] \frac{\partial E_1}{\partial t_l} \right\} = 0 \end{aligned} \tag{36}$$

which is equation (24) in Section 4.2.

Now, using comparative statics of the individual optimal choice of E_1 and E_2, it is straightforward but tedious to show that the last three curly parentheses in (36) are all negative. As a consequence, the first curly parenthesis in (36) must be positive. Using the first-order condition for E_2 in (18), this implies that:

$$-(1+r)\,t_l W + t_h \frac{(1-t_l)\,W + \bar{\omega}}{p\,(1-t_h)} - \tau r\left[(1-t_l)\,W + \bar{\omega}\right] - (1+r)\,(\theta - \bar{\omega}) > 0$$

and hence that:

$$\left[\bar{\omega}\left(\frac{1}{1-t_h}\right) - \theta\left(\frac{1+r}{1+r-r\tau}\right)\right] + W\left(\frac{t_h - t_l}{1-t_h} - \frac{\tau r}{1+r-r\tau}\right) > 0$$

Note that the expression in square brackets is negative if:

$$\bar{\omega} < \theta\frac{(1+r)\,(1-t_h)}{1+r-rt}$$

in which case $\left(\frac{t_h-t_l}{1-t_h} - \frac{\tau r}{1+r-rt}\right) > 0$.

Multiple Types

To see that the original optimal setting of policy instruments for just one type (A) implies that type B chooses too little education of both components, we investigate the first order conditions in (27) and (28) more closely. Before this, note that the first-best choice of E_1^B involves:

$$\frac{U_1}{U_2} = \frac{\eta}{[\eta W + \theta]/p_0}$$

Instead, inserting the 'A-values' into the first order condition (28) yields:

$$\frac{U_1}{U_2} = \frac{\eta}{[(1-t_l)\,\eta W + \omega]/p} = \frac{\eta}{[\eta W + \theta]/p_0 + W(1-\eta)[1/p_0 - (1-t_l)/p]}$$

Here it is easily seen that $1/p_0 - (1-t_l)/p > 0$ when $t_l > 0$ (or $\tau > 0$). Hence, the relative cost of obtaining education for pleasure exceeds the relative cost in the first-best situation, resulting in too little education with a consumptive content.

For E_2^B the first best would be characterised by:

$$p^0 \eta W g'\left(E_2^B\right) = \eta W + \theta$$

whereas instead the first order condition with 'A-values' reads:

$$p\,(1-t_l)\,\eta W g'\left(E_2^B\right) = (1-t_l)\,\eta W + \omega$$

Now multiply both sides of the equation by $(p^0/p)/(1-t_l)$ to get (after some manipulation):

$$p^0 \eta W g'\left(E_2^B\right) = \eta W + \theta + W[\frac{t_l}{(1-t_l)} + \frac{\tau r(1-\eta)}{(1+r)}]$$

Recall that the left-hand side represents the benefits from productive education, while the right-hand side represents the associated costs. As the RHS obviously exceeds that of the first-best equation above (since $t_l > 0$, and $\tau > 0$), we conclude that incentives for taking time out for education of the productive sort are too weak, resulting in E_2^B being too small.

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