The private and fiscal returns to schooling and the effect of public policies on private incentives to invest in education: a general framework and some results for the EU

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Abstract

This paper develops a comprehensive framework for the quantitative analysis of the private and fiscal returns to schooling and of the effect of public policies on private incentives to invest in education. This framework is applied to 14 member states of the European Union. For each of these countries, we construct estimates of the private return to an additional year of schooling for an individual of average attainment, taking into account the effects of education on wages and employment probabilities after allowing for academic failure rates, the direct and opportunity costs of schooling, and the impact of personal taxes, social security contributions and unemployment and pension benefits on net incomes. We also construct a set of effective tax and subsidy rates that measure the effects of different public policies on the private returns to education, and measures of the fiscal returns to schooling that capture the long-term effects of a marginal increase in attainment on public finances under conditions that approximate general equilibrium.

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1. Introduction

This paper develops a comprehensive framework for the quantitative analysis of the private and fiscal returns to schooling and of the effect of public policies on private incentives to invest in education. This framework is applied to 14 member states of the European Union. For each of these countries we construct estimates of the private return to an additional year of schooling for an individual of average attainment, taking into account the effects of education on wages and employment probabilities after allowing for academic failure rates, the direct and opportunity costs of schooling, and the impact of personal taxes, social security contributions and unemployment and pension benefits on net lifetime incomes. We also construct a set of effective tax and subsidy rates that measure the effects of different public policies on the private returns to education, and measures of the fiscal returns to schooling that capture the long-term effects of a marginal increase in attainment on public finances under conditions that approximate general equilibrium.

The paper builds on the extensive literature that has sought to quantify the economic returns to schooling and brings together several of its strands. A large number of studies have explored the effects of education on wages and employment using individual-level data.[1] Wage effect estimates obtained in this manner can be interpreted as approximations to the rate of return to schooling but only under very stringent assumptions that include the absence of direct educational costs and infinite working lives. Another set of papers has focused on the construction of more elaborate estimates of the rate of return to schooling by discounting the lifetime earnings profiles associated with different educational levels. While this "full discounting" approach is conceptually well suited for the joint analysis of wage and employment effects and for quantifying the impact of educational finance and tax and benefit policies on the returns to schooling, systematic attempts to bring all or most of these factors into the analysis and to isolate their respective effects seem to be rather scarce in the literature.[2] Two interesting papers that make considerable progress in this direction are Barceinas et al (2000a) and Blöndal, Field and Girouard (2002). Both of these studies allow explicitly for unemployment when calculating the rate of return to education. In addition, Barceinas et al take into account unemployment benefits, while Blöndal et al allow for taxes and isolate the

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[1] Wage equation studies have generally adopted the specification proposed by Mincer (1974). Psacharopoulos and Patrinos (2002) collect the results of such studies for a large number of countries and Card (1999) surveys the relevant literature focusing on estimation issues. On the impact of education on unemployment, see among others Ashenfelter and Ham (1979), Nickell (1979) and Mincer (1991).

[2] On the other hand, many studies have introduced explicit corrections for unemployment and taxes when calculating rates of return by the full discounting method (see Psacharopoulos, 1995). There are also many studies that implicitly allow for taxes and/or unemployment in the estimation of Mincerian rates of return by using data on net-of-tax wages or on total earnings rather than on gross hourly wage rates (see for instance Nickell, 1979).

contribution of educational subsidies to private returns. Another paper of interest is O'Donoghue (1999), who combines wage equation estimates with a microsimulation model to explore the effects of taxes and social benefits on the returns to schooling in four EU countries. This paper and a second study by Barceinas et al (2000b)[3] are the only ones we are aware of that investigate the fiscal implications of investment in education.

The paper is organized as follows. In section 2 we derive an almost closed-form expression for the private rate of return to schooling. This formula can be seen as a compromise between the two approaches outlined above. It provides a simple and intuitive way to combine the parameters commonly estimated in wage and employment equation studies with data on educational expenditure and academic failure rates and with a broad set of tax and social benefit parameters to construct comprehensive measures of the return to schooling that take into account a number of factors that have not generally been considered jointly in the literature. This is of course achieved at the price of some strong simplifying assumptions about the evolution of wages, employment probabilities and tax and benefit rates over the lifecycle. Hence, our procedure can only be regarded as an approximation to the full discounting method, but it does have the important advantage that it is much less data and computation intensive, and is therefore better suited for broad cross country comparisons.

Section 3 shows how this approach can be used to construct quantitative measures of the impact of various public policies on individual incentives to invest in education, essentially by applying the private returns formula under different counterfactual assumptions. We start from a hypothetical scenario in which there is no government intervention and sequentially introduce 1) educational subsidies and the public provision of free education, 2) personal income taxes, including employee social security contributions, 3) unemployment insurance and housing benefits for the unemployed and 4) retirement benefits. The effective tax rate on schooling and the components of this rate induced by each of these policies are then constructed by comparing private returns in the different scenarios. Section 4 extends our framework to analyse the fiscal implications of public investment in education. The fiscal rate of return to schooling and the net present fiscal value of an additional year of formal education are calculated using the same procedure as in section 2, but considering only tax and benefit flows and introducing some adjustments that attempt to approximate general equilibrium conditions.

Section 5 discusses the data and parameter values used in our calculations. Raw measures of the effects of schooling on wages, employment probabilities and participation rates come from Mincerian wage equations and employment and participation probits estimated separately for each country with individual-level data and corrected, to the extent possible, for endogeneity bias. Average and marginal tax and social benefit rates, measures of the direct cost of education and academic failure indicators come mainly from various OECD publications. Fiscal parameters are those applicable to a single and childless individual of average attainment in each country in 2000. Finally, sections 6 and 7 present the results of the analysis for 14 member

[3] We thank F. Alcalá for this reference.

countries of the European Union (EU) and section 8 concludes with a summary of the main findings and a discussion of their policy implications.

2. An almost closed-form private returns formula

Any individual enrolled in post-compulsory education faces at each point in his career a choice between continuing his training and withdrawing from school to enter the labour market on a full-time basis. While other factors are certainly at work, the option to remain in school is at least in part an investment decision for it involves a trade-off between current costs (foregone wages, tuition charges and other school-related expenses) and future benefits (the expected increase in earnings associated with higher qualifications).

As in the case of more standard investment projects, the financial payoff to an additional year of schooling can be quantified by computing its internal rate of return, which is formally defined as the discount rate that equates the present value of the relevant streams of incremental pecuniary costs and benefits. In this section we will derive a formula for the calculation of this rate of return. The calculation will take into account the explicit costs of schooling born by a representative agent in each country, his opportunity cost in the form of foregone labour income and lost work experience, and the expected increase in future net-of-tax labour earnings and unemployment and pension benefits arising both from higher wages and from higher employment probabilities.

Consider an individual who attends school for X years, successfully completes $S(X)$ grades, retires at time U and is expected to live until time Z. We are interested in the effects of one additional year of formal schooling on his expected flows of after-tax labour income and net social benefits, taking into account that educational attainment affects both wages and the probability of employment.

Wages increase over time as a result of exogenous technical progress and the accumulation of physical capital and experience. We will assume that the wage at time t of an individual with schooling X and $h = t - X$ years of experience is given by

$$(1)\ W(t,X,h) = A_t f\big(S(X)\big)e^{vh} = A_o e^{gt} f\big(S(X)\big)e^{v(t-X)} = A_o e^{(g+v)t} f\big(S(X)\big)e^{-vX} \quad \text{for } t\in[X,\, U]$$

where A_t is an efficiency index that reflects both technological progress and aggregate capital accumulation. The effects of schooling are captured by the function $f[S(X)]$, where S denotes school attainment measured by the number of successfully completed grades, which is in turn an increasing function of the time spent in school, X. For simplicity, the experience premium on wages, e^{vh}, is assumed to be a function of potential experience (i.e. of the time that has passed since the individual left school) rather than of actual years of employment, and to grow at a constant rate (which means that it will not display the hump often found in empirical wage-experience profiles).[4] We will approximate the wage of the "average worker" in the economy, W_0, by that corresponding to an individual of average attainment, X_0, at the mid-point of his career, that is,

$$(2)\ W_o(t) = W(t, X_o, H_o/2) = A_o e^{gt} f\left(S(X_o)\right) e^{\nu H_o/2}$$

where

$$(3)\ H_0 \equiv U - X_0,$$

is the expected duration of the working life of an individual of average attainment.

The probability of employment will be assumed to be an increasing (and time-invariant) function of schooling. We will denote by $p[S(X)]$ the function describing this relation in the case of an adult worker seeking full-time employment, and by $p_S(S) = \eta p(S)$ the analogous function for a student seeking part-time employment. Hence, η is an adjustment coefficient that corrects for the differential employment probability of students.

We will allow for taxes and for unemployment and pension benefits. To keep the problem tractable, we need to assume that tax rates depend only on the agent's status (that is, on whether he is employed, unemployed or retired) and do not change over time as his income rises with technical progress and experience.[5] To achieve this, we will assume that tax rates are a function of X alone, so the net-of-tax earnings per "efficiency unit of labour" at time t of an adult worker with X years of training who is employed full time will be given by

$$(4)\ F_e(X) = e^{-\nu X} f[S(X)] - T\left(e^{-\nu X} f[S(X)]\right)$$

where $T()$ is the total tax due per efficiency unit of labour. If the same worker is unemployed, he is entitled to a benefit which will be a function of previous earnings. An unemployed worker's net income per efficiency unit of labour will be given by

$$(5)\ F_u(X) = B\left(e^{-\nu X} f[S(X)]\right) - T\left(B\left(e^{-\nu X} f[S(X)]\right)\right)$$

where $B\left(e^{-\nu X} f[S(X)]\right)$ is the benefit per efficiency unit of labour, written as a function of the wage prior to the loss of employment. The expected net income at time t of an adult worker can then be written

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[4] There is some evidence (see for instance Brunello and Comi (2004) and the references therein) that ν is also an increasing function of educational attainment. Since we will not take this effect into account, our calculations will tend to underestimate the return to schooling.

[5] The first part of this assumption --that tax rates do not change over time as average incomes rise with technical progress and factor accumulation-- may not be a bad approximation in the medium or long run. While tax brackets are not explicitly indexed to average wages in any country in our sample, periodic reforms may work in this direction. Otherwise, fiscal drag would gradually raise income tax receipts as a fraction of GDP and this does not seem to have been the case in EU countries over the last two decades. The second half of the assumption --that tax rates remain constant over an individual's life cycle-- is harder to defend. To minimize the error it induces in our computations, we will work with tax rates that approximate those applicable to the representative worker at the mid-point of his career and at the midpoint of his retirement period.

$$(6)\quad F(X)A_0e^{(g+v)t} = \left\{p[S(X)]F_e(X) + \left(1-p[S(X)]\right)F_u(X)\right\}A_0e^{(g+v)t}$$

where we have multiplied *F(X)* by the non-education component of the wage function *W(t, X, t-X)* in order to recover total expected labour income from the functions $F_e()$ and $F_u()$ that give wages per efficiency unit of labour.

We will assume that students are not entitled to unemployment benefits (which is true in most countries, as a minimum period of previous employment is generally required for contributory benefits), and that their wages, W_S, do not rise with experience. We will write the gross income of a student with attainment x as a fraction $(1-\phi)$ of the wages of an adult full-time worker of average experience with the same qualifications,

$$(7)\quad W_s(t,x) = (1-\phi)W(t,x,H_o/2) = (1-\phi)f(S(x))A_0e^{gt}e^{vH_o/2}.$$

Hence, we can think of ϕ as the fraction of the work year devoted to full-time school attendance but it should be kept in mind that this parameter will also implicitly capture other factors (such as the lack of experience and the nature of the jobs available to young people who seek part-time or summer employment) that will influence the wages of students relative to those of adult workers. Under these assumptions, the expected net earnings at time t of a student who has completed x years of training are given by

$$(8)\quad A_0e^{gt}e^{vH_o/2}F_S(x) = p_S[S(x)]\left\{(1-\phi)f[S(x)] - T\left((1-\phi)f[S(x)]\right)\right\}A_0e^{gt}e^{vH_o/2}$$

where $p_S() = \eta p()$ is the relevant probability of employment as discussed above.

We will also take into account pensions. We will assume that the initial pension, P_U, is set as a function of the worker's average earnings (as captured by the educational component of wages)

$$(9)\quad P_u(X) = A_oe^{(g+v)U}P\left[f(S(X))e^{-vX}\right]$$

and that its real value grows over time at a constant rate, ω, so that

$$(10)\quad P_t(X) = P_u(X)e^{\omega(t-U)} = A_oe^{(g+v)U}P\left[f(S(X))e^{-vX}\right]e^{\omega(t-U)} = A_oe^{(g+v-\omega)U}P\left[f(S(X))e^{-vX}\right]e^{\omega t}$$

for $t > U$. Assuming as above that tax rates are a function of X but not of time, the net-of-tax pension at time t ($> U$) will be given by

$$(11)\quad A_oe^{(g+v-\omega)U}e^{\omega t}F_p(X) \equiv \left\{P\left[f(S(X))e^{-vX}\right] - T\left[P\left[f(S(X))e^{-vX}\right]\right]\right\}A_oe^{(g+v-\omega)U}e^{\omega t}.$$

Finally, we will assume that the direct cost to the agent of each year of schooling is a constant fraction μ_S of the earnings of the average worker,

$$(12)\quad \mu_sW_o(t) = \mu_sA_0e^{gt}f(S(X_o))e^{vH_o/2}.$$

Given these assumptions, the present value of the agent's expected lifetime net earnings can be written

$$(13)\ V(X) = \int_0^X A_0 e^{vH_0/2} F_s(t) e^{-(R+v)t} dt + \int_X^U A_0 F(X) e^{-Rt} dt +$$

$$+ \int_U^Z A_0 e^{(g+v-\omega)U} F_p(X) e^{-(R+g+v-\omega)t} dt - \int_0^X \mu_S A_0 e^{vH_0/2} f(S_0) e^{-(R+v)t} dt$$

where r is the discount rate, $S_0 \equiv S(X_0)$, and

$$(14)\ R \equiv r - g - v.$$

The first term on the right-hand side of (13) denotes the present value of expected labour earnings while attending school and (potentially) working part-time between times 0 and X; the second term gives the present value of labour income and unemployment benefits over the individual's post-school working life (between times X and U), and the third the discounted value of pension benefits between retirement and the expected time of death, Z. The last term corresponds to the present value of the direct costs of schooling born by the agent (i.e. net of public subsidies).

To calculate the rate of return to schooling, we will compute its net marginal product, which will be given by the derivative of the net lifetime earnings function, $V'(X)$, and solve for the value of the discount rate, r, that makes this derivative equal to zero when $X = X_0$ (i.e. for an individual of average attainment). Using Leibniz's rule to differentiate $V(X)$ and keeping in mind that S_0 and H_0 are fixed quantities (for they refer to the average worker in the entire economy and not to our reference young individual), we have

$$\begin{aligned} V'(X) = {} & A_0 e^{vH_0/2} F_s(X) e^{-(R+v)X} - A_0 e^{vH_0/2} \mu_s f(S_0) e^{-(R+v)X} \\ & + A_0 \left\{ \int_X^U F'(X) e^{-Rt} dt - F(X) e^{-RX} \right\} + A_0 e^{(g+v-\omega)U} \left\{ \int_U^Z F_p{}'(X) e^{-(R+g+v-\omega)t} dt \right\} \end{aligned}$$

A bit of algebra will show that

$$(15)\ \frac{V'(X)}{A_0 e^{-RX}} = e^{-vX} e^{vH_0/2} \left[F_s(X) - \mu_s f(S_0) \right] - F(X) + \frac{1 - e^{-RH}}{R} \left\{ F'(X) + \gamma(R) F_p{}'(X) \right\}$$

where

$$(16)\ \gamma(R) \equiv \frac{R}{R + g + v - \omega} \frac{1 - e^{-(R+g+v-\omega)(Z-U)}}{e^{RH} - 1}$$

is the relative discount factor that must be applied to the pension component of the benefits of schooling before they can be compared to its wage benefits.

Setting the derivative in (15) equal to zero when $X = X_0$ and operating, we have:

$$(17)\quad \frac{R}{1-e^{-RH_0}} = \frac{F'(X_o)+\gamma(R)F_p'(X_o)}{\left[F(X_o)-F_s(X_o)e^{-vX_o}e^{vH_o/2}\right]+\mu_s f(S_o)e^{-vX_o}e^{vH_o/2}}$$

This expression shows that the return to schooling is an increasing function of the ratio between the gain in expected net income induced by a marginal increase in school attendance and the cost of schooling. The denominator of this ratio can be written as the sum of an opportunity (F - F_S) and a direct cost component, and the numerator as the sum of two terms that capture the benefits that accrue respectively during the agent's working life and after retirement. Notice that, before being added to the wage component of the payoff to schooling, *F'()*, marginal retirement benefits *(F_p')* are weighted by a factor $\gamma(R)$ that discounts for their later accrual and takes into account their potentially different growth rate (ω rather than $g+v$) and expected duration (Z - U rather than H).

Table 1: Tax and benefit parameters used in the rate of return formula

$$(18)\quad \tau_e \equiv \frac{T\left(e^{-vX_o}f(S_o)\right)}{e^{-vX_o}f(S_o)},\quad \tau_u \equiv \frac{T\left(B\left(e^{-vX_o}f(S_o)\right)\right)}{B\left(e^{-vX_o}f(S_o)\right)},\quad \tau_s \equiv \frac{T\left((1-\phi)f(S_o)\right)}{(1-\phi)f(S_o)},\quad \tau_p \equiv \frac{T\left(P\left(e^{-vX_o}f(S_o)\right)\right)}{P\left(e^{-vX_o}f(S_o)\right)}$$

$$(18)\quad T'_e \equiv T'\left(e^{-vX_o}f(S_o)\right),\quad T'_u \equiv T'\left(B\left(e^{-vX_o}f(S_o)\right)\right),\quad T'_p \equiv T'\left(P\left(e^{-vX_o}f(S_o)\right)\right)$$

$$(19)\quad b \equiv \frac{B\left(e^{-vX_o}f(S_o)\right)}{e^{-vX_o}f(S_o)},\quad B' \equiv B'\left(e^{-vX_o}f(S_o)\right),\quad pb \equiv \frac{P\left(e^{-vX_o}f(S_o)\right)}{e^{-vX_o}f(S_o)},\quad PB' \equiv P'\left(e^{-vX_o}f(S_o)\right)$$

$$(20)\quad 1-T' \equiv (1-T'_e)+\frac{1-p}{p}(1-T'_u)B' \quad\Rightarrow\quad T' \equiv T'_e-\frac{1-p}{p}(1-T'_u)B'$$

$$(21)\quad (1-\tau) \equiv (1-\tau_e)+\frac{1-p}{p}(1-\tau_u)b \quad\Rightarrow\quad \tau = \tau_e-\frac{1-p}{p}(1-\tau_u)b$$

$$(22)\quad \Delta \equiv (1-\tau_e)-(1-\tau_u)b$$

$$(23)\quad \theta \equiv \frac{f'(S_o)}{f(S_o)}$$

where $p \equiv p(S_0)$.

To rewrite equation (17) in a form that can be used directly in our calculations, we define the tax and benefit parameters listed in Table 1. The symbols τ_e, τ_u, τ_S and τ_p denote the average income tax rates faced by the representative employed and unemployed adult workers, student part-time workers and pensioners, T'_e, T'_u and T'_p are the corresponding marginal tax rates, and b, pb, PB' and B' are the average and marginal *gross replacement rates* for unemployed workers and for pensioners.[6] Grouping some of these terms we construct T', τ and Δ so that (T' and τ are equal to zero in the absence of taxes), $p(1\text{-}T')$ and $p(1\text{-}\tau)$ are the expected marginal and average net-of-tax factors for adult workers, and Δ captures the difference in net earnings between employed and unemployed adult workers. Finally θ is the Mincerian returns parameter commonly estimated in microeconometric wage equation studies, and it measures the impact of schooling on gross wages.

It is easy to check that

$$(24)\ F(X_0) = p(1-\tau)e^{-vX_0}f(S_0)$$

$$(25)\ F_S(X_0) = p_s(1-\tau_s)(1-\phi)f(S_0)$$

$$(26)\ F_p(X_0) = (1-\tau_p)pbe^{-vX_o}f(S_o)$$

$$(27)\ F_p'(X_o) = \left(1-T'_p\right)PB'e^{-vX_o}\left[f'(S_o)S'(X_o) - vf(S_o)\right]$$

$$(28)\ F'(X_0) = p(1-T')e^{-vX_0}\left[f'(S_0)S'(X_0) - vf(S_0)\right] + p'S'(X_0)\Delta e^{-vX_0}f(S_0)$$

where it should be understood that $p()$, $p'()$ and $p_S()$ are evaluated at $S_0 = S(X_0)$. Notice that the components of $F'(X_0)$ and $Fp'(X_0)$ that capture the marginal increase in wages or pensions due to schooling include a negative term of the form $-vf(S_0)$. This is so because an extra year spent in school means one less year of experience, and this has a permanent effect on earnings that partially offsets the wage increase due to education, which is captured by the term $f'(S_0)S'(X_0)$.

Using these expressions, equation (17) becomes

$$(29)\frac{R}{1-e^{-RH_o}} = \frac{p(1-T')\left[\theta S'(X_o) - v\right] + \Delta p'S'(X_o) + \gamma(R)\left(1-T'_p\right)PB'\left[\theta S'(X_o) - v\right]}{\left[\text{p}(1\text{-}\tau) - \eta p(1-\phi)(1-\tau_s)e^{vH_o/2}\right] + \mu_s e^{vH_o/2}}$$
$$\equiv \frac{\theta_{net} + p'_{net} + PENS}{OPPC + DIRC} \equiv R'$$

Hence, (by (14)) the private rate of return to schooling is given by

$$(30)\ r_p = R_p + g + v$$

where g is the growth rate of average wages, v the contribution of experience to the growth of individual wages over the lifecycle and R_p is the value of R that solves equation (29).[7]

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[6] Notice that pb is the gross replacement ratio at the time of retirement. Using equations (1) and (9), we see that $pb = P_U/W_U$.

[7] The above calculations assume that unemployment benefits are set as a function of gross income in employment. This is so in most countries, but there are two exceptions. Germany and Austria set benefits as a fixed fraction (β) of net-of-tax income in employment and do not tax them. It is shown in Appendix 2 that equation (29) continues to hold in this case provided we redefine T', τ and Δ as follows:

$$(20')\ 1-T' \equiv \left[1 + \frac{1-p}{p}\beta\right](1-T'_e) \quad (21')\ (1-\tau) \equiv \left[1 + \frac{1-p}{p}\beta\right](1-\tau_e) \text{ and}$$

To interpret equation (29), notice that its left-hand side is an increasing function of R where the term $1\text{-}e^{-RH_0}$ that appears in the denominator serves to adjust for the fact that the "useful life" of the asset (the working life of the individual, H_0) is finite. The right-hand side, R', is simply the ratio of the marginal benefits derived from an additional year of schooling (which we can interpret as the "dividend" paid by human capital) to its cost, with all terms expressed as fractions of the initial gross earnings of an adult employed worker with average education, $Ae^{-\nu X_0}f(S_0)$. The first term in the numerator (θ_{net}) captures the expected increase in after-tax earnings and unemployment benefits holding the probability of employment constant and taking into account the opportunity cost of losing a year of experience to remain in school. The second term (p'_{net}) measures the gain in expected net earnings that comes from an increase in the probability of employment holding wages constant, and the third one gives the discounted value of the increase in expected retirement benefits. Notice that, except for the experience offsets, all these terms are directly proportional to the marginal productivity of time spent at school, $S'(X_0)$. The denominator measures the total cost of an additional year of schooling as the sum of two terms. The first one *(OPPC)* is the opportunity cost of school attendance (net foregone wages), and the second one *(DIRC)* the direct costs of schooling born by the student or his family.

Public policies influence the private return to schooling in many ways. Educational subsidies or the direct public provision of educational services at no charge will raise the return to schooling by lowering its direct cost to the individual *(DIRC)*. Pension benefits will also raise r_p, provided of course they are linked to wages (which is not always the case in our sample). The effect of taxation is more complicated. Notice that a proportional income tax (i.e. a tax system in which $T_e' = T_u' = T_p' = \tau_e = \tau_u = \tau_s$) would have absolutely no effect on the return to schooling whenever there are no direct costs (i.e. when $DIRC = 0$) because taxes would then reduce both the costs and the benefits of education in the same proportion. Hence, the effects of the tax system will come from differences among the tax rates that enter the formula and from their interaction with the direct cost term, *DIRC*. Under a proportional tax system, an increase in the (single) tax rate will reduce R' if $DIRC > 0$ and increase it otherwise (that is, if students receive a net subsidy) because higher taxes will reduce the benefits of education in a greater proportion that its costs in the first case, and by a smaller one in the second.

When we abandon the proportionality assumption, changes in marginal and average tax rates have different effects. An increase in either T_e', T_u' or T_p' reduces the return to schooling by lowering the net wage gains term, θ_{net}, or the value of retirement benefits, *PENS*. An increase in student taxes, τ_s, also reduces R' by increasing the opportunity cost of schooling, *OPPC*. An increase in τ_u, however, raises the incentive to invest in education because it increases the

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(22′) $\Delta \equiv (1-\tau_e)(1-\beta)$

earnings premium on being employed, p'_{net}, and lowers the opportunity cost of studying. Finally, an increase in the average tax rate on employed workers, τ_e, reduces both p'_{net} and *OPPC*. The net effect will be an increase in the rate of return whenever $R' > S'p'/p$, a condition which holds in all the countries in the sample we will consider below.

An important special case is the one where schooling has no employment benefits or direct costs (that is $\mu_S = p' = 0$), there are no retirement benefits and students do not work part-time ($\phi = 1$). In this case, the tax system affects the returns to schooling only through its progressivity at the average wage level: as the tax system becomes more progressive (i.e. as the ratio $(1-T_e')/(1-\tau_e)$ declines), the incentive to invest in education falls. This is a useful benchmark because in practice it is not a bad approximation to the situation in many countries, where the employment-related effects of schooling and its direct costs are relatively unimportant, at least after government intervention.

Finally, the effects of the average and marginal gross unemployment replacement ratios are also different. Raising B' increases the return to schooling through θ_{net}, while raising b reduces the return both by lowering p'_{net} and by increasing *OPPC*. Under a flat-rate benefit system (with $B' = b$), an increase in benefits is likely to reduce the return to schooling for realistic parameter values.[8]

3. Effective tax rates on schooling

To quantify the contribution of various forms of government intervention to the private return to schooling, it will be useful to compute the rate of return under a set of different counterfactual assumptions or *scenarios*. We will consider five such scenarios, starting from a hypothetical situation in which there is no government intervention and then adding various policies one by one. In scenario [1] *(NO GOV'T)* we assume that private agents pay the full costs of education and there are no taxes or social benefits. In scenario [2] we introduce *subsidies* to education and the public provision of schooling free of charge, maintaining the remaining assumptions. In [3] we introduce personal *taxes*, in [4] unemployment and housing *benefits* and in [5] *pensions* to arrive at our most comprehensive measure of the observed private returns to education *(OBS)*. Table 2 summarizes these hypotheses. In what follows, we will refer to estimates of r_p obtained under the assumptions of the *NO GOV'T* and *OBS* scenarios as *raw* and *all-in* returns respectively.

The rate of return estimates obtained under the different scenarios will be used to construct a set of effective tax and subsidy rates that measure the impact of public policies on private incentives to invest in education. We calculate the tax or subsidy wedge $(wedge_{gov't})$ generated by public policies as the difference between the raw and all-in rates of return, and define the effective tax rate on schooling $(etr_{gov't})$ as the ratio between the tax wedge and the raw return.

[8] The condition for this is $(1-p)(1-T_u')\theta' < (1-\tau_u)[p'S' + (1-p)R']$, which again holds for all the countries in the sample.

Table 2: Assumptions underlying the scenarios

	raw return NO GOV'T [1]	*educational subsidies* [2]	*personal taxes* [3]	*unemployment benefits* [4]	*all-in return OBS* [5]
direct costs	total	private	private	private	private
taxes	none	none	observed	observed	observed
unempl. benefits	none	none	none	observed	observed
pensions	none	none	none	none	observed

Letting r_i denote the estimated rate of return to schooling under scenario *i*, we have

$$(31)\quad wedge_{gov't} = r_{no\ gov't} - r_{obs} \quad \text{and} \quad etr_{gov't} = \frac{wedge_{gov't}}{r_{no\ gov't}}.$$

Notice that $wedge_{gov't}$ and $etr_{gov't}$ capture the joint effect of all the public policies we are considering. To isolate the impact of each individual policy, it will be useful to write $wedge_{gov't}$ and $etr_{gov't}$ as the sum of four factors that capture the separate effects of educational subsidies, personal taxes and unemployment and pension benefits as follows. First, we write $wedge_{gov't}$ in the form

$$(32)\quad \begin{aligned} wedge_{gov't} &= r_{no\ gov't} - r_{obs} = (r_{no\ gov't} - r_{subs}) + (r_{subs} - r_{taxes}) + (r_{taxes} - r_{ben}) + (r_{ben} - r_{obs}) \\ &\equiv -wedge_{subs} + wedge_{tax} + wedge_{ben} - wedge_{pens} \end{aligned}$$

Dividing through by $r_{no\ gov't}$, the corresponding partial tax and subsidy rates are given by

$$(33)\quad \begin{aligned} etr_{gov't} &= \frac{wedge_{gov't}}{r_{no\ gov't}} = \frac{-wedge_{subs} + wedge_{tax} + wedge_{ben} - wedge_{pens}}{r_{no\ gov't}} \\ &\equiv -subs_{edu} + etr_{tax} + etr_{ben} - subs_{pens} \end{aligned}$$

Notice that the partial wedges and rates are defined so that their signs are positive under normal circumstances, that is, whenever taxes and unemployment benefits reduce the private return to schooling and educational subsidies and pensions increase it.

An alternative decomposition of the tax rate on schooling

To gain some additional insight into the factors that affect the different components of the effective tax rate on schooling, it will be useful to construct an alternative decomposition of this variable. Let us denote by R'_{obs} the right-hand side of the rate of return formula given in equation (29),

$$(35)\ R_{obs}' = \frac{p(1-T')\left[\theta S'(X_o) - v\right] + \Delta p' S'(X_o) + \gamma(R)\left(1 - T'_p\right) PB'\left[\theta S'(X_o) - v\right]}{\left[\text{p}(1\text{-}\tau) - \eta p(1-\phi)(1-\tau_s) e^{vH_o/2}\right] + \mu_s e^{vH_o/2}}.$$

It will be convenient to divide both the numerator and the denominator of R'_{obs} by $p(1-\tau)$ so as to express all terms as fractions of the expected after-tax income of an active adult worker. As shown in Appendix 2, this yields an alternative expression for R'_{obs} of the following form

$$(36)\ R_{obs}' = \frac{(1-\pi)\theta' + (1-\rho)\varepsilon' + PENS'}{\left[1-\eta(1-\phi)\frac{1-\tau_s}{1-\tau}e^{vH_o/2}\right] + \frac{\mu_s}{p(1-\tau)}e^{vH_o/2}} = \frac{(1-\pi)\theta' + (1-\rho)\varepsilon' + PENS'}{OPPC' + DIRC'}$$

where

$$PENS' = \gamma(R)\frac{1-T'_p}{p(1-\tau)}PB'(\theta S' - v)$$

The parameters θ' and ε' that appear in the numerator of this expression are defined as

$$(37)\ \theta' \equiv \theta S'(X_o) - v$$

and

$$(38)\ \varepsilon' \equiv \frac{p'(S_o)}{p(S_o)}S'(X_o)$$

and measure the marginal contribution of schooling to expected income working respectively through the wage and employment channels. The other two coefficients that enter the numerator of R'_{obs}, π and ρ, can be interpreted as the tax rates on these two components of the return to schooling. The first one,

$$(39)\ \rho \equiv \frac{(1-\tau_u)b}{p(1-\tau)}\ ,$$

is the net replacement rate measured as a fraction of the expected net earnings of an active adult worker (rather than as a fraction of income in employment as this variable is commonly defined),[9] and the second,

$$(40)\ \pi \equiv 1 - \frac{1-T'}{1-\tau} = \frac{T'-\tau}{1-\tau}\ ,$$

is an index of the progressivity of the tax system.

Using equation (36), we will now construct an approximate decomposition of the overall tax rate on schooling (excluding pensions). The values of R' corresponding to the *NO GOV'T* and *OBS* scenarios can be written in the form

$$R'_{no\,gov't} = \frac{\theta' + \varepsilon'}{C} \quad \text{and} \quad R'_{obs} = \frac{(1-\pi)\theta' + (1-\rho)\varepsilon' + PENS'}{(1-s)C}$$

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[9] In the case of Germany and Austria, where (non-taxable) benefits are set as a fixed fraction, β, of net income in employment, the net replacement ratio is given by

$$(39')\ \rho \equiv \frac{\beta}{p + (1-p)\beta}$$

and equation (36) continues to hold as written.

where $C = OPPC' + DIRC'$ in the no-government scenario and s is the overall subsidy rate on total schooling costs, taking into account the effect of taxes and unemployment benefits on the opportunity cost of education.

Let us now define a new measure of the overall tax rate, t, by working directly with these two terms as

$$(41)\quad t \equiv \frac{R'_{no\,gov't} - R'_{obs}}{R'_{no\,gov't}} = 1 - \frac{R'_{obs}}{R'_{no\,gov't}}$$

It should be clear that t will not coincide with the effective tax rate defined above ($etr_{gov't}$) but the intuition will carry over since r is an increasing transformation of R'. (In our sample, the correlation between t and $etr_{gov't}$ is 0.98).

We now observe that

$$(42)\quad 1-t = \frac{R'_{obs}}{R'_{no\,gov't}} = \frac{\dfrac{(1-\pi)\theta' + (1-\rho)\varepsilon' + PENS'}{(1-s)C}}{\dfrac{\theta'+\varepsilon'}{C}} = \frac{1}{1-s}\left[(1-\pi)\frac{\theta'}{\theta'+\varepsilon'} + (1-\rho)\frac{\varepsilon'}{\theta'+\varepsilon'} + \frac{PENS'}{\theta'+\varepsilon'}\right]$$

Hence, the overall net-of-tax factor, $1\text{-}t$, is the product of an increasing function of the subsidy rate, s, and a term that is the sum of the weighted average of the net-of-tax factors on the wage and employment components of the return to schooling, with weights that are proportional to the shares of these components in the total return, and a term that captures the discounted value of marginal pension benefits (which could be subsumed in the first term, since it is also proportional to θ'). Notice that the "tax rate" on the wage component of the returns to schooling is our measure of progressivity, π, and that on the employment component is the modified net replacement rate, ρ. The first of these terms, in turn, can be decomposed into two parts that reflect, respectively, the progressivity of the tax and benefit schedules faced by employed and by unemployed workers. Letting π_e and π_u denote the partial progressivity measures for employed and unemployed workers, which are defined by

$$(43)\quad 1-\pi_e \equiv \frac{1-T'_e}{1-\tau_e} \quad \text{and} \quad 1-\pi_u \equiv \frac{(1-T'_u)B'}{(1-\tau_u)b},$$

it is easy to show that[10]

$$(44)\quad \pi = \pi_e + (1-p)\rho(\pi_u - \pi_e).$$

Hence, unemployment benefit parameters will affect π as well as ρ and their introduction may raise the overall tax rate, t, through an increase in average progressivity, especially in those countries where unemployment rates, approximated by $1\text{-}p$, are high. This effect will be particularly strong when unemployment compensation is paid at a fixed rate or benefit ceilings

[10] See Appendix 2.

are binding, since that makes the marginal tax rate on additional schooling equal to 100% for the unemployed.

4. The fiscal return to schooling

By raising wages and employment probabilities, public expenditure on education increases future tax revenues and pension liabilities and is likely to reduce expenditure on unemployment benefits. Proceeding as in section 2, we can treat such expenditure as an investment that generates a stream of net public revenues over the agent's lifecycle and compute a *fiscal rate of return to schooling* that will summarize the long-term impact of educational spending on government finances. This variable, which we will denote by r_f, will be defined as the discount rate that equates the present value of public schooling expenditure (which includes an opportunity cost component as school attendance reduces wage income and hence current tax payments) with the present value of the induced incremental flows of tax revenues and savings on social protection payments. This fiscal rate of return can also be interpreted as the maximum real rate of interest at which the government can borrow to finance educational expenditure without increasing the present value of current and future deficits. In addition, we will also compute the *net present fiscal value* of an additional year of schooling, defined as the difference in present value terms between incremental net fiscal revenues and public educational expenditures.

We will consider the streams of net tax revenues associated with adult and student workers and with pensioners. In addition to the personal taxes considered in the previous section, we will now take into account social security contributions by employers and consumption taxes. The tax revenue per efficiency unit of labour generated by an adult worker of schooling X is given by the difference between the benefits that accrue to him and the direct and indirect taxes paid by him directly or by his employer on his behalf, that is, by

$$(40)\quad G_e(X) \equiv T\left(e^{-vX} f\left[S(X)\right]\right) + \tau_c C\left[e^{-vX} f\left[S(X)\right] - T\left(e^{-vX} f\left[S(X)\right]\right)\right] + E\left(e^{-vX} f\left[S(X)\right]\right)$$

when employed and by

$$(41)\quad G_u(X) \equiv -B\left(e^{-vX} f\left[S(X)\right]\right) + T\left[B\left(e^{-vX} f\left[S(X)\right]\right)\right] + \tau_c C\left[B\left(e^{-vX} f\left[S(X)\right]\right) - T\left[B\left(e^{-vX} f\left[S(X)\right]\right)\right]\right]$$

when unemployed. In these expressions, the function *T()* captures personal taxes on workers, including employee social security contributions, as a function of their gross income, *E()* denotes social contributions paid by employers, *C()* gives consumption as a function of after-tax income, and τ_c is the tax rate on consumption. Notice that *T()*, *E()* and *C()* all give amounts per efficiency unit of labour.

Since the wages of adult workers grow at a rate $g+v$, the expected net tax revenue generated by an adult agent at time t will be given by

$$(42)\quad A_o e^{(g+v)t} G(X) \equiv q\left[S(X)\right]\left\{p\left[S(X)\right] G_e(X) + \left(1 - p\left[S(X)\right]\right) G_u(X)\right\} A_o e^{(g+v)t}$$

where $q()$ gives the probability that the agent will be active as a function of his attainment level and $p()$ the probability that he is employed, conditional on his being active. Notice that the participation rate is relevant for our calculations here because only those students that become active pay taxes or are entitled to unemployment benefits or (in most countries) to pensions.

Similarly, the expected net tax revenue generated at time t by a student with schooling X is given by

$$(43)\ A_o e^{gt} e^{vH_0/2} G_s(X) \equiv q_s[S(X)] p_s[S(X)] A_o e^{gt} e^{vH_0/2} \\ * \left\{ T((1-\phi) f(S(X))) + E((1-\phi) f(S(X))) + \tau_c C[(1-\phi) f(S(X)) - T((1-\phi) f(S(X)))] \right\}$$

where $q_S() = \eta_q q()$ gives the probability of participation of a student of attainment $S(X)$, that is, the probability that he will be seeking a part-time job while attending school. Finally, the total net tax revenue generated by a pensioner of schooling X will be given by

$$(44)\ A_o e^{(g+v-\omega)U} e^{\omega t} G_p(X) \equiv A_o e^{(g+v-\omega)U} e^{\omega t} * \\ \left\{ -P\left(f(S(X)) e^{-vX}\right) + T\left[P\left(f(S(X)) e^{-vX}\right)\right] + \tau_c C\left[P\left(f(S(X)) e^{-vX}\right) - T\left[P\left(f(S(X)) e^{-vX}\right)\right]\right] \right\}$$

The present value of the expected stream of tax revenues (net of unemployment and pension benefits and public expenditure on education) associated with a worker of achievement $S(X)$ can be written

$$(45)\ V_g(X) = \int_0^X A_o e^{vH_0/2} G_s(t) e^{-(R+v)t} dt + \int_X^U A_o G(X) e^{-Rt} dt - \int_0^X \mu_g A_o e^{vH_0/2} f(S_0) e^{-(R+v)t} dt \\ + \int_U^Z q[S(X)] G_p(X) A_o e^{(g+v-\omega)U} e^{-(R+g+v-\omega)t} dt$$

where $R \equiv r - g - v$, r is the discount rate, and $\mu_g A_t e^{vH_0/2} f(S_o)$ is annual government expenditure per student. Notice that the pension term, $G_p()$, enters the equation multiplied by $q()$, since we assume that only active workers are entitled to (contributory) retirement benefits.

Differentiating $V_g()$, and setting the result equal to zero when $X = X_0$ it is easily shown that the fiscal rate of return on schooling is given by

$$(46)\ r_f = R_f + g + v$$

where R_f is the value of R that solves the following equation

$$(47)\ \frac{R}{1-e^{-RH_0}} = \frac{G'(X_o) + \gamma(R)\left[q' S'(X_o) G_p(X_o) + q G_p'(X_o)\right]}{\left[G(X_o) - G_s(X_o) e^{-vX_0} e^{vH_0/2}\right] + \mu_g f(S_o) e^{-vX_0} e^{vH_0/2}}$$

and $\gamma(R)$ has been defined above in

$$(16)\ \gamma(R) \equiv \frac{R}{R+g+v-\omega} \frac{1-e^{-(R+g+v-\omega)(Z-U)}}{e^{RH_0}-1}.$$

Table 3: Parameters used in the fiscal returns formula

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(48) $c_s \equiv \frac{C[(1-\tau_s)(1-\phi)f(S_o)]}{(1-\tau_s)(1-\phi)f(S_o)}$ $c_e \equiv \frac{C\left[(1-\tau_e)e^{-vX_o}f(S_o)\right]}{(1-\tau_e)e^{-vX_o}f(S_o)}$

$c_u \equiv \frac{C\left[(1-\tau_u)be^{-vX_o}f(S_o)\right]}{(1-\tau_u)be^{-vX_o}f(S_o)}$ $c_p \equiv \frac{C\left[(1-\tau_p)pbe^{-vX_o}f(S_o)\right]}{(1-\tau_p)pbe^{-vX_o}f(S_o)}$

(49) $C'_e \equiv C'\left[(1-\tau_e)e^{-vX_o}f(S_o)\right]$ $C'_u \equiv C'\left[(1-\tau_u)be^{-vX_o}f(S_o)\right]$ $C'_p \equiv C'\left[(1-\tau_p)pbe^{-vX_o}f(S_o)\right]$,

(50) $e_s \equiv \frac{E[(1-\phi)f(S_o)]}{(1-\phi)f(S_o)}$ $e_e \equiv \frac{E\left[e^{-vX_o}f(S_o)\right]}{e^{-vX_o}f(S_o)}$ and $E'_e \equiv E'\left(e^{-vX_o}f(S_o)\right)$.

(51) $T_s \equiv \tau_s + \tau_c c_s(1-\tau_s) + e_s$

(52) $T_p \equiv -(1-\tau_p)(1-\tau_c c_p)pb$ $\Delta'_p \equiv -(1-\tau_c C'_p)(1-T_p')PB'$

(53) $T_e \equiv \tau_e + \tau_c c_e(1-\tau_e) + e_e$ $\Delta'_e \equiv T'_e + (1-T'_e)\tau_c C'_e + E'_e$

(54) $T_u \equiv -(1-\tau_c c_u)(1-\tau_u)b$ $\Delta'_u \equiv -(1-\tau_c C'_u)(1-T'_u)B'$

(55) $T_a = pT_e + (1-p)T_u$ $\Delta'_a \equiv p\Delta'_e + (1-p)\Delta'_u$

Proceeding as in section 2, we will rewrite equation (47) in terms of a more convenient set of parameters. (The detailed calculations are in Appendix 2.b). The relevant coefficients are defined in Table 3 and include the average and marginal propensities to consume out of after-tax income of students, pensioners and adult employed and unemployed workers (c_i and C'_i with i = s, p, e, u), and the average and marginal rates of employers' social security contributions for employed adult and student workers (e_e, e_s and E'_e) and a set of marginal (Δ'_i) and average (T_i) total tax rates for the different types of agents that capture the combined effect of the different types of taxes and of unemployment and retirement benefits.[11]

Looking at equation (53), for instance, T_e, is the fraction of the gross income of an employed adult worker that is paid in taxes either by himself or by his employer. This variable is the sum of the average rates of personal income tax and employer contributions to social security plus the result of applying the consumption tax rate to the fraction of after-tax income that is consumed. The term T_a measures the expected net tax revenue generated by an active adult worker, that is, the difference between taxes paid when employed (T_e) and net benefits received

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[11] In the case of Germany and Austria, the average and marginal total tax rates for unemployed workers will be given by

$T_u \equiv -(1-\tau_c c_u)(1-\tau_e)\beta$ and $\Delta'_u \equiv -(1-\tau_c C_u')(1-T_e')\beta$

when unemployed $(-T_u)$, both weighted by their respective probabilities. Similarly, Δ'_a captures the expected increase in net tax revenues per active worker that is generated by a marginal increase in his attainment level, S. Both of these expressions can be either positive or negative depending on employment probabilities and tax and benefit levels. The total tax rates on unemployed workers and pensioners (T_u and T_p), on the other hand, are always negative, since government transfers are assumed to be their only source of income.

Using this notation, equation (47) becomes

$$(56)\quad \frac{R}{1-e^{-RH_o}} = R_f' \equiv \frac{\left[T_a \frac{q'}{q}S' + \Delta'_a\,\theta' + (T_e - T_u)p'S'\right] + \gamma(R)\left[T_p \frac{q'}{q}S' + \Delta'_p\,\theta'\right]}{\left[T_a - \eta_q p_s T_s(1-\phi)e^{vH_o/2}\right] + \frac{\mu_g}{q}e^{vH_o/2}} \equiv \frac{N_1 + \gamma(R)N_2}{D}$$

where $q()$, $q'()$ and $p'()$ are all evaluated at S_0, $\eta_q = q_s/q$ and $\theta' = \theta S' - v$. The remaining variables have the same meaning as in section 2 (although some adjustments will have to be made in their values to approximate general equilibrium effects, as will be discussed below). It is also easy to show that the net present fiscal value of a year of schooling, calculated as of time X_o (i.e. when the representative individual leaves school), can be approximated by

$$(57)\ NPFV(r_0) = V_g'(X_o)e^{r_o X_o} =$$

$$= \left\{ N_1 \frac{1-e^{-(r_o-g-v)H_o}}{r_o-g-v} + N_2 e^{-(r_o-g-v)H_o}\,\frac{1-e^{-(r_o-\omega)(Z-U)}}{r_o-\omega} - D \right\} q e^{-vH_o/2} W_o$$

where r_0 is the discount rate, W_0 the average gross salary of a full-time worker with average schooling and N_1, N_2 and D have been defined in (56).

Equation (56) has essentially the same interpretation as the private returns formula given in section 2. That is, r_f is an increasing function of the growth rate of wages over the lifecycle and of the ratio of the marginal (fiscal) benefits of an additional year of schooling to its (budgetary) costs, adjusted for the finiteness of working lives. We have written R_f' so that all its cost and benefit components are measured as fractions of an adult worker's gross wages.

The numerator of R_f' in equation (56) measures the expected net annual contribution to the public budget of an additional year of schooling. Its first term captures the impact of an increase in the labour force participation rate. Since inactive workers have no labour income that can be taxed and are not entitled to unemployment benefits, increasing the labour force participation rate will increase net tax revenues provided tax payments by newly active workers exceed on average the social benefits paid to them. The second term, $\Delta_a'\theta'$, captures the net revenue effects of higher salaries, which increase tax payments by employed workers but also the benefit entitlements of the unemployed. The third term, $(T_e-T_u)p'S'$, reflects the impact of the increase in the probability of employment and is unambiguously positive since greater employment implies both higher tax revenues and lower unemployment payments (recall that T_u is always negative). Finally, the pension-related terms that appear in the numerator are weighted by the same discount factor as in the private returns calculation and are both negative, as pension liabilities will increase both with the rate of labour force participation and with wages.

The denominator of R_f' is the sum of the opportunity and direct budget costs of schooling. The opportunity cost term is the difference between expected net tax receipts from a full-time worker and net receipts from a part-time student worker. The direct cost component, finally, is equal to government expenditure per student divided by the labour force participation rate. This correction is required because expenditure is incurred for all students, but only those that enter the labour force pay taxes on labour income or are entitled to unemployment benefits.

5. Data and parameter values

This section gathers together the data required to calculate the private and fiscal returns to post-compulsory schooling in the member countries of the European Union with the exception of Luxembourg, for which some of the required data are not available. These rates of return will be calculated by applying the formulas derived in the previous sections to a representative individual for each country endowed with average school attainment. We will assume that this representative agent's income, when employed, is equal to the gross earnings of the average production worker (APW) as estimated by the OECD.[12] When computing the private rate of return, it will also be assumed that the agent is active throughout his working life -- that is, that he is active while attending school at post-compulsory levels and remains a member of the labour force until the average retirement age. Hence, the employment probabilities and related parameters used in this calculation are conditional on labour force participation. For the estimation of the fiscal returns, we will also take into account the effect of education on the probability of participation in the labour force of the representative individual.

To calculate the taxes on labour income to which the individual of reference would be subject in each country (including national and regional income taxes and social security contributions) and the unemployment, housing and retirement benefits for which he would be eligible, we have assumed that i) he is single and has no children (so as to abstract from cross-country differences in family support policies), and ii) that any unemployment spells he suffers are relatively short-lived and do not exhaust contributive benefits.

Our estimates of private returns will be obtained under partial equilibrium assumptions, that is, taking as given the aggregate level of schooling and factor prices. To calculate fiscal returns, on the other hand, we will try to approximate general equilibrium conditions. This will require adjustments that will reduce the values of some of the key parameters (in particular, θ, $p'$and q'), as will be discussed in section 7 below.

[12] This assumption is made for convenience, as it allows us to make use of the estimates of APW earnings and of the relevant tax rates that are provided by the OECD for all countries in the sample. It should be noted, however, that this is not necessarily a good approximation, for average wages and skill levels in manufacturing may differ from those in the overall economy.

Table 4: Parameter values used in the calculation of the private and fiscal return on schooling

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g = 1%, growth rate of average real wages. Source: AMECO Database, European Commission, DG for Economic and Financial Affairs.

v = 1.38%, percentage increase in real wages with each year of experience. See footnote no. 13.

$1-\phi$ = 0.2, part-time student earnings as a fraction of APW wages.

$c_e = C'_e$ = 0.8, average and marginal propensities to consume out of after-tax income for employed adult workers.

c_s = 1, average propensity to consume of employed students.

$c_u = C'_u = c_p = C'_p$ = 0.9, average and marginal propensities to consume of unemployed adult workers and pensioners.

Tables 4 and 5 define the variables and parameters used in the computation of the private and fiscal rates of return to schooling and gives their sources. We have set the growth rate of average real wages in the economy *(g)* to 1%. This is the observed average annual growth rate of real compensation per employee in the EU15 between 1981 and 2000. The experience component of the growth rate of individual wages over the lifecycle *(v)* has been set at 1.38% per annum. This figure has been obtained as the constant growth rate that better approximates the quadratic experience-earnings profile estimated for a typical EU country.[13] We have also assumed that student earnings from part-time work are 20% of the wages of an adult worker of average attainment and experience. Finally, we assign what we consider conservative values to the average and marginal propensities to consume of different types of workers (c_i and C'_i with $i = e, u, s, p$ for employed and unemployed adult workers, students and pensioners, respectively).

Our estimates of the direct costs of schooling (μ, μ_s and μ_g) are based on data on expenditure on secondary and higher education taken from recent issues of the OECD's *Education at a Glance*. These variables try to approximate the (total, private and public) cost per student of a marginal increase in enrollments, which would have to come at the upper secondary and university

[13] We estimate v by fitting a linear trend to the wage-experience profile predicted by a set of Mincerian regressions. Since HWW do not report the coefficients of potential experience and its square we proceed as follows. First, we estimate a Mincerian wage regression with 1996 ECHP data for those countries for which hourly wages can be recovered. We use the estimated coefficients of potential experience and its square to construct the time profile of the experience premium (in log terms) and regress it on a linear trend for each country. The slope coefficient of this regression provides a preliminary estimate of v for each country. We calculate the ratio of this quantity to the estimate of θ from the same regression (which is different from the one used in our calculations), and average these ratios across countries, obtaining a value of 0.1927. We then multiply this value by the average value of θ in our sample (after correcting it for the likely net bias). This gives a value of 1.38%, which is our final estimate for v.

Table 5: Variables used in the calculation of the private rate of return on schooling and sources of the data

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μ_s and μ_g = private and government expenditure per student and year, measured as a fraction of APW gross earnings. Source: *Education at a Glance*. See section 1 of Appendix 1.

μ and μ_g' = total expenditure per student and year, net and gross of government grants for non-tuition purposes, measured as a fraction of APW gross earnings. Source: *Education at a Glance*. See section 1 of Appendix 1.

W_0 = gross wage of the average production worker (APW) in 2000. Measured in US dollars using current exchange rates. Source: OECD (2001).

θ = Mincerian returns to schooling parameter. Source: constructed using estimates for 1995 taken from Harmon, Walker and Westergaard-Nielsen (2001) and other authors.

p, p' = probability of employment after leaving school, conditional on participation in the labour force, and derivative of p with respect to school attainment. Source: estimated using individual data from ECHP.

p_S = probability of employment while attending school, conditional on participation in the labour force. We estimate it as $p_S = \eta p$, where η is defined below.

η = correction factor capturing the greater difficulty of finding part-time employment while attending school. Source: calculated as the ratio between the probability of employment of those enrolled in education and those not enrolled in education among active workers aged 20 to 24, using data for 1998 from *Education at a Glance 2000*. See section 3 of Appendix 1.

q, q_S, q' and η_q = probability of labour force participation of adult workers and students, derivative of the first variable with respect to school attainment and adjustment factor for students. Constructed using the same sources and procedure as p, p_S, p' and η .

τ_e and T_e' = average and marginal tax rates on labour income (including national and regional income taxes and employee social security contributions) applicable in 2000 to a single employed worker earning APW wages. Source: OECD Tax database.

τ_S = average tax rate on student earnings from part-time work, estimated as the tax rate on labour income applicable in 2000 to a single worker earning 20% of the APW salary. Source: estimated using OECD (2001).

τ_u and T_u' = average and marginal tax rates on unemployment and housing benefits applicable to a single worker earning APW wages prior to the loss of employment. Source: estimated using OECD (2000).

τ_p and T_p' = average and marginal tax rates on pensioners at the midpoint of the retirement period. Source: estimated using OECD (2001 and 2005). See Section 2 of Appendix 1.

pb = gross pension replacement rate at the time of retirement (= initial pension before tax/gross wage at retirement). Source: OECD (2005). See Section 2 of Appendix 1.

PB' = marginal gross pension replacement ratio (increase in initial benefits resulting from a marginal increase in average income). Source: estimated using OECD (2005). See Section 2 of Appendix 1.

Table 5: Variables used in the calculation of the private rate of return on schooling and sources of the data -- continued

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ω = rate at which a worker's pension grows over time in real terms. Source: OECD (2005). See Section 2 of Appendix 1.

τ_c = Consumption tax rate. Source: Carey and Tchilinguirian (2000).

e_e and E'_e = average and marginal rates of employer social security contributions (expressed as a fraction of gross wages rather than total labour costs) applicable to a single employed worker earning APW wages. Source: OECD Tax database.

e_s = average rate of employer social security contributions for part-time student work. Estimated using the OECD Tax database.

b and B' = average and marginal gross replacement ratio. The average gross replacement ratio is defined as the ratio of gross unemployment and housing benefits to gross income in employment. Source: OECD (2000).

β = net replacement ratio (ratio of unemployment benefits to net after-tax earnings while employed). This is calculated for countries where benefits are linked to after-tax earnings in employment (and are not taxed). Source: OECD (2000).

$S'(X_0)$ = expected increase in schooling (measured in completed grades) per additional year spent in school. Estimated using OECD data on school survival probabilities as discussed in section 4 of Appendix 1.

S_0 = average years of school attainment of the adult (over 25) population in 1990. Source: de la Fuente and Doménech (2006).

X_0 = years required to complete average attainment. See section 4 of Appendix 1.

U = Average retirement age in 1995. Source: Blöndal and Scarpetta (1999).

$H = U - Max(6+X_0, 14)$ = estimated length of the (post-school) working life of the representative individual.

Z = Life expectancy at birth in 2000. Source: Eurostat. Calculated as a weighted average of male and female life expectancies with weights given by each sex's share in total employment.

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levels since attendance at lower levels is already compulsory in the EU. Public expenditure (μ_g) includes the operating costs of public educational institutions (net of research expenditure by universities), subsidies to private centers and two types of subsidies to households: tuition-related grants and cash subsidies that help defray living expenses and other costs. The private (household) expenditure indicator (μ_s) captures the net costs paid by families and is shown net of government transfers (which makes them negative in quite a few European countries). We do not take into account expenditure on books, school materials, lodging or transportation. Total expenditure (μ) is calculated as the sum of public and private expenditure (plus expenditure by enterprises on apprenticeship programmes in the case of Germany)[14] and is shown net of non-tuition grants, which we consider a transfer of income to the private sector rather than a real resource cost of education. We also calculate total expenditure inclusive of non-tuition grants. This variable will be denoted by μ_g' because we will use it in our calculation of fiscal returns as an estimate of the budgetary cost per student of an increase in attainment financed entirely by the government, holding constant the observed level of non-tuition subsidies.

All our indicators of the direct costs of schooling are weighted averages of expenditure per student at the secondary and tertiary levels and are measured as a fraction of the gross earnings of the average production worker *(W_0)*. We use weights of 2/3 and 1/3 for secondary and tertiary schooling respectively to try to capture the impact of a marginal change in upper secondary attainment under the assumption that half of the new graduates will go on to university.

Mincerian returns

A key input to our calculations is the Mincerian returns to schooling parameter *(θ)* that measures the percentage increase in gross wages (wages before income taxes and employee social security contributions) resulting from an additional year of schooling. Seeking a balance between the reliability of individual estimates and cross-country comparability, we have constructed a set of estimates for this parameter using the results of microeconometric wage regressions reported in Harmon, Walker and Westergaard-Nielsen (HWW, 2001), de la Fuente, Doménech and Jimeno (2003), de la Croix and Vandenberghe (2003) and Ciccone (2004).[15]

The first of these sources is the introduction to a collective volume summarizing the results of a large research project on the returns to education in Europe known as PURE *(Public funding and private returns to education)* that was sponsored by the European Commission. In this paper, HWW use relatively homogeneous data on hourly wages provided by the project's national teams to estimate the Mincerian returns parameter *(θ)* using a common econometric specification. For each country, they estimate separate wage equations for men and women controlling for potential experience (i.e. time since the completion of education) and the square of this variable. For the eight countries in our EU sample for which HWW provide estimates based on data on gross wages, our estimate of θ is obtained by averaging their male and female estimates, weighting them by the share of each sex in total employment (using data from the 2000 Labour Force Survey provided by Eurostat).

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[14] Educational expenditure by enterprises only appears to be significant in Germany, where the bulk of non-public spending on secondary education corresponds to contributions by business firms to apprenticeship programmes. (We thank L. Wössman for pointing this out).

[15] One alternative we have explored is to estimate the Mincerian parameter using data from the European Community Household Panel Survey (ECHP). However, this source has some serious disadvantages relative to the national data sets used in the studies cited above that in our view more than outweigh the potential advantages of using a common data source. In particular, the breakdown of the population by educational attainment is generally much coarser than in national sources, sample sizes are considerably smaller in many cases, and hourly wages cannot be recovered for all countries.

The remaining countries are Belgium, for which HWW provide no results, and a set of five countries (Austria, Greece, Italy, the Netherlands and Spain) for which the data used by HWW refer to net rather than gross wages (i.e. to wages after personal income taxes and employee social security contributions have been witheld). For Spain, Belgium and Italy, our estimates of θ are taken from a set of recent studies of the economic returns to education also sponsored by the European Commission (de la Fuente, Doménech and Jimeno (2003), de la Croix and Vandenberghe (2003) and Ciccone (2004)). The first two of these studies use data on gross wages and a specification that is identical to the one in HWW except in that a single equation is estimated for men and women jointly, including a sex dummy variable to allow for differences in wage levels. Using the same specification, Ciccone (2004) works with data on net wages but then adjusts his results to approximate gross returns using previous estimates of gross and net returns in Italy to construct a correction factor.

For the remaining countries, we have constructed estimates of the gross (before-tax) return to schooling as follows. In the case of the Netherlands, we have found in the chapter for this country of the PURE volume (Smits et al, 2001) an estimate of male and female returns to schooling based on gross wages in 1996 that is obtained with a specification almost identical to the one used by HWW (p. 183, Table 10.3).[16] Since similar estimates could not be found in the country chapters for Austria and Greece, we have adjusted HWW's results using the theoretical relationship between net and gross returns. The procedure is as follows. In the notation of section 2, the gross return to schooling is given by $\theta = f'(S)/f(S)$ and the net return by $\theta_n = F_e'(S)/F_e(S)$ where $F_e(S) = f(S) - T[f(S)]$. Working with this last expression, it is easy to show that

$$\theta_n = \frac{F_e'(S_o)}{F_e(S_o)} = \frac{(1-T_e')f'(S_e)}{(1-\tau_e)f(S_e)} = \frac{(1-T_e')}{(1-\tau_e)}\theta$$

where T_e' and τ_e are the marginal and average income tax rates applicable to the average employed worker. We have used this formula to estimate the gross return to schooling given HWW's estimate of the net return. The data on marginal and average tax rates required for the calculation are taken from the OECD Tax Database and come originally from *Taxing Wages* (OECD, 2001). They refer to the year 2000 and are those applicable to a single person with no children and APW gross earnings. This calculation yields adjustment ratios of 0.873 for Greece and of 0.792 for Austria.

All the estimates of θ we have used are obtained by OLS (or WLS) and are therefore potentially subject to conflicting biases arising from measurement error and from the omission of ability in the regression. The consensus view in the literature seems to be that the net effect is likely to be a small upward bias. On the basis of a review of the results of twin studies, Card (1999) argues that the net bias in OLS estimates of the returns to schooling is likely to be around 10%. We have used this figure to correct the estimates discussed above. The values of θ shown in Table 7

[16] The only difference is that, unlike HWW, Smits et al include a dummy for part-time workers in the female equation, but its estimated coefficient is zero.

below already incorporate this correction. They have been obtained by multiplying the original estimates by 0.9.

Employment and participation effects

Following Heckmann (1979), we use a two-stage procedure to estimate the effect of schooling on labour force participation rates and employment probabilities. First we estimate a probit model that relates the probability that a given individual will be active *(q)* to his or her level of education, measured by years of schooling, and to a series of personal characteristics and other variables that are listed in Table 6. Then, we estimate a second probit relating the probability of employment *(p)* to schooling and to a subset of the same explanatory variables, including as an additional regressor a variable that measures the propensity of the individual to participate in the labour market.[17] This variable, known as the inverse Mill's ratio, is constructed using the results of the first-stage regression. Its inclusion in the second equation serves to correct the likely sample selection bias that would arise in its absence.

Table 6: Non-schooling variables used in the participation and employment equations

	participation	*employment*
sex (male)	X	X
potential experience	X	X
potential experience squared	X	X
married (*)	X	
married*male	X	
children below twelve	X	
children below twelve* male	X	

(*) In addition to those that declare this status, we count as married those persons that are living in a "consensual union" with another person (question PD007).

The data are taken from the 1996 wave of the European Community Household Panel survey (ECHP), except in the case of Sweden where the data correspond to 1997. The years of schooling variable used in the participation and employment probits is constructed by combining information from two different questions in the ECHP survey with the theoretical durations of the different school cycles reported in de la Fuente and Doménech (2002, Table 4). The first question classifies respondents into three educational levels (low, medium and high, with high corresponding to tertiary studies and medium to upper secondary). The second question gives the age at which the individual left the highest schooling cycle he completed. This last question can in principle be used to construct a direct estimate of years of schooling, but the percentage of responses is low in four countries. An additional problem is that an estimate of years of schooling based on this question will be biased upward if the agent had to repeat a course or temporarily interrupted his studies at some point. Hence, we base our attainment estimates on

[17] In order to avoid identification problems, the explanatory variables used in the second equation should be a subset of the set of regressors of the first-stage equation (see Wooldridge, 2002). In our case, we

the response to the first question. On the other hand, we use the second question to try to refine the initial breakdown into three educational levels by distinguishing between primary and lower secondary education on the one hand, and between the first and second cycles of university on the other. For instance, a person who classifies himself as having a low education will be assumed to have completed lower secondary schooling except if the number of years of schooling implied by the answer to the second question is lower than the theoretical cumulative duration of this cycle, in which case we assume the individual has only completed primary schooling.

The detailed results of the estimation are in Tables A.12 and A.13 in section 5 of Appendix 1. The probabilities of employment *(p)* and of labour force participation *(q)* of adult workers are estimated as the prediction of the relevant equation for the average values of the regressors. Our preliminary estimates of p' and q' are the estimated marginal effects of schooling calculated at the sample means of all the regressors. Since these estimates potentially suffer from the same biases as the Mincerian coefficients discussed above, our final estimates of p' and q' are obtained by multiplying the preliminary estimates by 0.9 and 0.8 respectively. This correction is entirely ad-hoc since we lack an outside estimate of the size of the relevant net bias, but it seems plausible that the bias on p' will be of the same order of magnitude as that in wage equations, and that the bias on q' should be larger as agents who know early on that it is unlikely that they will be seeking a job in the future for reasons that we cannot control for will choose to leave school early.

We have been unable to use the ECHP data to estimate the employment and participation probabilities of students.[18] To get around this problem, we have used aggregate data from the 2003 edition of *Education at a Glance* to calculate rough correction factors for the employment and participation probabilities of students (η_p and η_q). This source reports the employment and participation rates of the 20 to 24 age group in 2001, distinguishing between those enrolled in educational institutions and those who have already completed their formal schooling. A preliminary estimate of the correction factors is obtained by dividing the first of these figures by the second one. To obtain the values of η_p and η_q shown in Table 7 below, we assign a value of 1 to countries where the preliminary estimate exceeds that value (that is, we assume that, other things equal, it is never easier to find part-time employment as a student than a full-time job). See section 2 of Appendix 1 for further details.

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assume that marital status and the number of children under twelve years of age affect the participation decision but not the probability of employment conditional on participation.

[18] The survey includes two questions that may in principle be used to identify students, but neither of them suits our purposes. The first one asks whether the individual is or has been enrolled in formal schooling during the current or preceding year, and the second one asks the person to identify his or her main activity, giving "student" as an option. The problem with the first question is that, because it mixes currently enrolled students with those who have recently completed their training, its use as a control variable will underestimate the effects of school enrollment on the variables of interest. For the second question, the problem is the opposite one, as it is likely that many employed students will fail to report education as their main occupation. In some countries, for instance, the intersection between self-reported students and the labour force or the employed population is empty.

Tax rates and unemployment and retirement benefits

Tax and benefit parameters are taken from various OECD sources and refer to single individuals with no children. All the personal tax rates used to calculate private returns incorporate (local, regional and national) income taxes and, when appropriate, employee (but not employer) social security contributions so as to be consistent with the definition of gross wages that seems to have been used in the wage equation estimates we are using. For the calculation of fiscal returns, employer social insurance contributions and consumption taxes are taken into account as well.

The average and marginal tax rates on adult employed workers (τ_e and T_e') and employer social security contribution rates for full-time workers (e_e and E_e') are taken directly from the OECD's on-line Tax Database (and originally from *Taxing Wages*) and refer to the year 2000. The tax rates on employed adult workers are those applicable to an individual earning the same salary as the average production worker (APW), i.e. with average earnings for full-time workers in the manufacturing sector. Employer social contribution rates on part-time student earnings (e_s) have been approximated, for lack of better information, by those applicable to workers earning 67% of APW wages. For most countries this is actually correct, as contributions are levied at a flat rate on gross wages, but in a handful of them this is not the case.

The average tax rate on student income (τ_s) and the average and marginal tax rates on pensioners (τ_p and T_p') have been constructed using the description of the 2000 tax systems of European countries given in *Taxing Wages 2000-2001* (OECD, 2001). In the case of students, we have assumed a gross income level equal to 20% of before-tax APW earnings. For pensioners, we use the tax rates corresponding to estimated gross pension income at the midpoint of the retirement period. We have relied on the notes given in the country chapters of OECD (2005) and in chapter S.1 of OECD (2001) on the tax treatment of pension income to complement our basic source on EU tax systems.

The consumption tax rate (τ_c) is taken from Carey and Tchilinguirian (2000). These authors construct τ_c as the ratio between consumption tax revenue (including excise and general consumption taxes) and total final consumption measured in gross terms (i.e. including indirect taxes) using data for the period 1991-97 taken from the OECD's *National Acccounts* and *Revenue Statistics*.

Unemployment benefit parameters (B', b and β) and the average and marginal tax rates on unemployed workers (τ_u and T_u') have been calculated using the information contained in the country chapters of the OECD's *Benefit Systems and Work Incentives 1999* (OECD, 2000) assuming again that we are dealing with a single individual with no children whose wage prior to the loss of employment was equal to APW earnings.[19] We have used this source rather than OECD (2001) because it contains a more detailed description of the tax treatment of unemployment benefits. For this calculation, we have assumed that any unemployment spells experienced by the representative worker are sufficiently brief that he does not exhaust the contributive benefits to which he is entitled. Replacement rates have been constructed taking into account benefit ceilings (the marginal rate, B', is set to zero when the ceiling is binding for our reference individual) and incorporate housing benefits for the unemployed but treating them as lump-sum payments. While this is incorrect in many cases, the description of these benefits provided by OECD (2000) is too sketchy to allow a more careful treatment, and the resulting error is unlikely to be important because housing benefits are generally a small fraction of income out of employment. The one exception to this is the UK, but the amount of the benefit appears to be fixed in this case. (See section 2 of Appendix 1 for additional details on tax and benefit parameters).

Data on retirement benefits under mandatory pension schemes have been taken from OECD (2005). This source provides estimates of starting pensions for workers with a "full carrer" of contributions (between age 20 and the statutory retirement age) at different levels of average income as well as information on pension indexation practices. Marginal benefit ratios (PB') linking starting pensions with pre-retirement income have been estimated by comparing the initial pensions of workers with average income levels of 100% and 150% of APW wages. Initial pensions expressed as a fraction of APW gross wages have then been projected to the midpoint of the worker's expected post-retirement life using the indexation rates taken from OECD (2005) and our assumption on the growth of average earnings. We use the relative income of pensioners at this point in life to calculate the relevant tax rates. For additional details see section 2 of the Appendix.

Academic failure rates, school durations and length of working lives

As noted above, we distinguish between school attainment measured by the number of successfully completed grades, S, and the number of years spent in formal schooling, X. These two quantities can differ because students may take several years to complete a single grade or may drop out of the system without passing a grade. To construct the function $S(X)$ that relates these two variables, we would need comparable data on repetition and drop out rates for the countries in the sample. Since we have not been able to find such information, we have constructed a rough approximation to $S(X)$ using OECD data on survival rates in tertiary studies and on other indicators that can be used to approximate the school survival rate at the upper secondary level.

In particular, we approximate the marginal contribution of time in school to academic progress, $S'(X_0)$, by an estimate of the yearly probability of survival in school (σ). This probability is

[19] While the tax parameters for employed workers and students correspond to 2000, the tax and benefit parameters for unemployed workers will reflect the regulations in force one year earlier. This is unlikely to be an important problem, as legislative changes between the two years appear to be infrequent and minor.

estimated separately for upper secondary (σ_{usec}) and tertiary studies (σ_{univ}) using the procedure discussed in section 4 of Appendix 1. The results are then averaged across levels in the usual way, so that the single value of $S'(X_0)$ that is used in the rate of return calculations is given by $S'(X_0) = (2*\sigma_{usec}+\sigma_{univ})/3$.

The estimates of σ are also used to correct upward the theoretical duration of these two school cycles so as to approximate the actual time spent in school by the average individual in each country. The corrected duration of each cycle will be given by $D_i = d_i/\sigma_i$, where d_i is its theoretical duration in years and $1/\sigma_i$ the average time required to complete each grade. The time spent in school by an individual of average attainment, X_0, is then computed in the usual manner but using the corrected rather than the theoretical durations of the upper secondary and tertiary school cycles (ignoring therefore any potential delays carried over from compulsory schooling). The calculation makes use of the breakdown of the adult population by attainment level given in de la Fuente and Doménech (2001) and refers to 1990.

The expected length of the working life of the representative individual (H_0) is calculated as the difference between the average retirement age and the age at which average attainment has been completed (provided this last figure is at least fourteen years). Retirement ages refer to 1995 and are calculated by averaging the estimates for males and females reported by Blöndal and Scarpetta (1999), weighting them by the share of each sex in total employment (using Eurostat data for 2000 referring to the age group 25-64). Average life expectancy (Z) is calculated in a similar way using separate estimates for males and females taken from Economic Policy Committee (2001) and ultimately from Eurostat.

Table 7 shows the actual data used in the rate of return calculations. Blank entries indicate that either the variable is not defined for a given country or is irrelevant for the calculations. For instance, β is defined only for Germany and Austria because these are the only two countries that link unemployment benefits to after-tax income in employment, and the marginal tax rate on unemployed workers, T_u', is not given for those countries where unemployment compensation is paid at a fixed rate or benefit ceilings are binding for the average worker (so that $B' = 0$ in any event) because the term that enters the rate of return calculations involves the product of these two variables.

Bold type is used in Table 7 to identify unreliable data. Bold entries in the table indicate that an observation is suspicious or that the data required for its calculation are unavailable and have been "estimated" by imputing to problem countries the values observed in close neighbours or in countries with similar income levels. Plain bold characters are used when data problems can be expected to have an important effect on the rate of return calculations, and bold italics are used otherwise. Missing information about educational expenditure or its financing has been a problem in four countries (Austria, Greece, Italy and Portugal) but this should not have a material impact on the estimated rates of return, except possibly in the case of Portugal where expenditure may appear to be artificially high when measured as a fraction of APW earnings due to the suspect and atypically low value of this variable relative to GDP per capita (see section 1c of Appendix 1). Our estimates of $S'(X_0)$ in Greece and the UK are also based on incomplete data, as no information on survival rates is available for the UK at the university level and for Greece in the upper secondary cycle.

Table 7: Data used in the calculation of the private and fiscal returns to schooling

	μ	μ_s	μ_g	$\mu_g{}'$	W_0	θ	p'	p	p_s
Austria	**35.33%**	-1.40%	36.73%	**37.70%**	21,364	7.74%	0.34%	95.66%	93.47%
Belgium	21.46%	0.32%	21.14%	22.99%	26,721	6.30%	1.50%	92.82%	92.82%
Denmark	21.38%	-4.44%	25.82%	26.21%	34,975	5.14%	0.48%	94.86%	92.80%
Finland	22.91%	-1.84%	24.74%	25.13%	29,587	7.83%	1.56%	88.16%	86.62%
France	32.76%	1.94%	30.82%	33.42%	19,171	6.99%	1.58%	92.67%	92.67%
Germany	21.29%	0.00%	18.26%	22.49%	29,423	7.85%	0.60%	94.13%	94.13%
Greece	21.56%	**0.98%**	20.58%	21.92%	9,734	7.39%	1.20%	88.59%	78.58%
Ireland	27.20%	0.73%	26.48%	30.07%	20,392	9.81%	2.14%	91.74%	90.04%
Italy	**25.28%**	0.74%	24.54%	**26.15%**	18,951	6.19%	1.88%	85.81%	73.02%
Netherlands	21.40%	-1.34%	22.74%	23.68%	26,062	6.03%	0.53%	96.14%	95.05%
Portugal	**39.51%**	**-0.33%**	**39.84%**	**40.14%**	**7,041**	8.73%	0.38%	95.79%	95.79%
Spain	25.64%	4.05%	21.59%	26.12%	13,816	7.54%	2.21%	80.05%	72.15%
Sweden	29.84%	-5.80%	35.64%	37.61%	25,118	3.56%	1.40%	89.89%	84.79%
UK	20.34%	0.94%	19.40%	22.31%	27,864	9.30%	0.70%	94.62%	94.62%
avge. EU14	*26.14%*	*-0.39%*	*26.31%*	*28.28%*	*22,159*	*7.17%*	*1.18%*	*91.50%*	*88.33%*

	q'	q	η	η_q	τ_s	τ_e	$T_e{}'$	τ_u	T'_u
Austria	1.13%	75.43%	0.977	0.222	18.20%	0.279	0.429		
Belgium	2.21%	79.89%	1.000	0.183	13.07%	0.419	0.555	0.00%	
Denmark	0.86%	86.82%	0.978	0.757	20.04%	0.441	0.507	33.84%	
Finland	1.28%	84.13%	0.983	0.566	23.20%	0.336	0.480	20.89%	34.63%
France	2.18%	79.25%	1.000	0.257	18.01%	0.268	0.335	11.15%	40.56%
Germany	1.29%	82.42%	1.000	0.628	20.50%	0.420	0.579		
Greece	1.16%	69.50%	0.887	0.122	15.90%	0.181	0.285	4.22%	15.90%
Ireland	2.94%	73.79%	0.982	0.228	0.00%	0.203	0.525	0.00%	
Italy	1.77%	71.87%	0.851	0.167	9.19%	0.285	0.404	0.67%	19.00%
Netherlands	1.53%	81.18%	0.989	0.695	10.52%	0.362	0.531	27.55%	37.05%
Portugal	1.12%	74.84%	1.000	0.218	11.00%	0.177	0.260	0.00%	0.00%
Spain	2.05%	69.26%	0.901	0.250	6.35%	0.185	0.288	10.68%	
Sweden	0.77%	91.37%	0.943	0.358	24.21%	0.329	0.352	31.97%	
UK	0.54%	82.81%	1.000	0.636	0.00%	0.236	0.320	0.00%	
avge. EU14	*1.49%*	78.75%	0.964	0.378	*13.73%*	*0.294*	*0.418*		

Notes:

- The values of θ, p' and q' shown in the table are the original OLS estimates multiplied by an adjustment coefficient (0.9 in the first two cases and 0.8 in the third one) that attempts to correct for the likely net endogeneity bias.
- Entries in bold type indicate unreliable estimates. For the sake of completeness, we generally estimate missing data by assuming that a country is similar to its neighbours.
- When the value of η given in Table A.6 of Appendix 1 exceeds 1, we use a value of 1.
- We estimate educational expenditure by enterprises in Germany to be 3.03% of APW wages.

Table 7: Data used in the calculations -- continued

	τ_p	T'_p	e_e	E'_e	e_s	τ_c	pb	PB'	ω
Austria	16.72%	33.73%	23.50%	23.50%	23.50%	20.0%	59.35%	78.30%	0
Belgium	15.84%	28.63%	32.70%	34.70%	31.70%	18.7%	30.91%	23.30%	0
Denmark	28.03%	39.80%	0.50%	0.00%	0.70%	25.7%	32.10%	4.30%	0
Finland	25.93%	37.87%	26.00%	26.00%	26.00%	22.7%	53.55%	71.50%	0.20%
France	9.91%	23.44%	41.20%	41.20%	29.10%	18.0%	39.54%	46.30%	0
Germany	3.80%	3.80%	20.50%	20.50%	20.50%	15.8%	34.63%	45.80%	1%
Greece	1.37%	5.00%	28.00%	28.00%	28.00%	18.6%	60.51%	84.00%	0
Ireland	0.00%	0.00%	12.00%	12.00%	8.50%	22.8%	22.19%	0.00%	1%
Italy	16.94%	25.50%	34.10%	34.10%	34.10%	16.0%	57.67%	78.80%	0
Netherlands	13.88%	20.05%	16.20%	12.30%	15.90%	18.7%	51.72%	68.30%	1%
Portugal	2.11%	14.00%	23.75%	23.75%	23.75%	20.5%	47.79%	64.30%	0
Spain	9.75%	28.62%	30.60%	30.60%	30.60%	13.7%	58.91%	81.20%	0
Sweden	27.45%	30.38%	32.90%	32.90%	32.90%	18.7%	47.24%	64.20%	0
UK	0.92%	10.00%	9.30%	12.20%	7.80%	16.9%	27.25%	13.70%	0
avge. EU14	*12.33%*	*21.49%*	*23.66%*	*23.70%*	*22.36%*	*19.06%*	*44.53%*	*51.71%*	*0.23%*

	β	B'	b	S'	X_0	U	H	Z
Austria	60%			91.14%	11.52	57.68	40.17	77.71
Belgium		0.0%	37.47%	91.59%	10.24	56.12	39.89	77.87
Denmark		0.0%	52.89%	96.70%	11.81	61.17	43.36	77.24
Finland		58.9%	54.41%	96.07%	11.05	58.95	41.90	77.32
France		57.4%	57.40%	93.23%	10.61	58.79	42.18	78.40
Germany	60%			95.77%	13.06	59.59	40.53	77.35
Greece		40.0%	40.00%	***94.18%***	7.98	61.55	47.55	77.82
Ireland		0.0%	23.59%	93.47%	9.51	62.07	46.56	76.18
Italy		30.0%	30.00%	93.57%	8.11	59.36	45.25	77.87
Netherlands		70.0%	73.05%	96.26%	11.02	57.33	40.31	77.76
Portugal		65.0%	65.00%	87.10%	6.50	62.32	48.32	75.29
Spain		0.0%	68.19%	92.89%	7.17	60.50	46.50	77.50
Sweden		0.0%	68.35%	87.83%	10.92	62.72	45.80	79.56
UK		0.0%	35.03%	**93.28%**	10.66	61.36	44.70	77.34
average EU14				*93.08%*	*10.01*	*59.97*	*43.79*	*77.52*

- *Note:* blank entries indicate that a parameter is not defined or not relevant for the calculations.

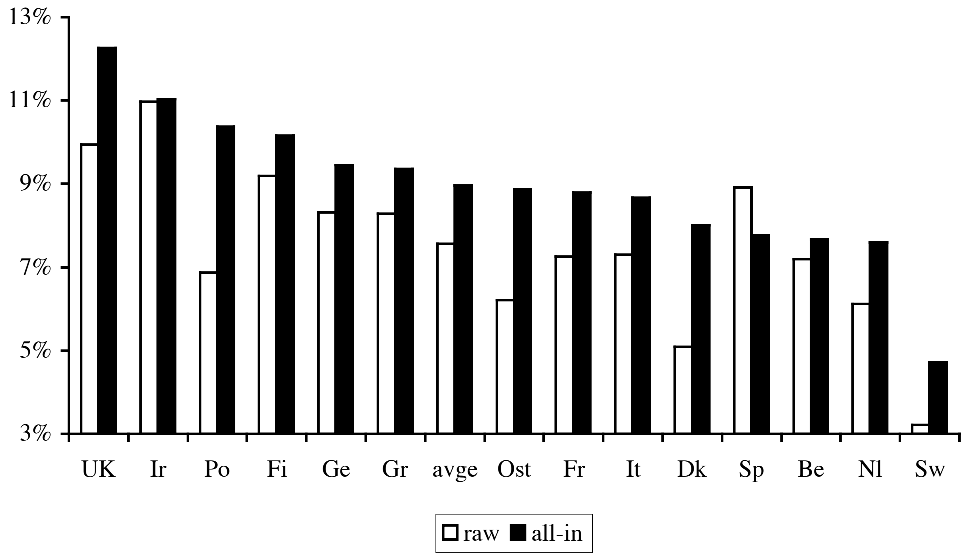
6. Results for the EU: i) Private returns and effective tax rates

Figure 1 displays our estimates of the rate of return to schooling in the member countries of the EU before and after taking into account the effects of public policies (i.e. what we have called the *raw* and *all-in* rates of return).[20] For most countries, the all-in rate of return, r_{obs}, lies

[20] In this figure, and elsewhere in the paper unless otherwise noted, the rates of return for the average EU country are obtained by entering the average values of the relevant parameters into the rate of return formula, and not by averaging the rates of return across countries. We use, in particular, the average values of T', Δ and τ, which are computed in a slightly different manner in Austria and Germany but enter the final formula in the same way.

between 7.5% and 10%, with a value of 8.96% for a hypothetical average EU country. Sweden is a clear outlier. The rate of return estimated for this country (4.72%) is almost three points lower than that of the Netherlands, which is the second country at the bottom of the distribution. By contrast, the estimated value of r_{obs} exceeds 10% in the UK, Ireland, Portugal and Finland. Raw returns vary between 3.21% in Sweden and 10.98% in Ireland.

Figure 1: Private rate of return to schooling in the EU

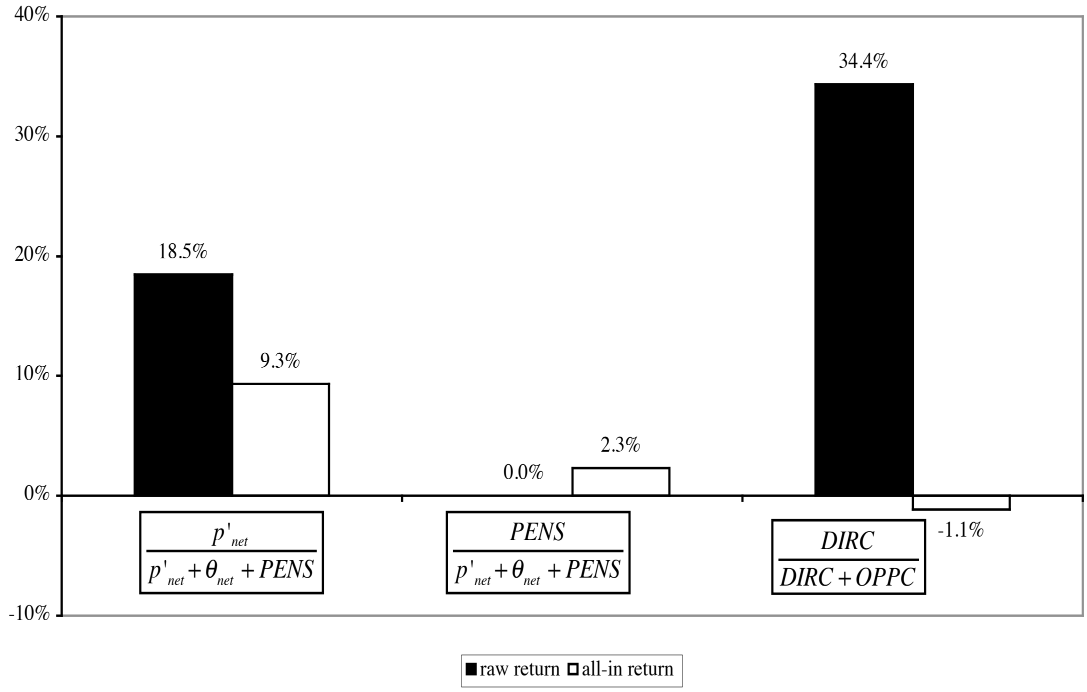


- *Legend: UK* = United Kingdom; *Ir* = Ireland; *Po* = Portugal; *Fi* = Finland; *Gr* = Greece; *Ge* = Germany; *avge.* = average; *It* = Italy; *Ost* = Austria; *Dk* = Denmark; *Sp* = Spain; *Be* = Belgium; *Nl* = Netherlands; *Sw* = Sweden.

Both the raw and the all-in returns to schooling are primarily determined by the wage-related benefits of education and by its opportunity cost, with employment-related effects and direct costs playing a secondary but far from negligible role. As shown in Figure 2, almost 20% of the raw benefits of schooling in the average EU country come from its impact on employment rates, and over one third of its costs are direct resource costs. When we consider government intervention, however, the picture changes significantly: the share of employment effects on the total benefits of schooling drops by almost one half, indicating that this component of returns is taxed more heavily than the wage component, and direct (private) costs become negative as a result of government subsidies in excess of household expenditure on schooling.[21] Pension benefits come into the picture once we introduce government, but their weight in the the total after-tax benefits of schooling is only of 2.3% in the average EU country.

[21] This may be somewhat misleading as our cost estimates do not take into account the purchase of books and other classroom materials or other school-related expenses such as transport.

Figure 2: Relative weight of different cost and benefit components of the return to schooling in the average EU country

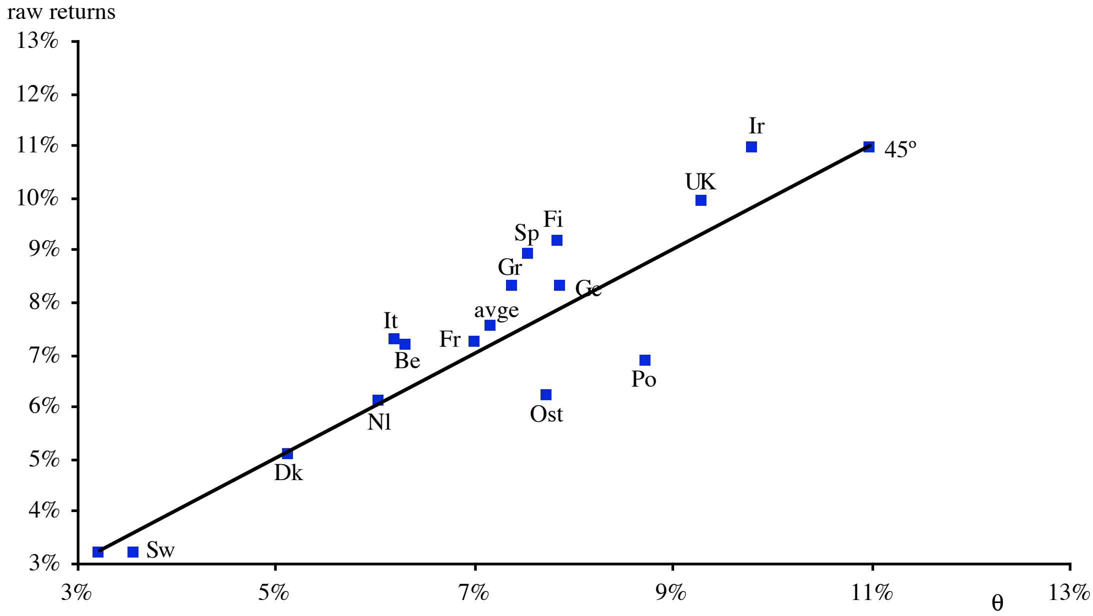


There is considerable variation across countries in these respects, however. Subsidies are particularly generous in the Scandinavian countries, while net private costs are highest in Spain, mainly as a result of the existence of a large private sector at the secondary level which is only partially subsidized by the state. Employment effects account for over 30% of the raw benefits of schooling in Spain, Italy and Sweden and for less than 5% in Germany, Portugal, Austria and the UK. Pensions account for less than 6% of the after-tax benefits of schooling in all countries. (See tables A.14 and A.15 in section 5 of Appendix 1 for the values of the different benefit and cost components of the raw and all-in rates of return).

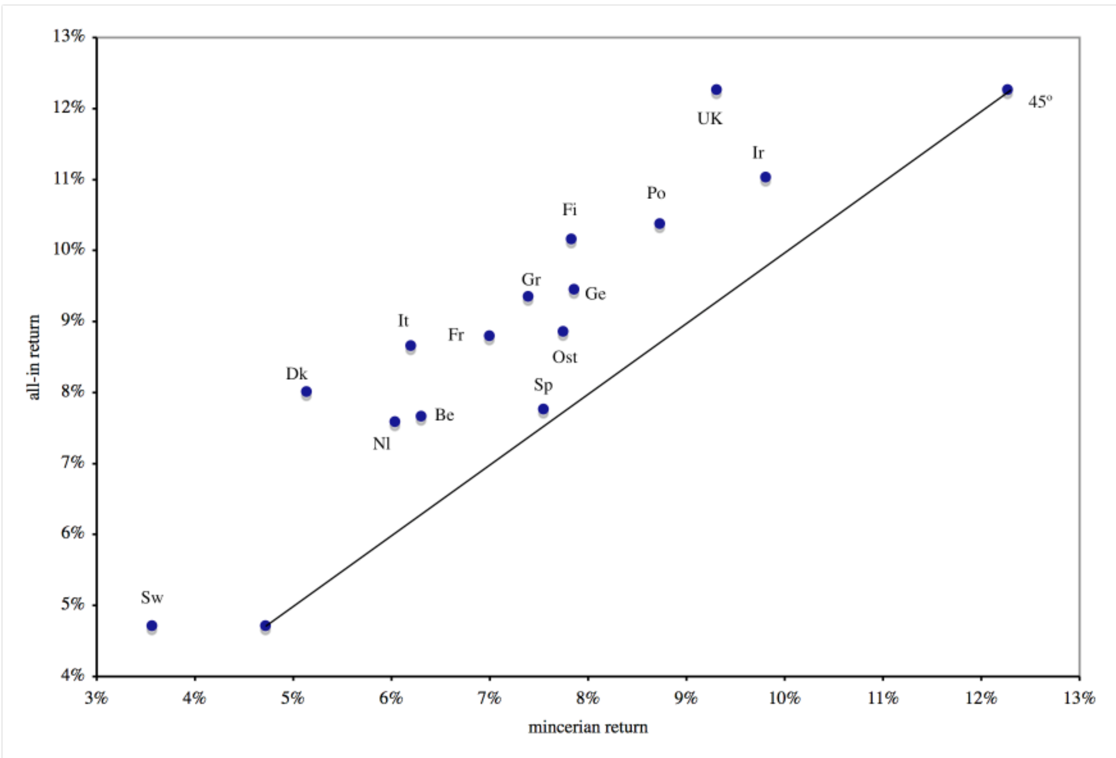
Figures 3a and 3b plot our estimates of raw and all-in returns against the Mincerian returns parameter *(θ)* that is often interpreted as a direct estimate of the returns to schooling. As may be suggested by the preceding discussion, the correlation between θ and both $r_{nogov't}$ and r_{obs} is high (0.87 and 0.91, respectively), but for many countries there are significant differences between θ and the different estimates of the rate of return that reflect, among other factors, the size of employment effects and the impact of taxes, subsidies and other public policies on all-in returns. In Denmark, for instance, the all-in return to schooling exceeds the value of θ by 56%.

Figure 3: Rate of return to schooling vs. Mincerian returns parameter

a. Raw return



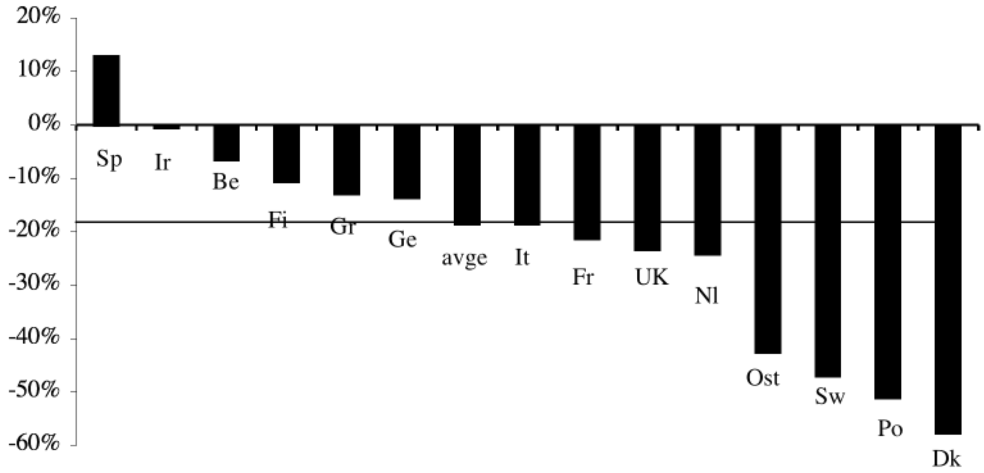
b. All-in return



The effect of public policies

A comparison between the raw and all-in rates of return displayed in Figure 1 suggests that government policies have an often large and rather uneven impact on educational returns. As shown in Figure 4, the effective tax rate on human capital ranges between -57.7% in Denmark and 12.8% in Spain.

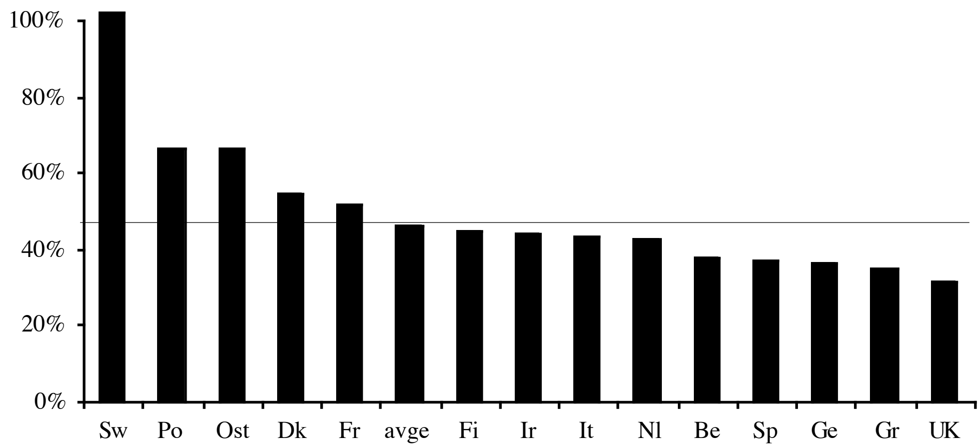
Figure 4: Effective tax rate on human capital ($etr_{gov't}$)



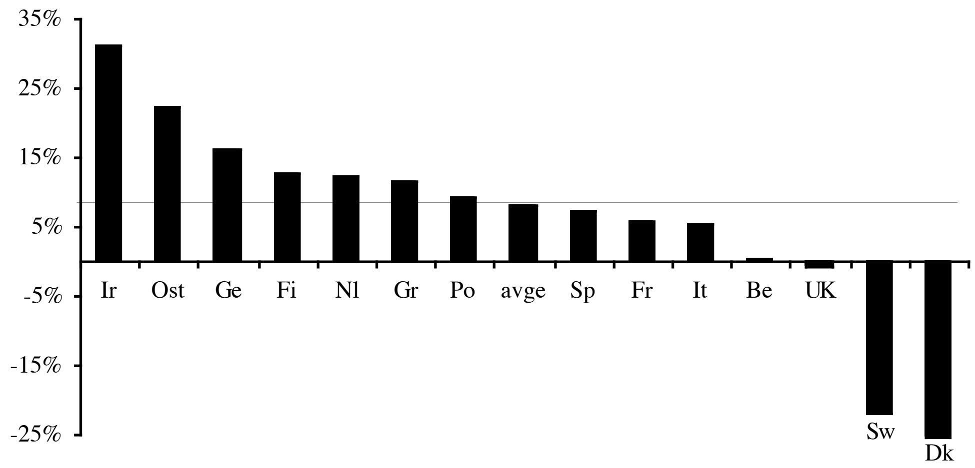
The detailed results of the wedge and tax rate calculations are shown in Tables A.17 and A.18 in section 5 of the Appendix and are summarized in Figures 4 and 5. Table 8 shows the numerical values of the effective tax rates that underlie Figure 4 and a number of the variables that enter the approximate decomposition of this variable given in equation (42) in section 3.

Figure 5: Components of the effective tax rate on human capital

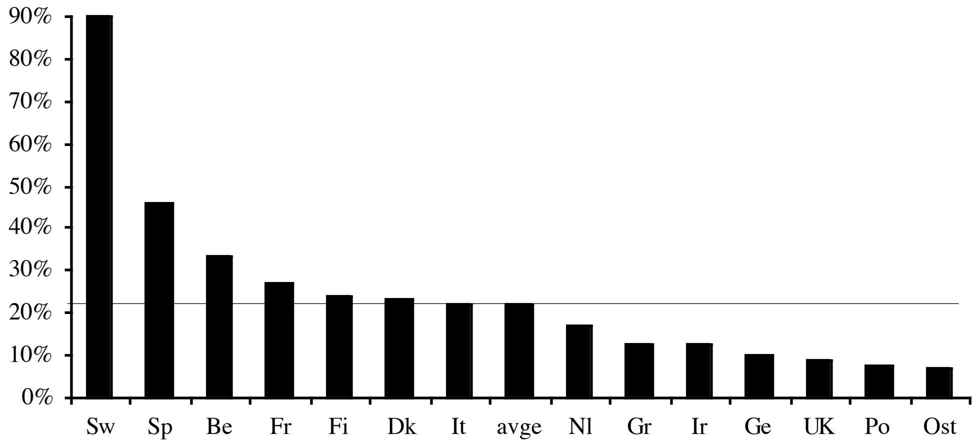
a. Educational subsidies ($subs$)



b. Taxes (etr_{tax})



c. Unemployment benefits (etr_{ben})



d. Pensions ($subs_{pens}$)

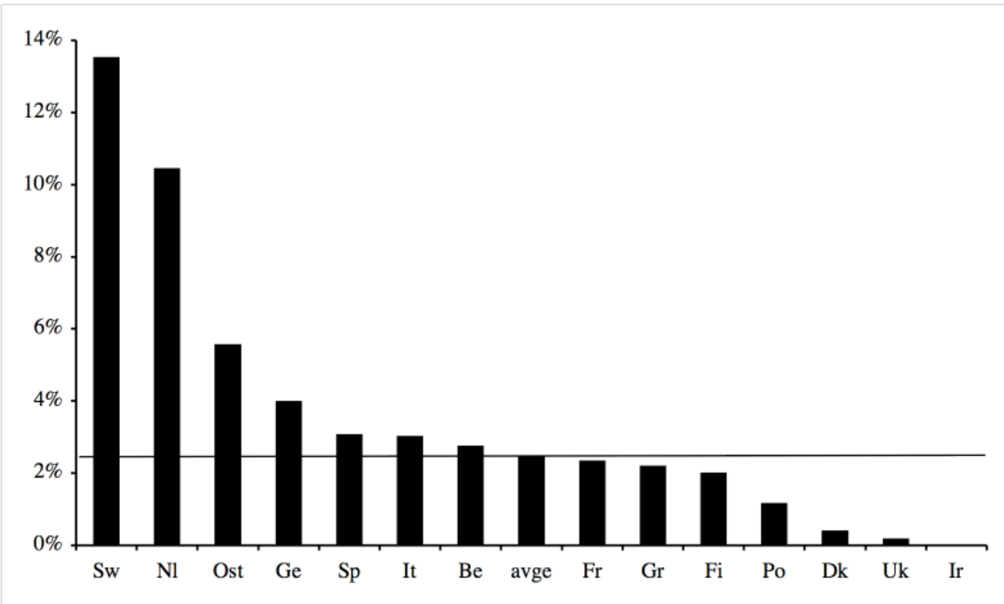


Table 8: Effective tax rate on schooling and its main determinants

	$etr_{gov't}$	$\frac{\varepsilon'}{\theta'+\varepsilon'}$	ρ	π	s	π_e	$\pi-\pi_e$	$\frac{\mu_g}{\mu}$
Spain	12.83%	0.313	0.787	0.264	0.303	0.126	0.137	0.842
Ireland	-0.54%	0.219	0.314	0.419	0.400	0.404	0.015	0.973
Belgium	-6.59%	0.253	0.662	0.270	0.393	0.234	0.036	0.985
Finland	-10.62%	0.217	0.676	0.208	0.371	0.217	-0.009	1.080
Greece	-12.97%	0.187	0.498	0.127	0.286	0.127	0.000	0.955
Germany	-13.65%	0.091	0.614	0.274	0.371	0.274	0.000	1.000
Italy	-18.58%	0.317	0.454	0.168	0.368	0.166	0.001	0.971
France	-21.36%	0.237	0.713	0.104	0.376	0.092	0.013	0.941
UK	-23.39%	0.086	0.472	0.133	0.343	0.110	0.023	0.954
Netherlands	-24.16%	0.107	0.835	0.262	0.402	0.265	-0.003	1.063
Austria	-42.54%	0.054	0.611	0.208	0.439	0.208	0.000	1.040
Sweden	-47.01%	0.440	0.715	0.104	0.497	0.034	0.070	1.194
Portugal	-51.11%	0.052	0.797	0.097	0.458	0.101	-0.003	1.008
Denmark	-57.66%	0.120	0.638	0.147	0.495	0.118	0.029	1.208
mean	*-22.67%*	*0.192*	*0.628*	*0.199*	*0.393*	*0.177*	*0.022*	*1.015*

	$etr_{gov't}$	$\frac{\varepsilon'}{\theta'+\varepsilon'}$	ρ	π	*s*	π_e	$\pi-\pi_e$	$\frac{\mu_g}{\mu}$
Spain	35.50%	**162.7**	**125.4**	132.5	**77.1**	71.4	**622.8**	**82.9**
Ireland	22.13%	113.7	**50.1**	**210.9**	101.8	**228.4**	70.3	95.9
Belgium	16.08%	131.4	105.4	136.0	100.0	132.3	165.3	97.0
Finland	12.05%	112.8	107.8	104.5	94.4	122.6	-40.5	106.4
Greece	9.70%	97.2	79.3	63.7	**72.8**	71.8	-1.3	94.0
Germany	9.02%	47.3	97.9	137.8	94.4	**155.0**	0.0	98.5
Italy	4.08%	**164.8**	**72.4**	84.3	93.7	94.1	5.3	95.6
France	1.31%	123.1	113.5	**52.3**	95.7	51.7	56.8	92.7
UK	-0.72%	45.0	75.3	66.6	87.4	62.2	102.7	94.0
Netherlands	-1.49%	55.6	**133.0**	131.6	102.3	149.7	-14.3	104.7
Austria	-19.88%	28.3	97.3	104.6	111.8	117.6	0.0	102.4
Sweden	-24.34%	**228.7**	113.9	**52.3**	**126.4**	**19.4**	**317.0**	**117.6**
Portugal	-28.44%	**27.3**	**127.0**	**49.0**	**116.5**	57.0	-15.3	99.3
Denmark	-34.99%	62.2	101.7	73.9	**125.8**	66.7	131.4	**119.0**
mean	*0.00%*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
std. dev.	*19.59%*	*57.4*	*22.7*	*44.4*	*15.4*	*52.6*	*171.9*	*9.3*

- *Note:* In the upper part of the table, *mean* is the unweighted average of each column.

In addition to the tax rates on the wage and employment benefits of education (π and ρ), the overall subsidy rate *(s)* and the share of employment effects *(ε'/(ε'+θ'))*, the table shows the fraction of the total direct costs of schooling that is paid by the government (μ_g/μ), the component of the progressivity indicator that reflects the operation of the tax system per se, abstracting from unemployment benefits *(π_e)*, and the increase in progressivity induced by after-tax unemployment benefits *(π-π_e)*. The lower panel of the table gives the normalized values of the different variables. The effective tax rate is measured in deviations from the sample average (notice that this is *not* the estimated tax rate for the hypothetical average EU country) and the rest of the variables are normalized by their respective sample means, which are set equal to 100. To help identify atypical behaviour, we show in bold type those entries that are more than a standard deviation away from the sample mean.

Taken together, public policies imply a net *subsidy* to human capital at a rate of 18.6% in the average European country. (Notice in Figure 4 that the average value of $etr_{gov't}$ is negative). Hence, educational subsidies and pension benefits more than offset the disincentive effects generated by personal taxes and unemployment benefits. The average subsidy rate *(subs)* stands at a very respectable 46% when we consider only the effects of public educational finance (Figure 5a) but both personal taxes and social benefits reduce the net return to schooling and partially offset direct subsidies to education. The effective tax rates induced by these factors in the average EU country are 8.2% and 21.9% respectively (Figures 5b and 5c). Somewhat surprisingly, unemployment protection seems to be a significantly more important source of distortions than taxes per se. Finally, the subsidy rate implied by pension benefits stands at 2.4% in the average EU country.

There are very important differences across countries in terms of both the total effective tax burden on human capital and the sources of this burden. Spain is the only country where the overall effective tax rate on schooling is positive. It is followed by Ireland and Belgium, where the net subsidy is below 10%. At the other end of the scale, the effective subsidy rate on schooling exceeds 40% in Austria, Sweden, Portugal and Denmark.

Figure 5 and Table 8 help us understand the sources of differences in effective tax rates across countries. In the case of Ireland, the main disincentive has to do with the very high progressivity of personal taxes at APW income levels *(π_e)*. In Spain and Belgium, the main problem has to do with unemployment protection. In these countries employment effects account for a large share of the total returns to schooling and are subject to high taxes (i.e. to large replacement ratios). In addition, benefit ceilings are binding in both countries at APW income levels making the marginal tax rate on the wage benefits of schooling equal to 100% for the unemployed. This, in turn, raises average progressivity ($\pi - \pi_e$ is positive and large) and therefore the tax rate on the wage component of the returns to schooling.

The four countries shown at the bottom of Table 8 are characterized by very large subsidy rates (although this result is somewhat suspect in the case of Portugal for reasons already discussed). In addition, the disincentive effects of personal taxes are low (except in Austria). In both Denmark and Sweden, the tax system actually raises the return to schooling. This surprising result arises from a combination of factors that includes low tax progressivity ratios at average income levels and the interaction between a negative private cost ($\mu_S < 0$) and a high average tax rate on adult workers. In Portugal and Austria, finally, the tax rate implied by unemployment benefits is very low because the probability of employment is rather insensitive to school attainment and the contribution of the tax-benefit schedule facing the unemployed to overall progressivity is either zero or negative.

Table 9: Correlation between the effective tax rate or its components and various determinants

	$\frac{\varepsilon'}{\theta'+\varepsilon'}$	ρ	π	s	π_e	$\pi-\pi_e$	$\frac{\mu_g}{\mu}$
$etr_{gov't}$	0.303	-0.237	**0.617**	**-0.812**	0.465	0.297	**-0.744**
subs	0.313	0.312	-0.399	**0.779**	-0.433	0.131	**0.638**
etr_{tax}	-0.339	-0.290	0.594	-0.452	**0.710**	-0.359	-0.576
etr_{ben}	**0.844**	0.326	-0.195	0.282	-0.455	**0.664**	0.325

To help isolate the key factors underlying the effective tax rate on schooling and its components, Table 9 shows the correlation between each of these indicators and the variables given in Table 8. These correlations suggest that the unemployment benefits component of the tax rate (etr_{ben}) is dominated by two factors: the weight of employment effects on the total benefits of schooling ($\varepsilon'/(\varepsilon'+\theta')$), and the contribution of social benefits to overall progressivity ($\pi-\pi_e$). The tax component (etr_{tax}) is mainly determined by the degree of pure tax progressivity (π_e) and the subsidy rate *(subs)* reflects government's contribution to the direct costs of schooling. The overall subsidy rate and the overall degree of progressivity are the main determinants of the total effective tax rate, $etr_{gov't}$.

How does the private return on schooling compare with that on alternative assets?

Table 10 compares the private *after-tax* return to education (under the all-in scenario, *OBS*) to the *before-tax* real return on debt and equity for those countries for which we could find homogeneous data. The real returns on bonds and stocks are averages for the period 1950-1989 and are taken from Dimson, Marsh and Staunton (2002).[22] Column [5] of this table shows what we will call the (private) *premium on human capital*. This variable is defined as the difference between the all-in rate of return on schooling (column [1] of the same table) and the average return on a portfolio where bonds and shares have the same weight (column [4]).

[22] The same source provides average returns for the period 1950-2000. This last year, however, is probably not a good reference point, for it marks the peak of a long bull market associated with a "technological bubble." At the time the first version of this paper was written, many Western stock market indices had lost around 50% of their value relative to their 2000 peaks. The average return on the equal weights portfolio we use as a reference was one percentage point higher over 1950-2000 than over 1950-89 (5.02% rather than 4.03%). This is a significant difference, but it does not qualitatively change our conclusions.

Table 10: *After-tax* rate of return on schooling vs. *before-tax* real return on financial assets, and premium on human capital

	[1] schooling r_{obs}	*[2] equity*	*[3] bonds*	*[4] avge. portfolio*	*[5] premium on h. capital*
Belgium	7.67%	6.50%	1.90%	4.20%	3.47%
Denmark	8.01%	6.20%	2.60%	4.40%	3.61%
France	8.80%	7.70%	3.70%	5.70%	3.10%
Germany	9.46%	9.50%	3.40%	6.45%	3.01%
Ireland	11.03%	6.90%	0.30%	3.60%	7.43%
Italy	8.66%	4.90%	0.20%	2.55%	6.11%
Netherlands	7.59%	7.50%	-0.30%	3.60%	3.99%
Spain	7.77%	4.50%	-0.90%	1.80%	5.97%
Sweden	4.72%	8.70%	-0.80%	3.95%	0.77%
UK	12.27%	8.30%	-0.30%	4.00%	8.27%
mean value	*8.60%*	*7.07%*	*0.98%*	*4.03%*	*4.57%*

These data suggest that schooling is a rather attractive investment from an individual point of view.[23] For the average country in this reduced sample, the real return to schooling exceeds the return on bonds by 7.62 points and that on equity by 1.53 points. When allowance is made for taxes on capital income (a complicated matter we will not address here), the premium on schooling will increase significantly. The return differential with bonds is positive in all countries and is always above 5 points. The before-tax return to equity, however, is marginally above the rate of return on schooling in Germany, and significantly so in Sweden due to a combination of outstanding stock market performance and the lowest returns to education in the sample. The premium on human capital, as defined above, is positive in all countries, and ranges from 0.77% in Sweden to 8.27% in the UK with a mean value of 4.57%.

[23] In order to draw unequivocal conclusions about the relative attractiveness of education as an investment, we would need to control for the riskiness of its returns. While the variation of earnings across workers with similar attainment levels is very high, much of this variation is not the result of random luck but of differences in individual abilities and career choices. We are not aware of any refined measures of earnings risk that can be used to make valid comparisons with other assets.

For an attempt in this line, see Palacios-Huerta (2003). This author, however, considers only the time-series component of wage risk for highly aggregated sex-race-experience groups. With these data, Sharpe ratios (which measure the expected return per unit of risk) clearly favour educational investment over shares in the US. Surprisingly, however, formal tests for mean-variance spanning suggest that the risk-adjusted returns of schooling dominate those of equities only for university education, but not for secondary schooling. Christiansen et al (2004) construct what are probably better measures of wage risk using the average residuals in Mincer equations for specific types of education. They find that the risk-return trade-off involved varies a lot with the type of studies but do not compare their results with the returns on financial assets.

On a somewhat different note, Padula and Pistaferri (2001) provide some evidence that introducing risk considerations may actually increase the attractiveness of investment in schooling. They find, in particular, that increases in attainment tend to lower wage risk and, as a result, increase the (risk-adjusted) rate of return on schooling. (Thanks to G. Brunello for providing this reference).

7. Results for the EU: ii) Fiscal returns

In this section we will use the equations derived in section 4 to explore the fiscal consequences of increasing average attainment by one year in each EU country. We will assume that the increase in the direct costs of schooling, including non-tuition grants at the existing level, is born entirely by the government (that is, we will use μ_g' as our measure of government expenditure in equations (56) and (57)). Aside from this, our raw data are the same that have already been used to calculate the private returns to schooling in the previous section. We will, however, introduce a number of deviations from our previous assumptions to try to obtain a more realistic estimate of the impact of schooling on public finances. First, we will now take into account the effects of schooling on labour force participation rates. Hence, our calculations in this section will apply to a representative individual who may or may not be active with probabilities based on observed labour force participation rates, rather than to an individual who remains active throughout his student and adult life, as was the case in the previous section.

Second, we will try to approximate the general equilibrium effects of schooling on wages and employment probabilities. As has already been noted, the estimates of the wage (θ) and employment (p' and q') benefits of schooling reported in Table 7 are partial equilibrium estimates that capture expected return to a single individual of staying one more year in school holding constant the aggregate attainment level and factor prices. It should be expected, however, that the realized marginal returns to schooling will be smaller when the government undertakes policies that raise average attainment at the aggregate level. As discussed in de la Fuente (2003)[24] the required correction to the wage benefits of schooling can be approximated by multiplying the estimated value of θ by one minus the share of capital in national income, which is around 1/3 in industrial countries. This adjustment, which holds the aggregate stock of capital constant and implicitly assumes that there is no capital mobility, can be regarded as rather conservative, especially for small countries. For the case of the employment and participation parameters we will introduce an ad-hoc correction that consists in reducing the original estimates of p' by two thirds and that of q' by one half. The correction factor for q' is smaller because the decision to join the labour force does not involve an element of competition with other workers for available jobs.

Our estimates of the fiscal rate of return to schooling are shown in Table A.19 in section 6 of Appendix 1, where we also discuss some technical problems that arise in connection with the calculation of this rate of return when pensions are taken into account. Table 11 shows our estimates of the net present fiscal value per student (NPFV) of an additional year of schooling. For this calculation we assume a real discount rate of 3%, which is more than twice as large as the observed real return on government bonds in the sample (see Table 10) over the last few decades. Both sets of calculations are carried out under five alternative sets of assumptions: in

[24] See in particular section 8 of the Appendix.

scenario [1] we consider only personal taxes (including employee social security contributions) and unemployment benefits, in [2] we add consumption taxes, in [3] employer social security contributions and in [4] retirement benefits.

Table 11: Net present fiscal value of an additional year of schooling

	[1] *personal taxes*	*[2]* *+ consump. taxes*	*[3]* *+ employer s. sec. contr.*	*[4]* *+ pensions = OBS*	*DCOST* *exp. per student*
Austria	-4,197	-3,822	-2,393	-4,817	8,055
Belgium	78	369	3,293	2,049	6,143
Denmark	-6,694	-6,268	-6,319	-6,590	9,166
Finland	1,861	3,124	7,261	4,133	7,434
France	-2,348	-1,651	1,919	280	6,407
Germany	2,579	3,252	6,123	2,735	6,619
Greece	-670	-327	727	-467	2,134
Ireland	4,767	6,483	8,890	8,560	6,132
Italy	-1,635	-1,247	917	-923	4,956
Netherlands	-1,533	-1,089	-490	-3,563	6,170
Portugal	-1,760	-1,380	-588	-1,163	2,827
Spain	-20	361	2,558	954	3,609
Sweden	-8,995	-9,728	-11,198	-11,809	9,446
UK	400	1,973	4,373	3,509	6,215
avge. EU14	*-1,181*	*-541*	*1,611*	*-198*	*6,267*

- *Notes:* The real discount rate used to calculate the NPV is 3%. All figures are in US dollars of 2000 at (that year's) current exchange rates. The last column gives total expenditure per student in the same units, inclusive of non-tuition transfers to households (calculated as $\mu_g'W_0$).

The NPFV estimates given in Table 11 can be interpreted as the negative of the net real cost of keeping the average student in school for an extra year, that is as (minus one times) the difference between the direct resource costs of schooling (*DCOST*, which are shown in the last column of Table 11) and the present value of the net tax revenues this expenditure generates.

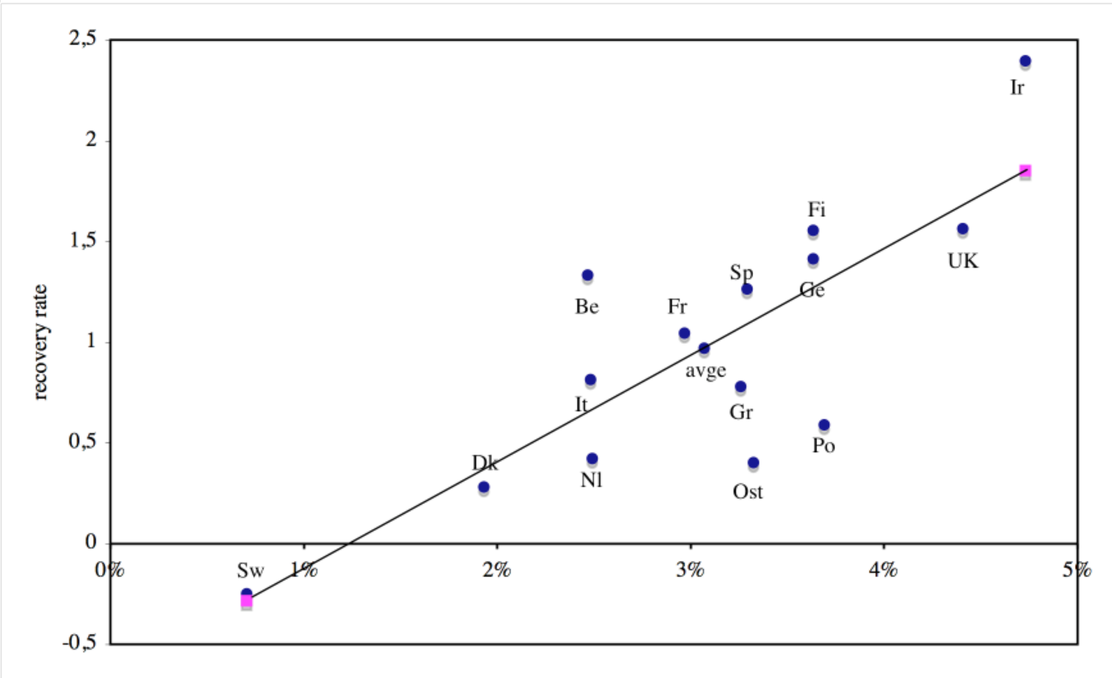
Our estimates imply that the net cost of an extra year of schooling is roughly 200 dollars in the average EU country. Since this figure is only a small fraction of the actual resource costs of education (which exceed $6,200), we must conclude that the net tax revenues generated by an increase in attainment allow the government to recoup the bulk of its educational outlays. To make the same point in a way that is perhaps clearer, Table 12 gives for each country and scenario the *recovery rate* on educational expenditure, defined as the percentage of the direct cost of education (including transfers to households) that is recovered through increases in taxes and savings on social insurance payments. Figure 6 shows that recovery rates seem to be driven mostly by the net wage returns to schooling as measured by $\theta' = \theta S'(X_0) - \nu$. Deviations from the fitted regression line reflect differences across countries in expenditure per student and in tax rates.

Table 12: Recovery rates on educational expenditure

	[1] personal taxes	[2] + consump. taxes	[3] + employer s. sec. contr.	[4] + pensions = OBS
Austria	47.9%	52.6%	70.3%	40.2%
Belgium	101.3%	106.0%	153.6%	133.4%
Denmark	27.0%	31.6%	31.1%	28.1%
Finland	125.0%	142.0%	197.7%	155.6%
France	63.3%	74.2%	130.0%	104.4%
Germany	139.0%	149.1%	192.5%	141.3%
Greece	68.6%	84.7%	134.0%	78.1%
Ireland	177.7%	205.7%	245.0%	239.6%
Italy	67.0%	74.8%	118.5%	81.4%
Netherlands	75.2%	82.4%	92.1%	42.3%
Portugal	37.7%	51.2%	79.2%	58.9%
Spain	99.4%	110.0%	170.9%	126.4%
Sweden	4.8%	-3.0%	-18.6%	-25.0%
UK	106.4%	131.7%	170.4%	156.5%
avge. EU14	*81.2%*	*91.4%*	*125.7%*	*96.8%*

- *Note:* A real discount rate of 3% is used in the calculations. The fraction of direct expenditure recovered is calculated as *(NPFV+DCOST)/DCOST.*

Figure 6: Recovery rate vs. θ'



- *Note:* recovery rates correspond to column [4] in Table 12.

Looking at Tables 11 and 12, we can divide the countries in our sample into three groups. In the first one, comprised only by Sweden, the recovery rate is negative, indicating that the net cost of schooling exceeds its direct costs because the present value of induced current and future net tax revenues is negative, even without taking into account pension liabilities. This is possible, even though increased attainment does indeed raise incomes and therefore tax revenues in the future, because it does not do so by enough to compensate for the loss of the taxes that young people would pay in the current year, were they to join the labour market immediately. In the second group, the present value of induced tax and benefit flows is positive, but smaller than the direct costs of education, yielding recovery rates between zero and one. Austria, Denmark, Greece, Italy, the Netherlands and Portugal fall in this group. Finally, in the third group, induced tax flows more than compensate for the direct costs of schooling, making the net present fiscal value of a year of schooling positive. This is the case in Belgium, Finland, France, Germany, Ireland, Spain and the UK.

These results suggest that any increase in public educational expenditure required to marginally raise current attainment levels would largely pay for itself over the long run through higher tax revenues and lower social insurance payments in the average EU country. Recovery rates on educational expenditure exceed 50% in all EU countries but four (Sweden, Denmark, Austria and the Netherlands), and lie above 100% in seven of them. The net fiscal surplus per student is considerable in some of these states and can potentially make a modest positive contribution to public budgets in the future.

8. Conclusion

In this paper we have constructed estimates of the private and fiscal returns to schooling in 14 European countries and analyzed the impact of various public policies on the first of these variables. The estimated private returns to a one-year increase in schooling, starting from currently observed average attainment levels, cluster between 7.5% and 10% in most member states of the EU. Sweden is a clear outlier at the bottom of the distribution, possibly as a result of severe wage compression, while the highest returns correspond to the UK and Ireland, followed by Portugal and Finland. In practically all European countries, the returns to schooling compare quite favorably with those available from standard financial assets. Taking as a reference a balanced portfolio of corporate shares and government bonds, the premium on education ranges from 0.8% in Sweden to 8.3% in the UK with a mean value of 4.9%.

Various public policies have a significant impact on the private return to schooling. On average, direct subsidies to education raise returns by 45% while personal taxes and unemployment benefits reduce them by 8% and 22% respectively and pensions raise them by 2.4%. In most countries, the combined effect of all these policies is a net subsidy to education. This subsidy exceeds 40% in Denmark, Portugal, Austria and Sweden, and has an average value of 18.6% in the entire sample. The only country where the net tax on schooling is positive is Spain, with an effective tax rate of 12.8%.

Our results indicate that in most countries the tax system generates only modest disincentives to invest in further education at observed average attainment levels. On the the other hand, distortions arising from unemployment insurance can be very important in countries where unemployment rates are high and a significant fraction of the benefits of schooling come through an increase in the probability of employment. From the point of view of minimizing such distortions, it would be preferable to uncap unemployment benefits while reducing average replacement rates. Efficiency gains, however, must be balanced against the equity considerations that rightly influence the design of the social protection system.

According to our calculations, public expenditure on post-compulsory education is at least partly self-financing over the long run in most EU countries. Leaving aside Sweden and Denmark, where educational subsidies are particularly generous, recovery ratios on public educational expenditure range between 40% in Austria and 240% in Ireland, with a mean value of 97%. This leaves the net budget cost in present value terms of an additional year of schooling in the average EU country at roughly 200 US dollars, working under conservative assumptions that include full government funding of all educational costs.

Policy implications regarding educational finance should be drawn with some care, particularly in the absence of reliable estimates of social returns that may be used to gauge the potential misalignment between private incentives and social needs. We see our finding that government expenditure in education largely pays for itself over time in most countries as a good reason for governments not to subordinate educational policies to short-term budget concerns. In our view, however, the balance of our findings does not necessarily imply that additional educational subsidies are called for. For most countries, the premium on human capital relative to financial assets is large enough to suggest that the incentives to enroll in post-compulsory courses are already quite adequate. This is true in part because existing subsidy levels are quite high. In all EU countries but one, such subsidies more than offset the disincentives created by taxes and by the social protection system.

APPENDIX 1: Data and detailed results

1. The direct costs of schooling

This section describes the construction of the direct cost of schooling variables (μ, μ_s, μ_g and μ_g'). As noted in the text, these variables are weighted averages of costs per student at the secondary and tertiary levels measured as a fraction of APW earnings. The primary data are taken from various recent issues of the OECD's *Education at a Glance*, to which we will refer as EAG.

a. Secondary education

Table A.1 summarizes the available data on educational expenditure at the secondary level. Column [1] shows total expenditure per student (in public and private educational institutions) in 1997 measured as a percentage of GDP per capita and column [2] shows the share of this expenditure that is publicly financed. Multiplying [1] by [2] we obtain public expenditure per student (column[4]) and private expenditure as a residual (column [3]). The data refer mostly to

Table A.1: Expenditure per student as a percentage of GDP per capita secondary level

	[1] total	*[2] %gov't*	*[3] private*	*[4] public*
Austria	36%	97.0%	1.1%	34.9%
*Belgium**	29%	94.0%	1.7%	27.3%
Denmark	28%	98.0%	0.6%	27.4%
Finland	25%	**99.4%**	0.1%	24.9%
France	31%	95.0%	1.6%	29.5%
Germany	28%	**97.0%**	***0.8%***	***27.2%***
Greece	19%	**90.2%**	***1.9%***	***17.1%***
Ireland	19%	97.0%	0.6%	18.4%
Italy	**29%**	100.0%	0.0%	29.0%
Netherlands	23%	96.0%	0.9%	22.1%
Portugal	29%	**99.9%**	0.0%	29.0%
Spain	27%	88.0%	3.2%	23.8%
Sweden	27%	100.0%	0.0%	27.0%
UK	23%	**88.2%**	2.7%	20.3%
avge. EU14	*26.64%*	*95.7%*	*1.09%*	*25.55%*

- *Sources and notes:*

[1] EAG 2000 (Table B4.2 with data for 1997). We use "all secondary" rather than "upper secondary" because these data are available for more countries. The one exception is Italy. The data for this country refer to 1998 and are taken from EAG 2001.

[2] These data are only available for tertiary studies and for all other levels combined, so we use the second category. The main source is EAG 2000 (Table B2.1 with data for 1997). For this year, the data refer to the initial source of funds. For Finland, Greece, Portugal and the UK (shown in bold type), the source is EAG 2002 (Table B4.2 with data for 1999). As noted in the text, these data refer to shares in final expenditure.

(*) The data for Belgium refer to the Flanders region.

1997 and the main source is the 2000 edition of *Education at a Glance* (EAG 2000). Exceptions are highlighted in bold type and discussed in the notes to the table and in the following paragraph.

For most countries, the data on the share of government financing given in column [2] refer to the initial source of funds. For the countries shown in bold type, however, the data come from a different issue of EAG and refer to final expenditure after transfers from the public to the private sector (i.e. describe who pays in the end, and not where the money originally came from). For the UK, however, EAG gives the share of private (final) expenditure which is financed by public transfers. Hence, we subtract these transfers from private spending and add them to public expenditure before computing the government's share in the financing of educational institutions. For Finland, EAG reports that the amount of such transfers is "negligible." For the remaining countries there is no information on subsidies, and we implicitly assume they are zero. Since private final expenditure is extremely low in Portugal the resulting mistake will be insignificant. For Greece, however, the margin of error is considerably larger. To indicate this, we use bold italics for this country in columns [3] and [4]. As in the text, we will use this character type to identify results that are based on incomplete information when this is not expected to be a source of substantial errors, and plain bold type to identify results where the error caused by incomplete data is potentially important for the calculations.

For Germany, EAG (2000) reports a share of public expenditure of only 76%. It also indicates, however, that in this country "nearly all private expenditure is accounted for by contributions from the business sector to the dual system of apprenticeship at the upper secondary level"(p. 62).[25] Since we are interested in the cost of education to households, we will treat enterprise contributions as public expenditure. As no specific figure is given for enterprise contributions, we will assume a share of "public" expenditure (including business contributions) of 97%, which is the value observed in Austria.

b. Higher education

Table A.2 replicates Table A.1 for the case of higher education to obtain preliminary estimates of total, private and public expenditure per student as a percentage of GDP per capita. As above, the available data on the government's share refer to final expenditures for the countries shown in bold type in column [2] and to the initial source of funds for the rest. In Finland, the share of private expenditure financed by public transfers is negligible. For the other countries there is no information on this variable but, given the small size of overall private final expenditure, the potential error caused by our implicit assumption that such transfers are zero is small.

[25] We thank L. Wössmann for pointing this out.

Table A.2: Expenditure per student as a percentage of GDP per capita tertiary level: i) preliminary estimates

	[1] total	*[2] %gov't*	*[3] private*	*[4] public*
Austria	43%	**98.7%**	0.6%	42.4%
*Belgium**	33%	90.0%	3.3%	29.7%
Denmark	29%	99.0%	0.3%	28.7%
Finland	35%	**97.4%**	0.9%	34.1%
France	34%	88.0%	4.1%	29.9%
Germany	43%	93.0%	3.0%	40.0%
Greece	29%	**99.9%**	0.0%	29.0%
Ireland	39%	79.0%	8.2%	30.8%
Italy	**28%**	82.0%	5.0%	23.0%
Netherlands	45%	97.0%	1.4%	43.7%
Portugal	**28%**	98.0%	0.6%	27.4%
Spain	32%	77.0%	7.4%	24.6%
Sweden	64%	91.0%	5.8%	58.2%
UK	40%	88.0%	4.8%	35.2%
avge. EU15	*37.3%*	*91.3%*	*3.23%*	*34.05%*

- *Sources and notes:*

[1] The source is EAG 2000 (Table B4.2 with data for all tertiary programmes in 1997) except in the cases of Italy and Portugal. The Italian data refer to 1998 and are taken from EAG 2001. The information for Portugal is from EAG 2002 and refers to 1999.

[2] The main source is EAG 2000 (Table B2.1 with data for tertiary education in 1997). For this year, the data refer to the initial source of funds. For Austria, Finland and Greece (shown in bold type), the source is EAG 2002 (Table B4.2 with data for 1999). As in the previous table, these data refer to shares in final expenditure.

(*) The data for Belgium refer to the Flanders region.

The preliminary figures given in Table A.2 have to be adjusted to eliminate the cost of research carried out in universities and to reflect public transfers to students that are intended to help defray living expenses and other non-tuition costs. (Notice that our preliminary public expenditure figures already incorporate tuition grants since the share of government reflects the initial source of funds destined for educational institutions). The data required for these adjustments are given in Table A.3. Column [5] shows the share of R&D expenditure in total spending on tertiary-level educational institutions. Column [6] shows public subsidies to households to cover student living costs and non-tuition expenses, measured as a percentage of GDP per capita.

Bold entries in Table A.3 indicate missing observations that have been estimated in various ways. We have imputed to those countries for which the share of R&D is missing the values observed in close neighbours or in countries with similar income levels (see the notes to the table). When data on subsidies are not available, an approximation has been constructed using related information from a different issue of EAG which is shown in column [7]. This column gives an estimate of the amount of public subsidies for living costs and other non-tuition expenses measured as a fraction of government direct expenditure on tertiary educational institutions. The numerator is financial aid to students (scholarships and other grants) net of the amount earmarked for the payment of tution fees when available. The bold entries in column [6] are obtained by multiplying [7] by direct government expenditure on educational institutions (column [4] in Table A.2).

Table A.3: Expenditure per student as a percentage of GDP per capita tertiary level: ii) data for adjustments

	[5] *sh. R&D*	*[6]*** *subsidies*	*[7]* *sh. subs.*
Austria	**0.381**	6.62%*	
Belgium	0.367	**5.62%**	0.189
Denmark	0.272	17.42%	
Finland	0.356	7.02%	
France	0.156	1.82%	
Germany	0.381	4.67%	
Greece	0.227	**1.02%**	0.035
Ireland	0.164	7.44%	
Italy	**0.241**	**2.73%**	0.119
Netherlands	0.393	7.78%	
Portugal	**0.227**	1.28%	
Spain	0.241	1.46%	
Sweden	0.480	22.72%	
UK	0.359	6.92%	
avge. EU14	*0.303*	*6.75%*	

- *Sources and notes:*

[5] EAG 2002 (Table B6.2 with data for tertiary education in 1999). Since no data are available for Austria, Italy and Portugal, we assign to these countries the values observed in Germany, Spain and Greece, respectively.

[6] EAG 2000 (Table B3.2 with data for 1997, except for Germany, where it is for 1996). No data are available for Belgium, Greece and Ireland. The figures given for these countries are estimated as explained in the text using [7].

(*) For Austria, there is no breakdown between subsidies earmarked for the payment of tuition fees and the rest. We assume that all subsidies are for living costs, as the data in Table A.2 suggests that the government pays directly for the bulk of the costs of educational institutions.

(**) The information available in EAG includes the fraction of total transfers (including those for tuition costs) that corresponds to student loans. We assume that only 25% of the amount of the loan is a subsidy and that this subsidy finances tuition and non-tuition costs in the same proportion. To correct the original figure for non-tuition transfers, we reduce it by one fourth of the share of loans in total transfers.

[7] EAG 2002 (Table B5.2 with information for tertiary education in 1999).

Table A.4 shows the adjusted estimates of private, public and total expenditure per student at the tertiay level measured as a percentage of GDP per capita. Adjusted total expenditure is obtained by subtracting R&D spending from the uncorrected total. Adjusted public expenditure is raw public expenditure minus research expenditure (which we attribute exclusively to the government) plus transfers to students for non-tuition costs. Adjusted private expenditure is gross private expenditure minus subsidies for non-tuition costs. Bold italics are used for total and public costs in Austria, Italy and Portugal because, as noted above, there is no data on research expenditure by universities. Finally, the column labeled *adjusted public'* is calculated by adding subsidies to the adjusted total costs. This variable tries to approximate the public cost per student of an increase in enrollments totally financed by the government under the assumption that the current level of non-tuition related transfers is maintained.

Table A.4: Expenditure per student as a percentage of GDP per capita tertiary level: iii) adjusted estimates

	[8] adjusted total	*[9] adjusted private*	*[10] adjusted public*	*[11] adjusted public'*
Austria	***26.64%***	-6.06%	***32.70%***	***33.26%***
Belgium	20.90%	-2.32%	23.22%	26.52%
Denmark	21.10%	-17.13%	38.23%	38.52%
Finland	22.54%	-6.11%	28.66%	29.57%
France	28.68%	2.26%	26.42%	30.50%
Germany	26.64%	-1.66%	28.30%	31.31%
Greece	22.41%	-0.99%	23.40%	23.43%
Ireland	32.61%	0.75%	31.86%	40.05%
Italy	***21.25%***	2.31%	***18.94%***	***23.98%***
Netherlands	27.33%	-6.43%	33.76%	35.11%
Portugal	***21.64%***	-0.72%	***22.36%***	***22.92%***
Spain	24.28%	5.90%	18.39%	25.75%
Sweden	33.27%	-16.96%	50.23%	55.99%
UK	25.62%	-2.12%	27.75%	32.55%
avge. EU14	*25.35%*	*-3.52%*	*28.87%*	*32.10%*

- *Note:* the adjusted estimates shown in columns [8] to [10] are calculated as follows:
adjusted total = total * (1 - sh. R&D), i.e. [8] = [1] * (1 - [5])
adjusted private = private - subsidies, i.e. [9] = [3] - [6]
adjusted public = public - (sh.R&D*total) + subsidies, i.e. [10] = [4] - ([1]*[5]) + [6]
adjusted public' = adjusted total + subsidies, i.e [11] = [8] + [6]

c. Total expenditure

We average expenditure per student across educational levels, using a weight of 2/3 for secondary schooling and of 1/3 for higher education. The results are shown in Table A.5, which gives average expenditure per student as a percentage of GDP per capita. For the rate of return calculations we will want to express total expenditure per student as a fraction of APW gross earnings. To obtaine the values of μ, μ_s, μ_g and μ_g' shown in Table 7 in the text, we multiply the figures shown in columns [1]-[4] of Table A.5 by the ratio of GDP per capita to APW gross earnings, which is shown in column [5]. This ratio is calculated using data for 1999 taken from the country chapters of the OECD's *Benefit Systems and Work Incentives 1999* and from the 2002 edition of *Education at a Glance* (Table X2.2).

Entries in bold italics in columns [1] to [4] are carried over from previous tables. The entry for Portugal in column [4] is shown in bold type because Portuguese APW earnings are atypically low relative to GDP per capita. As a result, Portuguese expenditure per student will appear to be rather high when normalized by APW wages. Since we are not sure reported Portuguese

APW earnings are an adequate indicator of average wages and since their use will have a noticeable effect on the rate of return calculations, the values of the cost variables reported in Table 7 for Portugal, as well as the APW wage, W_0, will be shown in bold type to indicate that these data may be misleading.

Table A.5: Expenditure per student as a % of GDP per capita weighted average of secondary and (adjusted) tertiary levels

	[1] total	*[2] private*	*[3] public*	*[4] public'*	*[5] GDPpc/APW earnings*
Austria	***32.88%***	-1.30%	***34.18%***	***35.09%***	1.075
Belgium	26.30%	0.39%	25.91%	28.17%	0.816
Denmark	25.70%	-5.34%	31.04%	31.51%	0.832
Finland	24.18%	-1.94%	26.12%	26.52%	0.947
France	30.23%	1.79%	28.44%	30.83%	1.084
Germany	27.55%	0.01%	27.54%	29.10%	0.773
Greece	20.14%	***0.91%***	***19.23%***	20.48%	1.071
Ireland	23.54%	0.63%	22.91%	26.02%	1.156
Italy	***26.42%***	0.77%	***25.65%***	***27.33%***	0.957
Netherlands	24.44%	-1.53%	25.97%	27.04%	0.876
Portugal	***26.55%***	-0.22%	***26.77%***	***26.97%***	**1.488**
Spain	26.09%	4.13%	21.97%	26.58%	0.983
Sweden	29.09%	-5.65%	34.74%	36.66%	1.026
UK	23.87%	1.10%	22.77%	26.18%	0.852
avge. EU14	*26.21%*	*-0.45%*	*26.66%*	*28.46%*	*0.995*

- *Note:* Weighted average of the values shown in Tables A.1 and A.4 with weights of 2/3 and 1/3 respectively. (For *public'* we use column [1] of Table A.1 and column [4] of Table A.4). In the case of Germany, the public expenditure shown in column [3] includes enterprise contributions to vocational training programmes. The contribution of this item to combined or total educational expenditure per student amounts to 3.03% of APW gross earnings.

2. Further details on the estimation of tax and benefit parameters

The country chapters of OECD (2000) and OECD (2001) contain a description of the personal tax system (including employee social security contributions) in member states in 1999 and 2000 respectively. OECD (2000) also describes the social protection system in each country, focusing on unemployment benefits and social assistance but not on pension schemes, and describes in greater detail than OECD (2001) the tax treatment of social benefits.

Both publications contain a set of tables at the end of each chapter where they describe the tax and benefit position of several types of representative individuals, including a single person with no children whose earnings in employment were equal to APW wages, and some of the relevant tax or replacement rates. For a number of countries, the description of the tax system is ambiguous or incomplete at times and we have been unable to reproduce exactly the tax and benefit amounts given in the tables, but the discrepancies are minor in all cases. Whenever possible, we have relied on the tables (or on summary tables containing average and marginal tax rates that are included in the OECD's on-line tax database) rather than on the text, as it seems reasonable to assume that the OECD staff who produce these tables have more information about the peculiarities of tax and benefit systems than is contained in the descriptions given in these publications.

Thus, marginal and average tax rates and employer social security contributions for employed workers have been taken directly from the OECD tax database and coincide with those given in the appropriate country tables of OECD (2001a). The average tax rate applicable to unemployed workers (τ_u) and the average gross replacement ratio (*b*, defined as the ratio of gross income out of employment to before-tax income in employment) have also been generally constructed by using directly the amounts given in the end-of-chapter tables in OECD (2000). The average replacement ratio is obtained by adding housing benefits to unemployment insurance and dividing the result by APW wages. The average tax rate is calculated by dividing total tax payments (personal taxes and social security) by the sum of unemployment and housing benefits. The only country where we have deviated slightly from the end-of-chapter tables is Italy. For this country, we treat the housing benefit as a tax deduction (which is the form that it takes according to the description in the text), rather than as a cash payment, which seems to be the way it is treated in the end-of-chapter table.

We have had to use the description of the national tax and benefit systems to calculate the average tax rate on student income from part-time work and the marginal tax rate on unemployment benefits. In the case of students, our calculations are based on OECD (2001a). In most countries existing tax allowances or zero-rate brackets are such that student part-time workers earning 20% of APW wages will pay no income tax. The exceptions are the Nordic countries, where they would be subject to proportional local taxes. In most countries, however, employee social security contributions would have to be paid at standard rates. The exceptions to this norm are the UK, which exempts wages below a certain level from these contributions, and Ireland where they are exempted from most but not all social contributions. In the case of Denmark, we have assumed that young part-time workers opt out of certain unemployment and pension schemes that appear to be voluntary.

Marginal tax rates for unemployed workers are constructed using the information given in OECD (2000) taking into account the deductibility of social security contributions from income tax where appropriate. Since this parameter is only relevant when the marginal replacement ratio, B', is different from zero (because it enters the calculations only as a product with B'), we have not calculated it for countries where benefits are paid at a fixed rate or benefit ceilings apply to our reference worker. As noted in the text, for this calculation we have treated housing benefits as lump sum payments. As a result, our marginal tax rates do not incorporate the loss of these benefits that would result from increases in unemployment insurance payments (reflecting higher wages in previous employment). In order for our calculations to be consistent with the end-of-chapter tables in terms of the total tax due, we have assumed that in the Netherlands the unemployed only contribute to the general social security schemes, and not to employee schemes, and that in Finland the unemployed are subject only to contributions to the sickness insurance fund and not to the old age pension fund. The second assumption contradicts the text, which states that both types of contributions are levied on the unemployed. In the case of France, the marginal tax rate has been computed numerically, by calculating the tax increase generated by a one-franc increase in gross benefits. The reason is that the tax system in this country is quite complicated in a number of respects that include the (partial) deductibility of social contributions from income tax, the calculation of tax deductions and the final correction of income tax *(décote)* that reduces the total tax burden at low income levels but greatly increases the marginal tax rate.

The marginal gross replacement ratio *(B')*, and the net replacement ratio in the case of Austria and Germany, have also been calculated using the description of benefit systems given in OECD (2000). In these two countries, unemployment benefits are not taxed and are set as a fixed fraction *(β)* of after-tax income in employment. In the remaining countries, benefits are either paid at fixed rates or are proportional to gross income in employment, possibly with a ceiling that we have taken into account in our calculations (by setting *B'* equal to zero when the ceiling is binding for our reference individual). Finland uses a mixed system with a fixed and a variable component. In this country, daily benefits are equal to the sum of three components: a basic, fixed-rate benefit (FRB), plus 42% of daily reference earnings in excess of the basic benefit, plus 20% of daily reference earnings in excess of a higher amount (which is still lower than the reference earnings of our representative individual). Reference earnings are defined as 95% of gross daily earnings. Hence, the marginal rate for benefits corresponding to APW wages is given by 0.95*(0.42+0.20) = 0.589.

Pension benefits and taxes on pensioners

Our data on pension benefits are taken from OECD (2005) and refer to the year 2002.

Table A.6: Pension indexation practices and assumptions

	pensions indexed to:	*assumed* *ω*
Austria	discretionary	0
Belgium	prices	0
Denmark	prices	0
Finland	80% prices, 20% wages	0,20%
France	prices	0
Germany	wages	1%
Greece	discretionary	0
Ireland	wages	1%
Italy	prices (75% to 100% depending on amount)	0
Netherlands	wages	1%
Portugal	prices	0
Spain	prices	0
Sweden	wages - 1.6%	0
UK	prices	0

- *Source:* OECD (2005), Table 2.3, pp.35-6.

Table A.6 summarizes the pension indexation practices of the countries in our sample. In most of them pensions, once granted, grow in line with an index of consumer prices. In some of them, however, pensions are indexed totally or partially to average wages while in others increases in existing pensions are discretionary. The last column shows our assumption about the real rate of growth of pensions (ω). When they are indexed to prices, pensions remain constant in real terms and we set $\omega = 0$. When they are indexed to wages, they grow in real terms at the same rate as wages (g = 1%). Following the OECD, we have assumed that pensions are indexed to prices in those countries where pension increases are discretionary. We have made the same assumption in Sweden, where the growth rate of pensions is set to the growth rate of average earnings minus 1.6 percentage points. The reason is that under our assumptions about real wage growth (of 1%), this would imply a loss in the real value of pensions that we do not find plausible in the long run.

The OECD calculates benefit entitlements (under mandatory pension schemes) for individuals with a full career of contributions (from age 20 until the statutory retirement age) under the assumption that all workers' real wages increase at a uniform rate (of 2% per year). One implication of these assumptions is that an individual's income remains constant throughout his career when expressed as a fraction of APW wages. As a result, the gross replacement ratio the OECD calculates can be interpreted as the ratio of the initial pension to either the gross wage at the time of retirement or the worker's average wage throughout his career when this average is calculated revalorizing past wages in line with average earnings growth. For the average individual, in addition, both of these variables will also be equal to current APW wages.

Our assumptions are somewhat different. As the reader will recall we assume a lower rate of average wage growth (1%) but allow individual wages to rise over time with experience (at an annual rate of 1.38%), so our assumed rate of growth of individual wages is a bit higher than the OECD's. On the other hand, the working lives of our representative agents would be shorter than assumed by the OECD since we use observed average retirement ages, which are lower than statutory ages. On balance, however, the two sets of assumptions should be sufficiently close for us to be able to use the OECD's estimates of pension levels in our calculations.

Under our assumptions, each individual's wages will increase over time relative to APW wages and final and average wages will differ. Hence, we will interpret the gross replacement ratios provided by the OECD as the ratio of the initial pension to the worker's average earnings (which coincides with APW wages for our hypothetical representative individual). We will then adjust this variable as required under our assumptions to recover the ratio of the starting pension to final wages, which is one of the parameters *(pb)* that enter our calculations. We will use estimated benefit levels at different levels of average income (100% and 150% of APW wages) to calculate a *marginal benefit ratio (PB')* that will measure the increase in initial pension entitlements resulting from a 1 euro increase in average work earnings.

Table A.7: Gross and marginal pension replacement ratios

	starting pension/APW wages		*marginal benefit ratio PB'*	*gross replacement ratio pb*	*P/APW wage at midpoint of retirement*
	[1]	*[2]*	*[3]*	*[4]*	*[5]*
income level =	*100% APW*	*150% APW*	*100% APW*	*100% APW*	*100% APW*
Austria	78,30%	117,45%	78,30%	59,35%	70,8%
Belgium	40,70%	52,35%	23,30%	30,91%	36,5%
Denmark	43,30%	45,45%	4,30%	32,10%	40,0%
Finland	71,50%	107,25%	71,50%	53,55%	66,4%
France	52,90%	76,05%	46,30%	39,54%	48,0%
Germany	45,80%	68,70%	45,80%	34,63%	45,8%
Greece	84,00%	126,00%	84,00%	60,51%	77,4%
Ireland	30,60%	30,60%	0,00%	22,19%	30,6%
Italy	78,80%	118,20%	78,80%	57,67%	71,8%
Netherlands	68,30%	102,45%	68,30%	51,72%	68,3%
Portugal	66,70%	98,85%	64,30%	47,79%	62,5%
Spain	81,20%	121,80%	81,20%	58,91%	74,6%
Sweden	64,80%	96,90%	64,20%	47,24%	59,6%
UK	37,10%	43,95%	13,70%	27,25%	34,3%
average	*60,29%*	*86,14%*	*51,71%*	*44,53%*	*56,18%*

- *Source:* Columns [1] and [2] from OECD (2005), Table 4.1, p. 49. Column [2] has been renormalizad to show the starting pension as a fraction of APW wages.

Table A.7 shows the original OECD data and the estimated values of some of the magnitudes required for our calculations. Columns [1] and [2] show the starting pensions corresponding to average earnings of 100% and 150% of APW wages expressed in both cases as a percentage of APW wages. Dividing the difference between these two magnitudes by the difference in average earnings as a fraction of APW wages (i.e. by 0.5), we obtain the marginal benefit ratio *(PB')* shown in column [3].[26]

Next, we want to calculate the gross replacement rate for the average individual expressed as a fraction of his final salary. As we do throughout the paper, we identify APW wages with the wage of an agent of average attainment, X_0, at the mid-point of his career, that is, with

$$W_o(t) = A_o e^{gt} f\left(S(X_o)\right) e^{vH_o/2}$$

where $H_0 \equiv U - X_0$ is the expected duration of the working life of an individual of average attainment. On the other hand, wages at retirement for the average individual are given by

$$W_U = W(U, X_o, U - X_o) = A_o e^{(g+v)U} f\left(S(X_o)\right) e^{-vX_o}$$

Hence, the ratio between the two quantities is given by

26 While this is only an approximation to the true marginal benefit ratio, the approximation should be quite good, as benefits appear to be an approximately linear function of average earnings over the relevant income range in all countries in our sample. See OECD (2005) p. 57 and country chapters.

$$(A.1)\ \frac{W_u}{W_o(U)} = \frac{A_o e^{(g+v)U} f\big(S(X_o)\big) e^{-vX_o}}{A_o e^{gU} f\big(S(X_o)\big) e^{vH_o/2}} = \frac{e^{vU} e^{-vX_o}}{e^{vH_o/2}} = \frac{e^{v(U-X_o)}}{e^{vH_o/2}} = \frac{e^{vH_o}}{e^{vH_o/2}} = e^{vH_o/2}$$

We calculate the value of the ratio given in (A.1) for each country using the estimated value of H_o in each case. Dividing column [1] by this ratio, we obtain the desired gross replacement rate *(pb),* which is shown in column [4]. That is, we calculate

$$(A.2)\ pb = \frac{P_U(X_o)}{W_U(X_o)} = \frac{P_U(X_o)}{W_o(U)} \frac{W_o(U)}{W_U(X_o)} == \frac{P_U(X_o)}{W_o(U)} \frac{1}{e^{vH_o/2}}$$

Finally, we want to estimate the ratio of the average worker's pension to contemporaneous APW wages at the midpoint of the period between retirement and the expected time of death, $U + (Z - U)/2$. Since average wages grow by assumption at a constant rate $g = 1\%$ and a retired person's pension grows at a rate ω (see Table A.6) we have

$$(A.3)\ \frac{P\left(U + \frac{Z-U}{2}\right)}{W_o\left(U + \frac{Z-U}{2}\right)} = \frac{P(U) e^{\omega(Z-U)/2}}{W_o(U) e^{g(Z-U)/2}} = \frac{P(U)}{W_o(U)} \frac{1}{e^{(g-\omega)(Z-U)/2}}$$

Hence, to get the desired quantity we need to divide column [1] by the exponential function shown in (A.3). The result is shown in column [5].

Table A.8: Midpoint average and marginal tax rates on pension income

	average τ_p	*marginal* T'_p
Austria	16,72%	33,73%
Belgium	15,84%	28,63%
Denmark	28,03%	39,80%
Finland	25,93%	37,87%
France	9,91%	23,44%
Germany	3,80%	3,80%
Greece	1,37%	5,00%
Ireland	0,00%	0,00%
Italy	16,94%	25,50%
Netherlands	13,88%	20,05%
Portugal	2,11%	14,00%
Spain	9,75%	28,62%
Sweden	27,45%	30,38%
UK	0,92%	10,00%
average	*12,33%*	*21,49%*

Estimates of "mid-retirement" earnings relative to APW wages have been used to calculate the average and marginal tax rates applicable to pensioners. Multiplying the ratios shown in column [5] of Table A.7 by APW wages in the year of reference, we obtain an estimate of pensioner income. As above, we use the description of national tax systems given in OECD (2001) to calculate our agent's income tax liability and social security contributions. We supplement this source with the additional notes on the peculiarities of the taxation of pensioners that are given in the country chapters of OECD (2005) and, for some countries, in a special section of OECD (2001).[27] The results of our calculations are shown in Table A.8. As above, the marginal tax rate for France has been computed numerically and marginal tax rates have been calculated taking into account the deductibility of social security contributions from income taxes whenever relevant.

3. Correction for differential student employment probabilities and activity rates

Casual observation suggests that, at least in some countries, finding a part-time or summer job while attending school may be harder than finding a full-time job, and that the propensity of students to enter the labour market tends to be much lower than that of those who have completed their education. Since these factors can have an important effect on the opportunity cost of education and hence on its private return, they should be taken into account in our calculations.

Table A.9: Probability of employment, population 20-24 in and out of school

	in education		*not in education*		*η = ratio in/not in edu.*	
	[1]	*[2]*	*[3]*	*[4]*	*[5]*	*[6]*
	p	*q*	*p*	*q*	η	η_q
Austria	92.45%	19.34%	94.62%	87.05%	0.977	0.222
Belgium	87.50%	16.33%	86.12%	89.07%	1.016	0.183
Denmark	90.91%	69.62%	92.93%	91.93%	0.978	0.757
Finland	82.40%	46.38%	83.86%	82.00%	0.983	0.566
France	95.12%	22.95%	79.57%	89.46%	1.195	0.257
Germany	98.37%	52.42%	89.69%	83.41%	1.097	0.628
Greece	65.79%	10.38%	74.17%	85.35%	0.887	0.122
Ireland	93.22%	20.85%	94.98%	91.63%	0.982	0.228
Italy	64.00%	12.95%	75.21%	77.52%	0.851	0.167
Netherlands	95.35%	62.50%	96.44%	89.94%	0.989	0.695
Portugal	91.55%	19.94%	91.33%	91.30%	1.002	0.218
Spain	74.26%	22.44%	82.39%	89.82%	0.901	0.250
Sweden	85.29%	32.69%	90.43%	91.27%	0.943	0.358
UK	93.41%	54.33%	91.18%	85.39%	1.024	0.636
average EU14	*85.94%*	*34.14%*	*86.79%*	*87.55%*	*0.988*	*0.390*

- *Source:* EAG 2003 (Table C4.1) with data for 2001.

To calculate the required correction factors *(η and η_q)* we have used data on the probability of employment of the 20 to 24 age group in 1998 taken from the 2003 edition of *Education at a Glance*. Columns [1] to [4] of Table A.9 show the probability of employment of this group conditional on participation in the labour force *(p)* and its labour force participation rate *(q)*, distinguishing between those enrolled in educational institutions and those who have already

[27] In most countries retirees are either totally or partially exempt from social security contributions. In some of them, they have access to special tax allowances or are taxed on only a fraction of their pension income.

completed their formal schooling. Columns [5] and [6] show preliminary estimates of the correction factors, η and η_q. These variables are constructed by dividing the relevant employment probability or participation rate for those attending school by its counterpart for those out of school.

To go from Table A.9 to Table 7 in the text (which shows the values of the correction factors that are used in the rate of return calculations), we assign a value of 1 to countries where the preliminary estimate of η shown here exceeds that value --that is, we assume that, other things equal, it is never easier to find part-time employment as a student than a full-time job.

4. Academic failure rates

As noted in the text, we distinguish between completed school grades, S, and time spent in school, X where $S = S(X)$ with $0 < S'(X) < 1$. To calculate the rate of return we need to estimate X_0 and $S'(X_0)$. To do this properly, we would need data on repetition and drop-out rates at different levels of schooling. Since these data are apparently not available, we have constructed a very rough approximation of year-by-year drop out probabilities using the data provided by the OECD (EAG 2002) on upper secondary and university survival rates.

We will assume that whenever a student starts one of these cycles but leaves school without completing it, the last year spent in school is wasted, and that this is the only type of academic failure that takes place. This is clearly incorrect for two reasons that will generate opposing biases in our estimates. First, we are ignoring repeaters, which will lead us to underestimate failure rates and effective completion times and, second, we are not taking into account that students may leave in mid-cycle after successfully completing a grade in order to take up a job or for other reasons. Since the first of these effects can be expected to be greater than the second one, it is likely that we are underestimating failure rates.

Under our assumptions, we can approximate S' by the one-year probability of survival in school, which we will denote by σ. The OECD provides estimates of survival rates in tertiary education that are calculated as the ratio between the number of graduates in a given year and the number of incoming students in the typical year of entrance into the programme. These estimates, which are shown in column [1] of Table A.10, reflect the probability of survival during the entire duration of the university cycle, that is, the probability that a student who enters university will eventually graduate. Calling the overall survival rate Σ, denoting by d the theoretical duration of university, and assuming that the probability of failure is the same for all years in the cycle, we have $\Sigma = \sigma^d$, which can be solved for the one-year survival probability, $\sigma = Exp(ln\ \Sigma/d)$. Then, the expected (actual) duration of university can be approximated by $D = d/\sigma$, where $1/\sigma$ is the average time it takes to complete a grade. The original data and the results of the calculations are shown in Table A.10. The missing observation for Greece is filled by setting the value of σ for this country equal to the average value of those corresponding to Portugal and Spain.

Table A.10: Estimates of university survival rates

	whole cycle	*duration*	*yearly survival*	*years per grade*	*adjusted duration*
	Σ	d	σ	$1/\sigma$	D
Austria	0.59	4	0.876	1.141	4.564
Belgium	0.60	4	0.880	1.136	4.545
Denmark	0.69	4	0.911	1.097	4.389
Finland	0.75	5	0.944	1.059	5.296
France	0.59	4	0.876	1.141	4.564
Germany	0.70	4	0.915	1.093	4.373
Greece		4	**0.893**	**1.120**	**4.480**
Ireland	0.85	4	0.960	1.041	4.166
Italy	0.42	5	0.841	1.189	5.947
Netherlands	0.69	5	0.928	1.077	5.385
Portugal	0.49	4	0.837	1.195	4.781
Spain	0.77	5	0.949	1.054	5.268
Sweden	0.48	4	0.832	1.201	4.806
UK	0.83	4	0.954	1.048	4.191
average EU14			*0.900*	*1.114*	*4.768*

- *Sources:* Theoretical durations are from de la Fuente and Doménech (2001). Σ is taken from EAG (2002) (Table A2.2, survival rates for all tertiary type A programmes, with data for 2000). The only exceptions are Portugal and Greece. For Portugal, the data are taken from EAG (2000) and refer to 1993. For Greece there are no data, so we set the value of σ for this country equal to the average of Portugal and Spain.

For the case of upper secondary schooling, we proceed in the same way after estimating the overall survival rate (which the OECD does not provide) as the ratio between the gross graduation rate in a given year and the net enrollment ratio in secondary education at age 15 three years earlier. The first of these variables, which is defined as the ratio of upper secondary graduates to the total population of the theoretically relevant age, measures the output of graduates, while the second one approximates the intake of students in early years of this cycle. The data and the results are shown in Table A.11. For the UK there are no data on graduation rates, so we assume that σ has the same value as in Ireland.

Finally, the value of $S'(X_0)$ used in our calculations is the weighted average of the estimated values of σ at the upper secondary and university levels, with weights of 2/3 and 1/3 respectively.

Table A.11: Estimates of upper secondary survival rates

	graduation rate	*enrollment at 15*	*whole cycle*	*duration*	*yearly prob.*	*years per grade*	*adjusted duration*
			Σ	d	σ	$1/\sigma$	D
Austria	0.7	0.94	0.745	4	0.929	1.076	4.306
Belgium	0.79	0.97	0.814	3	0.934	1.071	3.212
Denmark	0.96	0.98	0.980	4	0.995	1.005	4.021
Finland	0.91	1	0.910	3	0.969	1.032	3.096
France	0.85	0.96	0.885	3	0.960	1.041	3.124
Germany	0.92	0.98	0.939	3	0.979	1.021	3.064
Greece	0.83	0.92	0.902	3	0.966	1.035	3.105
Ireland	0.76	0.97	0.784	3	0.922	1.085	3.254
Italy	0.79	0.86	0.919	5	0.983	1.017	5.086
Netherlands	0.95	0.99	0.960	2	0.980	1.021	2.042
Portugal	0.56	0.9	0.622	4	0.888	1.126	4.504
Spain	0.67	0.94	0.713	4	0.919	1.088	4.353
Sweden	0.71	0.97	0.732	3	0.901	1.110	3.329
UK		1		3	**0.922**	**1.085**	**3.254**
average EU14					*0.946*	*1.058*	*3.554*

- *Sources:* Theoretical durations are from de la Fuente and Doménech (2002, Table 4). Gross graduation rates from EAG 2003 (Table A1.1 with data corresponding generally to 2001), and net enrollment rates from EAG 2000 (Table C1.3, with data for 1998).

- *Notes:* for Austria and the Netherlands, the total (unduplicated) graduation rate is missing; I add up graduation rates across programme types, which may introduce some double counting. For Greece I use graduation rates for 1998 taken from EAG 2000 because the 2003 figures give very low graduation rates that seem implausible. For Portugal, I also use EAG 2000, as graduation data are missing in EAG 2003. For the UK there is no data on graduation rates, so we assume σ has the same value as in Ireland.

5. Detailed results: private returns

Tables A.12 and A.13 report the results of the participation and employment probits discussed in section 5. In both cases, the coefficients we report are not the direct estimates of the original parameters of the probit model, but the estimated marginal effects (calculated at the sample means of all the regressors) that measure the expected change in the relevant probability in response to a marginal increase in each of the explanatory variables.

The upper panels of Tables A.14 and A.15 show the raw and all-in rates of return to schooling and their different cost and benefit "components." The lower panels display the normalized values of these variables. To interpret this table, recall the rate of return formula derived in Section 2 of the text which can be written

$$(29')\quad \frac{R}{1-e^{-RH_o}} = R' \equiv \frac{\theta_{net} + p'_{net} + PENS}{OPPC + DIRC} \equiv \frac{NUM}{DENOM}$$

In this expression, θ_{net} and p'_{net} capture the net after-tax benefits of a marginal increase in schooling that are linked, respectively, to higher earnings and to higher employment probabilities, while *PENS* (which is zero in the non-government scenario) measures the discounted value of pension benefits and *OPPC* and *DIRC* the opportunity and direct costs of schooling, with all variables measured as fractions of the expected after-tax earnings of an adult worker. Thus, *NUM* measures the total payoff to an additional year of schooling and *DENOM* its total cost. (Notice that θ_{net}, p'_{net} and *PENS* are normalized by the average value of their sum, *NUM*, and *OPPC* and *DIRC* are normalized by the average value of *DENOM*).

Table A.12: Marginal effects in the employment probit

	S	*potexp*	*potexp*^{2}	*male*	*no. of observ.*	*predicted prob.*
Austria	0.00381	0.00074	0.00000	0.03210	5883	0.9566
	(2.74)	(0.52)	(0.01)	(3.82)		
Belgium	0.01671	0.00384	-0.00004	0.04398	4201	0.9282
	(7.51)	(1.48)	(0.65)	(3.52)		
Denmark	0.00531	0.00002	0.00001	0.01521	4001	0.9486
	(3.54)	(0.02)	(0.27)	(2.05)		
Finland	0.01732	0.00622	-0.00006	0.01981	7201	0.8816
	(9.32)	(2.43)	(1.19)	(2.26)		
France	0.01759	0.00763	-0.00008	0.04000	9184	0.9267
	(10.99)	(4.55)	(2.03)	(4.91)		
Germany	0.00670	-0.00094	0.00003	0.01723	10314	0.9413
	(5.10)	(0.82)	(0.89)	(2.87)		
Greece	0.01338	0.01753	-0.00023	0.11621	8801	0.8859
	(8.62)	(9.99)	(5.96)	(8.32)		
Ireland	0.02376	0.00216	0.00002	-0.02042	5746	0.9174
	(10.70)	(1.46)	(0.52)	(1.36)		
Italy	0.02085	0.02284	-0.00028	0.08986	14125	0.8581
	(15.62)	(12.88)	(7.22)	(9.08)		
Netherlands	0.00588	-0.00061	0.00003	0.02130	7472	0.9614
	(4.39)	(0.69)	(1.38)	(4.42)		
Portugal	0.00421	0.00495	-0.00006	0.02740	8903	0.9579
	(4.51)	(4.21)	(2.58)	(4.20)		
Spain	0.02451	0.01549	-0.00016	0.10596	12438	0.8005
	(14.74)	(7.64)	(3.71)	(8.39)		
Sweden	0.01558	0.01010	-0.00015	0.00540	7625	0.8989
	(9.66)	(8.20)	(5.88)	(0.75)		
UK	0.00779	0.00131	0.00001	-0.02254	5528	0.9462
	(5.69)	(1.49)	(0.29)	(3.61)		

- *Explanatory variables: S* = years of schooling: *potexp* = potential experience; *male* = dummy variable, it is equal to 1 for males and to 0 for females.

-*Note: t* statistics in parentheses below each coefficient. *Predicted prob.* is the model's prediction for the probability of employment at the mean values of all regressors.

Table A.13: Marginal effects in the participation probit

	S	*potexp*	*potexp2*	*male*	*married*	*married* male*	*children*	*children* male*
Austria	0.01412	0.03168	-0.00090	0.04690	0.00346	0.10533	-0.12881	0.22000
	(5.76)	(16.12)	(20.63)	(2.29)	(0.19)	(3.99)	(6.44)	(8.14)
Belgium	0.02762	0.03790	-0.00099	0.06309	0.00906	0.17848	-0.04683	0.07769
	(11.58)	(16.12)	(18.66)	(2.55)	(0.47)	(5.69)	(2.20)	(2.22)
Denmark	0.01074	0.02174	-0.00056	0.01729	0.01998	0.09344	-0.06255	0.06286
	(5.00)	(11.92)	(14.27)	(0.81)	(1.19)	(4.17)	(3.62)	(2.44)
Finland	0.01605	0.04439	-0.00095	0.03584	0.08624	-0.01168	-0.08830	0.12441
	(7.82)	(29.52)	(29.88)	(2.31)	(5.34)	(0.48)	(5.16)	(6.12)
France	0.02729	0.04423	-0.00107	0.02704	-0.05936	0.18942	-0.11084	0.17617
	(13.44)	(29.66)	(33.63)	(1.56)	(4.00)	(9.59)	(7.61)	(8.21)
Germany	0.01617	0.02731	-0.00078	0.01553	-0.02672	0.09744	-0.20522	0.16018
	(8.69)	(19.57)	(25.68)	(1.01)	(2.07)	(5.47)	(15.00)	(10.22)
Greece	0.01453	0.03535	-0.00083	0.01155	-0.12543	0.37983	-0.10487	0.20072
	(8.10)	(20.40)	(24.37)	(0.65)	(6.66)	(17.86)	(5.66)	(6.25)
Ireland	0.03677	0.02559	-0.00068	0.16867	-0.08166	0.28036	-0.16513	0.14284
	(12.87)	(11.69)	(15.24)	(8.53)	(3.61)	(10.39)	(8.17)	(4.22)
Italy	0.02213	0.05138	-0.00115	0.04667	-0.16309	0.31393	-0.09557	0.18048
	(16.13)	(32.94)	(37.27)	(3.54)	(10.46)	(19.25)	(6.60)	(7.30)
Netherl.	0.01917	0.02969	-0.00089	0.00131	-0.01937	0.18805	-0.23483	0.18086
	(7.14)	(16.28)	(22.84)	(0.25)	(0.90)	(8.87)	(14.94)	(8.99)
Portugal	0.01405	0.03395	-0.00073	0.08731	0.00954	0.20149	-0.03735	0.10261
	(6.47)	(21.06)	(23.96)	(5.68)	(0.63)	(10.25)	(2.25)	(3.81)
Spain	0.02564	0.05237	-0.00115	0.04758	-0.19008	0.37001	-0.10246	0.16359
	(15.07)	(32.29)	(35.51)	(3.32)	(11.65)	(20.41)	(6.74)	(6.22)
Sweden	0.009602	0.023926	-0.000488	0.026965	0.056125	-0.003068	-0.023953	0.051618
	(6.53)	(23.90)	(22.51)	(3.11)	(6.07)	(0.22)	(2.21)	(3.72)
UK	0.00671	0.01674	-0.00053	0.03290	0.04715	0.11469	-0.24850	0.10363
	(2.68)	(9.44)	(14.65)	(1.28)	(3.39)	(5.28)	(14.24)	(4.80)

- *Explanatory variables: S* = years of schooling: *potexp* = potential experience; *male* = dummy variable, it is equal to 1 for males and to 0 for females; married = dummy variable, equal to 1 for married individuals or those living in consensual unions with other persons; *children* = dummy variable for individuals with children under the age of twelve.

-*Note: t* statistics in parentheses below each coefficient.

Table A.14: Raw return to schooling and its components

a. Observed values

	$r_{no\ govt}$	*NUM*	θ_{net}	p'_{net}	*DENOM*	*OPPC*	*DIRC*
Ireland	10.98%	0.091	0.071	0.020	1.044	0.669	0.375
UK	9.94%	0.076	0.069	0.007	0.965	0.689	0.277
Finland	9.19%	0.069	0.054	0.015	0.956	0.650	0.306
Spain	8.91%	0.066	0.045	0.020	0.955	0.602	0.353
Germany	8.32%	0.064	0.058	0.006	0.974	0.692	0.282
Greece	8.28%	0.061	0.049	0.011	0.967	0.668	0.299
Italy	7.31%	0.055	0.038	0.018	1.004	0.659	0.345
France	7.25%	0.062	0.048	0.015	1.117	0.679	0.438
Belgium	7.20%	0.055	0.041	0.014	0.966	0.684	0.283
Portugal	6.87%	0.063	0.060	0.003	1.242	0.691	0.551
Austria	6.22%	0.057	0.054	0.003	1.176	0.710	0.466
Netherlands	6.11%	0.048	0.043	0.005	0.993	0.710	0.283
Denmark	5.08%	0.039	0.034	0.005	0.987	0.698	0.288
Sweden	3.21%	0.028	0.016	0.012	1.068	0.659	0.409
avge. EU14	*7.56%*	*0.059*	*0.048*	*0.011*	*1.029*	*0.675*	*0.354*

b. Normalized values

	$r_{no\ govt}$	*NUM*	θ_{net}	p'_{net}	*DENOM*	*OPPC*	*DIRC*
Ireland	145.3	153.9	120.2	33.6	101.5	65.0	36.5
UK	131.6	127.2	116.2	11.0	93.8	66.9	26.9
Finland	121.6	116.3	91.1	25.2	92.9	63.2	29.7
Spain	117.9	110.3	75.8	34.5	92.8	58.5	34.3
Germany	110.1	107.0	97.3	9.7	94.6	67.3	27.4
Greece	109.6	102.2	83.1	19.1	94.0	64.9	29.1
Italy	96.7	93.3	63.7	29.5	97.6	64.0	33.6
France	95.9	105.0	80.2	24.8	108.6	66.0	42.6
Belgium	95.2	91.8	68.6	23.2	93.9	66.4	27.5
Portugal	90.9	105.9	100.3	5.6	120.7	67.1	53.6
Austria	82.3	96.6	91.4	5.3	114.3	69.0	45.3
Netherlands	80.9	80.2	71.6	8.6	96.5	69.0	27.5
Denmark	67.3	65.0	57.2	7.8	95.9	67.9	28.0
Sweden	42.5	47.2	26.4	20.7	103.8	64.0	39.8
avge	*100.0*	*100.0*	*81.5*	*18.5*	*100.0*	*65.6*	*34.4*

Table A.15: Observed (all-in) return to schooling and its components

a. Observed values

	r_{obs}	*NUM*	θ_{net}	p'_{net}	*PENS*	*DENOM*	*OPPC*	*DIRC*
UK	12.27%	0.050	0.047	0.003	0.000	0.497	0.484	0.013
Ireland	11.03%	0.045	0.034	0.011	0.000	0.512	0.502	0.010
Portugal	10.38%	0.047	0.046	0.001	0.000	0.573	0.578	-0.005
Finland	10.16%	0.035	0.031	0.003	0.001	0.434	0.459	-0.025
Germany	9.46%	0.028	0.025	0.001	0.001	0.368	0.368	0.000
Greece	9.36%	0.043	0.037	0.005	0.001	0.599	0.586	0.014
Austria	8.86%	0.034	0.032	0.001	0.001	0.488	0.507	-0.018
France	8.80%	0.037	0.033	0.003	0.001	0.538	0.512	0.026
Italy	8.66%	0.032	0.024	0.007	0.001	0.485	0.475	0.010
Denmark	8.01%	0.018	0.017	0.001	0.000	0.288	0.348	-0.060
Spain	7.77%	0.038	0.032	0.004	0.001	0.644	0.588	0.056
Belgium	7.67%	0.022	0.018	0.003	0.001	0.358	0.354	0.004
Netherlands	7.59%	0.023	0.021	0.001	0.002	0.391	0.409	-0.018
Sweden	4.72%	0.014	0.010	0.003	0.001	0.389	0.468	-0.080
avge. EU14	8.96%	0.033	0.029	0.003	0.001	0.471	0.477	-0.005

b. Normalized values

	r_{obs}	*NUM*	θ_{net}	p'_{net}	*PENS*	*DENOM*	*OPPC*	*DIRC*
UK	136.9	151.4	142.9	8.2	0.2	105.4	102.7	2.7
Ireland	123.2	137.4	103.3	34.1	0.0	108.7	106.6	2.1
Portugal	115.8	142.5	139.5	1.7	1.3	121.6	122.6	-1.0
Finland	113.5	107.0	94.2	10.6	2.2	92.1	97.3	-5.2
Germany	105.6	84.2	76.8	4.1	3.2	78.2	78.2	0.0
Greece	104.4	132.0	114.0	15.1	3.0	127.1	124.3	2.9
Austria	98.9	104.0	96.9	2.7	4.4	103.6	107.5	-3.9
France	98.2	112.7	100.3	10.0	2.4	114.2	108.7	5.5
Italy	96.7	98.4	73.3	22.3	2.8	102.8	100.7	2.1
Denmark	89.4	54.1	51.0	2.9	0.1	61.1	73.8	-12.7
Spain	86.7	114.9	97.6	12.8	4.5	136.5	124.7	11.9
Belgium	85.6	65.6	55.2	8.6	1.7	75.9	75.0	0.9
Netherlands	84.7	70.7	63.0	1.7	6.0	83.0	86.8	-3.8
Sweden	52.6	42.1	31.0	7.7	3.4	82.5	99.3	-16.9
avge. EU14	*100.0*	*100.0*	*88.4*	*9.3*	*2.3*	*100.0*	*101.1*	*-1.1*

Table A.16 shows estimates of the private rate of return to schooling under each of the scenarios discussed in section 3 of the text. The upper block of the table gives the actual rates of return, and the lower one a set of normalized rates of return that are obtained by setting the average value for each scenario to 100. Table A.17 shows the change in the rate of return as we move across scenarios (i.e. the tax or subsidy wedges defined in the text) and Table A.18 converts these wedges into the implied subsidy or tax rates by dividing them by the rate of return in the no-government scenario.

Table A.16: Net private rates of return to schooling under different scenarios

	NO GOV'T [1]	*+subsidies* [2]	*+ taxes* [3]	*+ unempl. benefits* [4]	*+ pensions = OBS* [5]
Austria	6.22%	10.35%	8.96%	8.52%	8.86%
Belgium	7.20%	9.91%	9.88%	7.47%	7.67%
Denmark	5.08%	7.87%	9.16%	7.99%	8.01%
Finland	9.19%	13.31%	12.15%	9.98%	10.16%
France	7.25%	11.00%	10.59%	8.63%	8.80%
Germany	8.32%	11.32%	9.97%	9.13%	9.46%
Greece	8.28%	11.16%	10.22%	9.18%	9.36%
Ireland	10.98%	15.82%	12.40%	11.03%	11.03%
Italy	7.31%	10.46%	10.08%	8.44%	8.66%
Netherlands	6.11%	8.73%	7.98%	6.95%	7.59%
Portugal	6.87%	11.44%	10.82%	10.30%	10.38%
Spain	8.91%	12.24%	11.59%	7.50%	7.77%
Sweden	3.21%	6.48%	7.18%	4.28%	4.72%
UK	9.94%	13.07%	13.16%	12.25%	12.27%
avge. EU14	*7.56%*	*11.05%*	*10.43%*	*8.78%*	*8.96%*

	NO GOV'T [1]	*+subsidies* [2]	*+ taxes* [3]	*+ unempl. benefits* [4]	*+ pensions = OBS* [5]
Austria	82.3	93.6	85.9	97.0	98.9
Belgium	95.2	89.7	94.7	85.2	85.6
Denmark	67.3	71.3	87.9	91.1	89.4
Finland	121.6	120.5	116.5	113.8	113.5
France	95.9	99.6	101.6	98.3	98.2
Germany	110.1	102.5	95.6	104.0	105.6
Greece	109.6	101.0	98.0	104.6	104.4
Ireland	145.3	143.2	118.9	125.7	123.2
Italy	96.7	94.6	96.6	96.2	96.7
Netherlands	80.9	79.0	76.5	79.2	84.7
Portugal	90.9	103.5	103.7	117.3	115.8
Spain	117.9	110.8	111.1	85.4	86.7
Sweden	42.5	58.6	68.8	48.8	52.6
UK	131.6	118.3	126.2	139.6	136.9
avge. EU14	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*

Table A.17: tax or subsidy wedge induced by various public interventions

	educational subsidies [2]-[1]	*personal taxes [2]-[3]*	*social benefits [3]-[4]*	*pensions [5]-[4]*	*all gov't [1]-[5]*
Austria	4.13%	1.39%	0.44%	0.34%	-2.64%
Belgium	2.72%	0.03%	2.41%	0.20%	-0.47%
Denmark	2.79%	-1.29%	1.17%	0.02%	-2.93%
Finland	4.12%	1.16%	2.17%	0.18%	-0.98%
France	3.75%	0.41%	1.97%	0.17%	-1.55%
Germany	3.00%	1.35%	0.84%	0.33%	-1.14%
Greece	2.88%	0.94%	1.04%	0.18%	-1.07%
Ireland	4.84%	3.42%	1.37%	0.00%	-0.06%
Italy	3.15%	0.38%	1.63%	0.22%	-1.36%
Netherlands	2.61%	0.75%	1.03%	0.64%	-1.48%
Portugal	4.57%	0.62%	0.52%	0.08%	-3.51%
Spain	3.33%	0.65%	4.10%	0.27%	1.14%
Sweden	3.27%	-0.70%	2.90%	0.43%	-1.51%
UK	3.12%	-0.09%	0.91%	0.02%	-2.33%
avge. EU14	*3.49%*	*0.62%*	*1.65%*	*0.18%*	*-1.40%*

Table A.18: Net implicit subsidy or tax rate induced by various public interventions

	educational subsidies [2]-[1]	*personal taxes [2]-[3]*	*social benefits [3]-[4]*	*pensions [5]-[4]*	*all gov't [1]-[5]*
Austria	66.40%	22.30%	7.11%	5.55%	-42.54%
Belgium	37.76%	0.45%	33.47%	2.74%	-6.59%
Denmark	54.88%	-25.39%	22.99%	0.39%	-57.66%
Finland	44.82%	12.57%	23.61%	1.98%	-10.62%
France	51.76%	5.61%	27.11%	2.32%	-21.36%
Germany	36.02%	16.23%	10.10%	3.97%	-13.65%
Greece	34.74%	11.39%	12.56%	2.17%	-12.97%
Ireland	44.11%	31.12%	12.45%	0.00%	-0.54%
Italy	43.09%	5.20%	22.31%	3.01%	-18.58%
Netherlands	42.76%	12.20%	16.82%	10.42%	-24.16%
Portugal	66.57%	9.06%	7.54%	1.14%	-51.11%
Spain	37.39%	7.32%	45.97%	3.06%	12.83%
Sweden	101.88%	-21.87%	90.26%	13.51%	-47.01%
UK	31.42%	-0.93%	9.11%	0.16%	-23.39%
avge. EU14	*46.20%*	*8.17%*	*21.89%*	*2.42%*	*-18.57%*

6. Detailed results: fiscal returns

Table A.19 gives our estimates of the fiscal rate of return to schooling under the different assumptions discussed in the text.

Table A.19: Fiscal rate of return on schooling

	[1] *personal taxes*	*[2]* *+ consump. taxes*	*[3]* *+ employer s. sec. contr.*	*[4]* *+ pensions = OBS*
Austria	0.68%	1.17%	2.11%	
Belgium	3.03%	3.15%	3.91%	3.64%
Denmark	0.82%	1.19%	1.18%	1.02%
Finland	3.77%	4.10%	4.92%	4.43%
France	1.52%	2.11%	3.66%	3.12%
Germany	3.97%	4.13%	4.70%	4.05%
Greece	1.79%	2.54%	3.70%	2.03%
Ireland	5.34%	5.67%	6.17%	6.14%
Italy	1.81%	2.21%	3.39%	2.40%
Netherlands	2.25%	2.52%	2.82%	
Portugal	0.09%	1.18%	2.42%	1.36%
Spain	2.98%	3.37%	4.74%	4.00%
Sweden	-1.42%	-1.25%	-0.52%	-1.70%
UK	3.19%	3.80%	4.53%	4.35%
avge. EU14	*2.35%*	*2.74%*	*3.58%*	*2.91%*

A number of things should be noted about these estimates. The first is that the introduction of pension benefits does raise some problems for their calculation, for pensions represent a large negative cash flow at the "end of the project" and, as is well known, this can give rise to multiple solutions or to the absence of them in the calculation of internal rates of return. For two of the countries in the sample, indeed, the fiscal rate of return equation has no solution. This is illustrated for the case of Austria in Figure A.1, which shows the net present fiscal value of schooling as a function of the discount rate. In all other cases, the rate of return equation has two solutions, at least one of which is negative, as illustrated in Figure A.2 for the case of the average EU14 country. In these cases we report the larger of the two solutions. When it is positive, this figure is not misleading as the net present value of schooling will be positive for any interest rate between zero and the reported rate of return and negative thereafter, so this is indeed the highest positive interest rate at which the government can borrow to finance educational expenditure without increasing the present value of its current and future deficits.

Figure A.1: Net present fiscal value of a year of schooling as a function of the discount rate, Austria

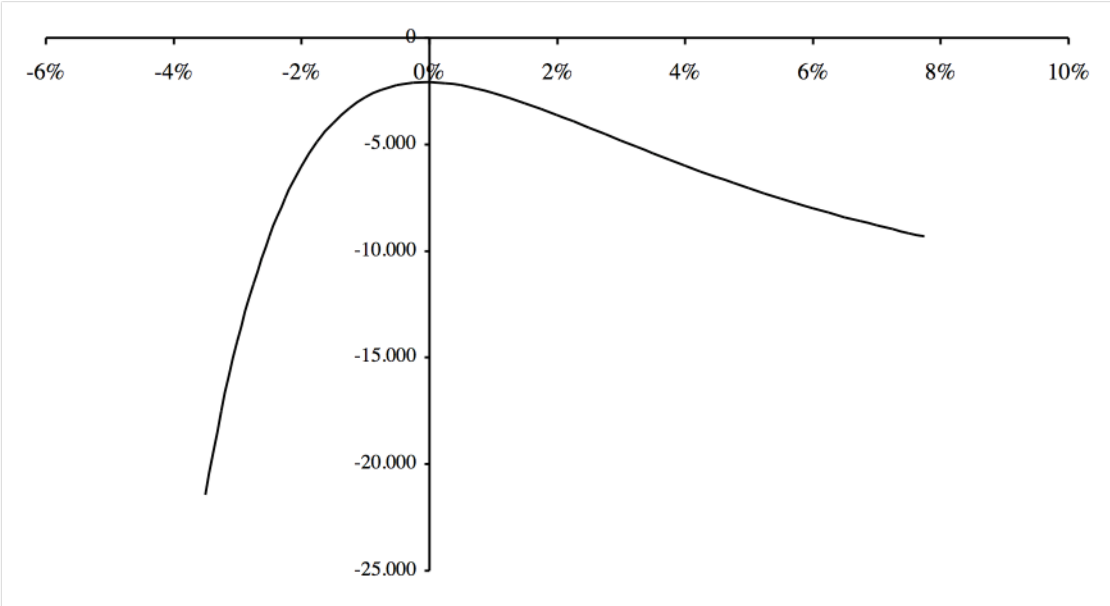
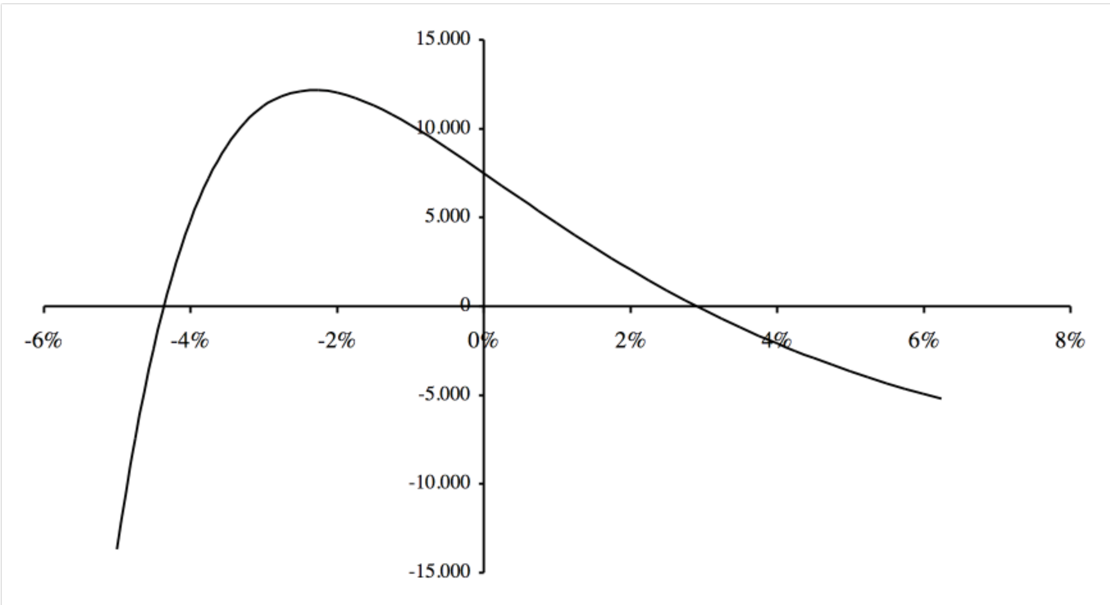
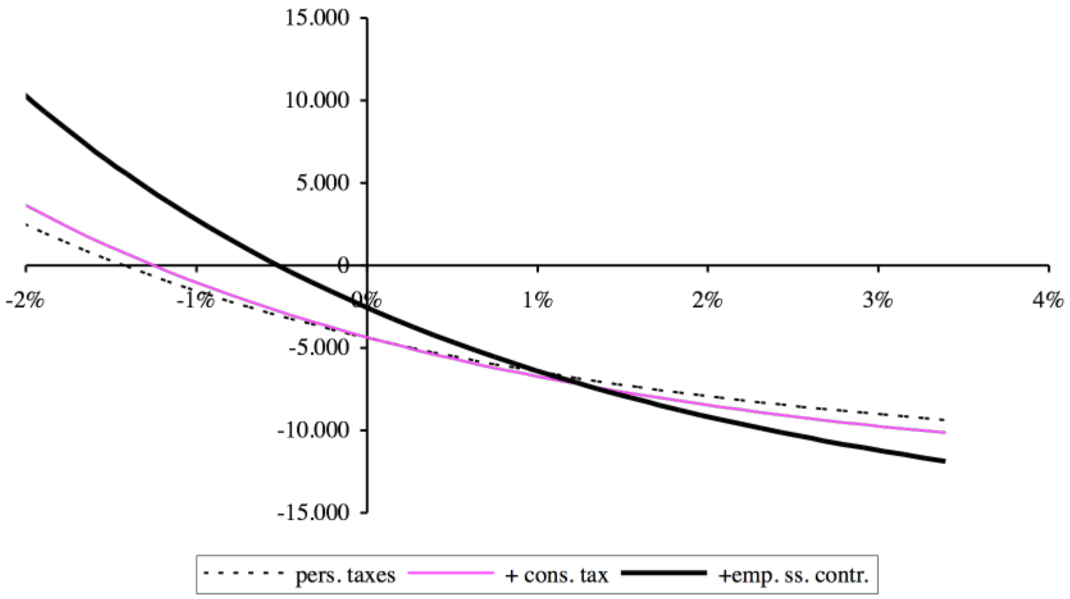


Figure A.2: Net present fiscal value of a year of schooling as a function of the discount rate, average EU14 country



Finally, it should be kept in mind that internal rates of return and net present values do not necessarily move in the same direction. Sweden is a clear example of this. Comparing table A.19 with Table 11 in the text, we see that the introduction of consumption taxes and employer social security contributions increases the fiscal rate of return but reduces the net present fiscal value obtained with a 3% real discount rate. Since taking into account such taxes when calculating the returns to a marginal increase in schooling raises tax receipts in the future but also increases the opportunity cost of schooling in terms of foregone tax revenues from currently active workers, their effect on net present values will depend on the discount rate and, as illustrated in Figure A.3, the resulting changes in the internal rate of return and on the net present fiscal value at a given discount rate may be of opposite signs.

Figure A.3: Net present fiscal value of a year of schooling as a function of the discount rate, under different scenarios, Sweden



APPENDIX 2: Detailed calculations

1. The private return to schooling

The lifetime net income function given in the text can be written

$$(1)\ V(X) = A_0 e^{vH_0/2}\int_0^X F_s(t)e^{-(R+v)t}dt \ - \ A_0\mu_S e^{vH_0/2} f(S_0)\int_0^X e^{-(R+v)t}dt$$

$$+ \ A_0\int_X^U F(X)e^{-Rt}dt + \ A_0 e^{(g+v-\omega)U}F_p(X)\int_U^Z e^{-(R+g+v-\omega)t}dt$$

where $S_0 \equiv S(X_0)$ and

$$(2)\ R \equiv r - g - v.$$

Differentiating (1) with respect to X, we have

$$V'(X) = A_0 e^{vH_0/2}F_s(X)e^{-(R+v)X} - A_0 e^{vH_0/2}\mu_s f(S_0)e^{-(R+v)X}$$
$$+ A_0\left\{\int_X^U F'(X)e^{-Rt}dt - F(X)e^{-RX}\right\} + A_0 e^{(g+v-\omega)U}F_p{}'(X)\left\{\int_U^Z e^{-(R+g+v-\omega)t}dt\right\}$$

or

$$\frac{V'(X)}{A_0} = e^{-(R+v)X}e^{vH_0/2}\left[F_s(X) - \mu_s f(S_0)\right] - F(X)e^{-RX}$$
$$+ F'(X)\frac{e^{-RX} - e^{-RU}}{R} + e^{(g+v-\omega)U}F_p{}'(X)\frac{e^{-(R+g+v-\omega)U} - e^{-(R+g+v-\omega)Z}}{R+g+v-\omega}$$

$$\frac{V'(X)}{A_0} = e^{-(R+v)X}e^{vH_0/2}\left[F_s(X) - \mu_s f(S_0)\right] - F(X)e^{-RX}$$
$$+ F'(X)e^{-RX}\frac{1-e^{-R(U-X)}}{R} + e^{(g+v-\omega)U}F_p{}'(X)e^{-(R+g+v-\omega)U}\frac{1-e^{-(R+g+v-\omega)(Z-U)}}{R+g+v-\omega}$$

In this expression, notice that

$$U - X = H$$

and

$$e^{(g+v-\omega)U}e^{-(R+g+v-\omega)U} = e^{-RU} = e^{-R(X+H)}.$$

Hence,

$$\frac{V'(X)}{A_0} = e^{-(R+v)X}e^{vH_0/2}\left[F_s(X) - \mu_s f(S_0)\right] - F(X)e^{-RX}$$
$$+ F'(X)e^{-RX}\frac{1-e^{-RH}}{R} + F_p{}'(X)e^{-RX}e^{-RH}\frac{1-e^{-(R+g+v-\omega)(Z-U)}}{R+g+v-\omega}$$

which can be written

$$\frac{V'(X)}{A_o} = e^{-(R+\nu)X} e^{\nu H_0/2}\left[F_s(X) - \mu_s f(S_0)\right] - F(X)e^{-RX}$$
$$+ e^{-RX}\frac{1-e^{-RH}}{R}\left\{F'(X) + F_p'(X)e^{-RH}\frac{R}{1-e^{-RH}}\frac{1-e^{-(R+g+\nu-\omega)(Z-U)}}{R+g+\nu-\omega}\right\}$$

or

$$(3)\ \frac{V'(X)}{A_o e^{-RX}} = e^{-\nu X} e^{\nu H_0/2}\left[F_s(X) - \mu_s f(S_0)\right] - F(X)$$
$$+ \frac{1-e^{-RH}}{R}\left\{F'(X) + F_p'(X)\frac{R}{R+g+\nu-\omega}\frac{1-e^{-(R+g+\nu-\omega)(Z-U)}}{e^{RH}-1}\right\}$$

It will be useful to define

$$(4)\ \gamma(R) \equiv \frac{R}{R+g+\nu-\omega}\frac{1-e^{-(R+g+\nu-\omega)(Z-U)}}{e^{RH}-1}$$

and to write equation (3) in the form

$$\frac{V'(X)}{A_o e^{-RX}} = e^{-\nu X} e^{\nu H_0/2}\left[F_s(X) - \mu_s f(S_0)\right] - F(X) + \frac{1-e^{-RH}}{R}\left\{F'(X) + \gamma(R)F_p'(X)\right\}$$

Evaluating this expression at X_0 and setting it equal to zero,

$$\frac{1-e^{-RH}}{R}\left\{F'(X_o) + \gamma(R)F_p'(X_o)\right\} = F(X_o) - e^{-\nu X}e^{\nu H_0/2}\left[F_s(X_o) - \mu_s f(S_o)\right],$$

we arrive at

$$(5)\ \frac{R}{1-e^{-RH}} = \frac{F'(X_o) + \gamma(R)F_p'(X_o)}{F(X_o) - F_s(X_o)e^{-\nu X}e^{\nu H_0/2} + \mu_s f(S_o)e^{-\nu X}e^{\nu H_0/2}}.$$

As discussed in the text, the functions $F()$, $F_S()$ and $F_P()$ that determine, respectively, the expected net-of-tax earnings of an adult active worker, a part-time student worker and a pensioner, are defined by

$$(6)\ F_S(x) = p_S[S(x)]\{(1-\phi)f[S(x)] - T((1-\phi)f[S(x)])\}$$

$$(7)\ F_p(X) \equiv P\left[f(S(X))e^{-\nu X}\right] - T\left[P\left[f(S(X))e^{-\nu X}\right]\right]$$

$$(8)\ F(X) = p[S(X)]F_e(X) + (1-p[S(X)])F_u(X)$$

where

$$(9)\ F_e(X) = e^{-\nu X}f[S(X)] - T(e^{-\nu X}f[S(X)]) \quad \text{and}$$

$$(10)\ F_u(X) = B(e^{-\nu X}f[S(X)]) - T\left[B(e^{-\nu X}f[S(X)])\right]$$

give, respectively, the net earnings of an employed and an unemployed adult worker per efficiency unit of labour.

To rewrite equation (5) in a more convenient form, we proceed as follows. First, we define the average tax rates for the representative employed and unemployed adult workers, student part-time workers and pensioners (τ_e, τ_u, τ_s and τ_p) and the gross replacement ratios, *b* and *pb* (that is, the ratio between gross earnings in employment and gross earnings out of employment or in retirement) by

$$(11)\ \tau_e \equiv \frac{T\left(e^{-vX_0} f(S_o)\right)}{e^{-vX_0} f(S_o)},\ \ \tau_u \equiv \frac{T\left(B\left(e^{-vX_0} f(S_o)\right)\right)}{B\left(e^{-vX_0} f(S_o)\right)},\ \ \tau_s \equiv \frac{T\left((1-\phi) f(S_o)\right)}{(1-\phi) f(S_o)},$$

$$\tau_p \equiv \frac{T\left(\kappa e^{-vX_0} f(S_o)\right)}{\kappa e^{-vX_0} f(S_o)},\ \ b \equiv \frac{B\left(e^{-vX_0} f(S_o)\right)}{e^{-vX_0} f(S_o)}\ \ \text{and}\ \ pb \equiv \frac{P\left(e^{-vX_o} f(S_o)\right)}{e^{-vX_o} f(S_o)}$$

Using these expressions, we have

$$(12)\ F_e(X_0) =$$

$$\left[e^{-vX_0} f(S_0) - T\left(e^{-vX_0} f(S_0)\right)\right] = \left[1 - \frac{T\left(e^{-vX_0} f(S_0)\right)}{e^{-vX_0} f(S_0)}\right] e^{-vX_0} f(S_0) = (1-\tau_e) e^{-vX_0} f(S_0)$$

and, by the same procedure

$$(13)\ F_u(X_0) = (1-\tau_u) b e^{-vX_0} f(S_0)$$

$$(14)\ F_p(X_o) = (1-\tau_p) pb e^{-vX_o} f(S_o)$$

$$(15)\ F_S(X_0) = \eta p(1-\phi)(1-\tau_s) f(S_o)$$

where

$$(16)\ \ p \equiv p(S_o)\,.$$

Hence, $F(X_0)$ can be written

$$(17)\ F(X_o) = pF_e(X_o) + (1-p)F_u(X_o) = \left[p(1-\tau_e) + (1-p)(1-\tau_u)b\right] e^{-vX_0} f(S_o)$$
$$= p(1-\tau) e^{-vX_0} f(S_o)$$

where

$$(18)\ (1-\tau) \equiv (1-\tau_e) + \frac{1-p}{p}(1-\tau_u) b \ \ \Rightarrow \ \ \tau = \tau_e - \frac{1-p}{p}(1-\tau_u) b$$

Next, we compute the following derivatives:

$$(19)\ F_e'(X_o) = (1-T'_e) e^{-vX_0} \left[f'(S_o) S'(X_o) - vf(S_o)\right]$$

$$(20)\ F_p'(X_o) = \left(1-T'_p\right)BP'e^{-vX_o}\left[f'(S_o)S'(X_o) - vf(S_o)\right]$$

$$(21)\ F'_u(X_0) = \left(1-T'_u\right)B'e^{-vX_0}\left[f'(S_0)S'(X_0) - vf(S_0)\right]$$

where

$$(22)\ T'_e \equiv T'\left(e^{-vX_0}f(S_0)\right),\quad T'_u \equiv T'\left(B\left(e^{-vX_0}f(S_0)\right)\right)\quad \text{and}\quad T'_p \equiv T'\left(P\left(e^{-vX_o}f(S_o)\right)\right)$$

are the marginal tax rates applicable to the reference employed and unemployed worker and to the representative pensioner and

$$(23)\ B' \equiv B'\left(e^{-vX_o}f(S_o)\right)\ \text{and}\quad PB' \equiv P'\left(e^{-vX_o}f(S_o)\right)$$

the marginal unemployment benefit rates for the average worker and pensioner. Differentiating *F()*, we have:

$$(24)\ F'(X_0) = p'(S_0)S'(X_0)F_e(X_0) + p(S_0)F_e'(X_0) - p'(S_0)S'(X_0)F_u(X_0) + \left(1-p(S_0)\right)F_u'(X_0)$$

$$= p'S'\left[F_e(X_0) - F_u(X_0)\right] + pF_e'(X_0) + (1-p)F_u'(X_0)$$

$$= p'S'\left[(1-\tau_e) - (1-\tau_u)b\right]e^{-vX_0}f(S_0) + \left[p\left(1-T'_e\right) + (1-p)B'\left(1-T'_u\right)\right]e^{-vX_0}\left[f'(S_0)S'(X_0) - vf(S_0)\right]$$

$$= p'S'\Delta e^{-vX_0}f(S_0) + p\left(1-T'\right)e^{-vX_0}\left[f'(S_0)S'(X_0) - vf(S_0)\right]$$

where we have defined

$$(25)\ 1-T' \equiv \left(1-T'_e\right) + \frac{1-p}{p}\left(1-T'_u\right)B' \ \Rightarrow\ T' \equiv T'_e - \frac{1-p}{p}\left(1-T'_u\right)B' \quad \text{and}$$

$$(26)\quad \Delta \equiv (1-\tau_e) - (1-\tau_u)b.$$

Inserting the expressions we have just derived into the right-hand side of equation (5) and dividing through by $e^{-vX}f(S_0)$, we have

$$(27)\ R' = \frac{p\left(1-T'\right)\left[\theta S'(X_o) - v\right] + \Delta p'S'(X_o) + \gamma(R)\left(1-T'_p\right)PB'\left[\theta S'(X_o) - v\right]}{\left[\mathrm{p}(1\text{-}\tau) - \eta p(1-\phi)(1-\tau_s)e^{vH_o/2}\right] + \mu_s e^{vH_o/2}}$$

where

$$(28)\ \theta \equiv \frac{f'(S_0)}{f(S_0)}$$

is the Mincerian returns to schooling parameter. This is equation (29) in the text. For some purposes it will be more convenient to divide through by $F(X_0) = p(1-\tau)e^{-vX}f(S_0)$, so that all terms are expressed as fractions of the expected starting earnings of an active adult worker. We have then:

$$(29)\ R' = \frac{\frac{1-T'}{1\text{-}\tau}(\theta S'-\nu)+\frac{\Delta}{1\text{-}\tau}\varepsilon S'+\gamma(R)\frac{1-T'_p}{\text{p}(1\text{-}\tau)}PB'(\theta S'-\nu)}{\left[1-\eta(1-\phi)\frac{1-\tau_s}{1\text{-}\tau}e^{\nu H_o/2}\right]+\frac{\mu_s}{\text{p}(1\text{-}\tau)}e^{\nu H_o/2}}$$

$$= \frac{(1-\pi)\theta'+(1-\rho)\varepsilon'+PENS'}{\left[1-\eta(1-\phi)\frac{1-\tau_s}{1\text{-}\tau}e^{\nu H_o/2}\right]+\frac{\mu_s}{\text{p}(1\text{-}\tau)}e^{\nu H_o/2}}$$

where

$$(30)\quad \varepsilon \equiv \frac{p'(S_o)}{p(S_o)}$$

is the semielasticity of the probability of employment function and we have defined

$$(31)\ \theta' \equiv \theta S'(X_o)-\nu,\quad \varepsilon' \equiv \varepsilon S'(X_o)\ \text{ and }\ PENS' = \gamma(R)\frac{1-T'_p}{\text{p}(1\text{-}\tau)}PB'(\theta S'-\nu) = \gamma(R)\frac{1-T'_p}{\text{p}(1\text{-}\tau)}PB'\theta'$$

The terms π and ρ are defined by

$$(32)\quad 1-\pi \equiv \frac{1-T'}{1-\tau} \qquad \Rightarrow \qquad \pi = 1-\frac{1-T'}{1-\tau} = \frac{T'-\tau}{1-\tau}$$

and[28]

$$(33)\quad \rho \equiv \frac{(1-\tau_u)b}{p(1\text{-}\tau)}$$

Notice that ρ is a modified average net replacement ratio (calculated as a fraction of the expected net earnings of an active worker rather than as a fraction of net income in employment), and that π can be interpreted as a measure of progressivity. The ratio $\frac{1-T'}{1-\tau}$ is the elasticity of the expected net earnings of an adult active worker with respect to gross earnings in employment.

A special case

The above derivation assumes that unemployment benefits are set as a function of gross income in employment. This is so in most countries, but there are two exceptions. Germany and Austria

[28] Notice that

$$(1\text{-}\tau) \equiv (1-\tau_e)+\frac{1-p}{p}(1-\tau_u)b = (1-\tau_e)-(1-\tau_u)b+\frac{(1-\tau_u)b}{p} = \Delta+\frac{(1-\tau_u)b}{p}$$

Hence,

$$\Delta = (1\text{-}\tau)-\frac{(1-\tau_u)b}{p}$$

and

$$\frac{\Delta}{1\text{-}\tau} = \frac{(1\text{-}\tau)-\frac{(1-\tau_u)b}{p}}{1\text{-}\tau} = 1-\frac{(1-\tau_u)b}{p(1\text{-}\tau)} \equiv 1-\rho$$

set benefits as a fixed fraction (β) of net-of-tax income in employment and exempt them from tax. In this case, the calculations above have to be adjusted as follows.

First, the net income of an unemployed worker (per efficiency unit of labour) will be given by

$$(10')\ \ F_u(X) = \beta F_e(X)$$

Hence,

$$(8')\ \ F(X) = p(S)F_e(X) + (1-p(S))F_u(X) = pF_e(X) + (1-p)\beta F_e(X) = [p+(1-p)\beta]F_e(X)$$

from where

$$(17')\ F(X_o) = [p+(1-p)\beta](1-\tau_e)e^{-vX} f(S_o)$$

$$(24')\ F'(X_o) = \ p'S'(X_o)(1-\beta)F_e(X_o) + [p+(1-p)\beta]F_e'(X_o)$$

$$= p'S'(1-\beta)(1-\tau_e)f(S_o)e^{-vX} + [p+(1-p)\beta](1-T'_e)e^{-vX}(f'(S_o)S' - vf(S_o))$$

If we define

$$(25')\ 1-T' \equiv \left[1+\frac{1-p}{p}\beta\right](1-T'_e)\ \ ,$$

$$(18')\ (1\text{-}\tau) \equiv \left[1+\frac{1-p}{p}\beta\right](1-\tau_e) \quad \text{and}$$

$$(26')\ \ \Delta \equiv (1-\tau_e)(1-\beta)$$

we can write F and F' in the same form as in the previous section

$$(17)\ \ F(X_o) = p(1-\tau)f(S_o)e^{-vX}$$

$$(24)\ \ F'(X_o) = \ = p'S'\Delta e^{-vX} f(S_o) + p(1-T')e^{-vX}[f'(S_o)S'(X_o) - vf(S_o)]$$

and equations (27) and (29) continue to hold as written. Notice, however, that in this case ρ is defined by

$$1-\rho \equiv \frac{\Delta}{1\text{-}\tau} = \frac{(1-\tau_e)(1-\beta)}{\left[1+\frac{1-p}{p}\beta\right](1-\tau_e)} = \frac{1-\beta}{1-\beta+\frac{\beta}{p}}$$

from where

$$(33')\ \ \rho = 1 - \frac{1-\beta}{1-\beta+\frac{\beta}{p}} = \frac{\frac{\beta}{p}}{1-\beta+\frac{\beta}{p}} = \frac{\beta}{p(1-\beta)+\beta} = \frac{\beta}{p+(1-p)\beta}\ .$$

Decomposition of the progressivity ratio

We can relate π to π_u and π_e as follows:

$$1-\pi \equiv \frac{p(1-T')}{p(1-\tau)} = \frac{p(1-T'_e)+(1-p)(1-T'_u)B'}{p(1-\tau)} = \frac{p(1-\tau_e)\frac{(1-T'_e)}{(1-\tau_e)}+(1-p)(1-\tau_u)b\frac{(1-T'_u)B'}{(1-\tau_u)b}}{p(1-\tau)}$$

$$= \frac{p(1-\tau_e)}{p(1-\tau)}(1-\pi_e)+\frac{(1-p)(1-\tau_u)b}{p(1-\tau)}(1-\pi_u) = \left[1-(1-p)\rho\right](1-\pi_e)+(1-p)\rho(1-\pi_u)$$

or

$$(1-\pi) = (1-\pi_e)-(1-p)\rho\left[(1-\pi_e)-(1-\pi_u)\right] = (1-\pi_e)-(1-p)\rho\left(\pi_u-\pi_e\right)$$

$$\pi = 1-(1-\pi_e)+(1-p)\rho\left(\pi_u-\pi_e\right)$$

$$\pi = \pi_e + (1-p)\rho\left(\pi_u-\pi_e\right).$$

Finally, notice that in the cases of Austria and Germany we will have $\pi_u = \pi_e$ since net benefits are set as a fixed fraction of after-tax income in employment.

2. The fiscal returns to schooling

We want to use the same procedure developed above to quantify the impact of schooling on government expenditures and revenues. Proceeding as above, the net present value of government net revenues is given by

$$(34)\ V_g(X) = A_o e^{vH_o/2}\int_0^X G_s(t)e^{-(R+v)t}dt \ + \ A_o\int_X^U G(X)e^{-Rt}dt \ - \ A_o e^{vH_o/2}\mu_g f(S_o)\int_0^X e^{-(R+v)t}dt$$
$$+ A_o e^{(g+v-\omega)U} q\left[S(X)\right]G_p(X)\int_U^Z e^{-(R+g+v-\omega)t}dt$$

where $R \equiv r - g - v$, r is the discount rate and μ_g the cost of education born by the government as a fraction of the average worker's wage.

Differentiating $V_g()$,

$$V_g'(X) = A_o e^{vH_o/2}G_s(X)e^{-(R+v)X} - A_o e^{vH_o/2}\mu_g f(S_o)e^{-(R+v)X}$$
$$+ A_o\left\{\int_X^U G'(X)e^{-Rt}dt - G(X)e^{-RX}\right\} + A_o e^{(g+v-\omega)U}\left[q'S'G_p(X)+qG_p'(X)\right]\left\{\int_U^Z e^{-(R+g+v-\omega)t}dt\right\}$$

$$= A_o e^{vH_o/2}G_s(X)e^{-(R+v)X} - A_o e^{vH_o/2}\mu_g f(S_o)e^{-(R+v)X}$$
$$+ A_o e^{-RX}\left\{G(X)\frac{1-e^{-RH}}{R} - G(X)\right\} + A_o e^{-R(X+H)}\left[q'S'G_p(X)+qG_p'(X)\right]\frac{1-e^{-(R+g+v-\omega)(Z-U)}}{R+g+v-\omega}$$

and proceeding as in the previous section, it is easy to show that

$$(35)\quad \frac{R}{1-e^{-RH}} = \frac{G'(X_o) + \gamma(R)\left[q'S'(X_o)G_p(X_o) + qG_p'(X_o)\right]}{G(X_o) - G_s(X_o)e^{-vX}e^{vH_o/2} + \mu_g f(S_o)e^{-vX}e^{vH_o/2}}$$

where

$$(36)\,\gamma(R) = \frac{1-e^{-(R+g+v-\omega)(Z-U)}}{e^{RH}-1}\frac{R}{R+g+v-\omega}$$

$$(37)\; G_s(X) = q_s[S(X)]p_s[S(X)] \\ *\left\{T\big((1-\phi)f(S(X))\big) + E\big((1-\phi)f(S(X))\big) + \tau_c C\big[(1-\phi)f(S(X)) - T\big((1-\phi)f(S(X))\big)\big]\right\}$$

$$(38)\; G_p(X) \equiv -P\left(f(S(X))e^{-vX}\right) + T\left[P\left(f(S(X))e^{-vX}\right)\right] + \tau_c C\left[P\left(f(S(X))e^{-vX}\right) - T\left[P\left(f(S(X))e^{-vX}\right)\right]\right]$$

$$(39)\; G(X) = q[S(X)]\left\{p[S(X)]G_e(X) + \left(1-p[S(X)]\right)G_u(X)\right\}$$

with

$$(40)\; G_e(X) = T\left(e^{-vX}f[S(X)]\right) + \tau_c C\left[e^{-vX}f[S(X)] - T\left(e^{-vX}f[S(X)]\right)\right] + E\left(e^{-vX}f[S(X)]\right)$$

$$(41)\; G_u(X) = -B\left(e^{-vX}f[S(X)]\right) + T\left(B\left(e^{-vX}f[S(X)]\right)\right) + \tau_c C\left(B\left(e^{-vX}f[S(X)]\right) - T\left(B\left(e^{-vX}f[S(X)]\right)\right)\right)$$

The functions $q(S)$ and $q_S(S) = \eta_q q(S)$ describe the probabilities that an adult worker and a student respectively will be active as a function of their attainment level. Hence, $G(S)$ denotes the expected net tax revenue (net of unemployment benefits) for an adult worker of attainment S, $G_p()$ that generated by a pensioner, and $G_S(s)$ by a student of attainment s --- with all three variables expressed in amounts per efficiency unit of labour.

We will now calculate the different terms that appear in equation (35). To proceed, we will define the average and marginal propensities to consume out of after-tax income (c and C') of students, pensioners and adult employed and unemployed workers,

$$(42)\quad c_s \equiv \frac{C[(1-\tau_s)(1-\phi)f(S_o)]}{(1-\tau_s)(1-\phi)f(S_o)} \qquad c_e \equiv \frac{C\left[(1-\tau_e)e^{-vX}f(S_o)\right]}{(1-\tau_e)e^{-vX}f(S_o)}$$

$$c_u \equiv \frac{C\left[(1-\tau_u)be^{-vX}f(S_o)\right]}{(1-\tau_u)be^{-vX}f(S_o)} \qquad c_p \equiv \frac{C\left[(1-\tau_p)pbe^{-vX}f(S_o)\right]}{(1-\tau_p)pbe^{-vX}f(S_o)}$$

$$(43)\quad C'_e \equiv C'\left[(1-\tau_e)e^{-vX}f(S_o)\right] \quad C'_u \equiv C'\left[(1-\tau_u)be^{-vX}f(S_o)\right] \quad C'_p \equiv C'\left[(1-\tau_p)pbe^{-vX}f(S_o)\right]$$

and the average and marginal rates of employer's social security contributions for employed adult and student workers

$$(44)\; e_s \equiv \frac{E[(1-\phi)f(S_o)]}{(1-\phi)f(S_o)} \quad e_e \equiv \frac{E\left[e^{-vX}f(S_o)\right]}{e^{-vX}f(S_o)} \quad \text{and} \quad E'_e \equiv E'\left(e^{-vX}f(S_o)\right).$$

Using this notation, and the average and marginal tax rates defined in the previous section, we have:

$$(45)\ G_s(X_o) = q_s p_s\{\tau_s + e_s + \tau_c c_s(1-\tau_s)\}(1-\phi)f(S_o) \equiv q\eta_q p_s T_s(1-\phi)f(S_o)$$

$$(46)\ G_p(X_o) = -(1-\tau_p)(1-\tau_c c_p)pbe^{-vX}f(S_o) \equiv T_p e^{-vX}f(S_o)$$

$$(47)\ G_e(X_o) = [\tau_e + \tau_c c_e(1-\tau_e) + e_e]e^{-vX}f(S_o) \equiv T_e e^{-vX}f(S_o)$$

$$(48)\ G_u(S_o) = -(1-\tau_c c_u)(1-\tau_u)be^{-vX}f(S_o) \equiv T_u e^{-vX}f(S_o)$$

and therefore

$$(49)\ G(X_o) = q\{pG_e(X_o) + (1-p)G_u(X_o)\} = q\{pT_e + (1-p)T_u\}e^{-vX}f(S_o) \equiv qT_a e^{-vX}f(S_o).$$

where we have defined the following average "total tax rates,"

$$(50)\quad T_s \equiv \tau_s + e_s + \tau_c c_s(1-\tau_s)$$

$$T_p \equiv -(1-\tau_p)(1-\tau_c c_p)pb$$

$$T_e \equiv \tau_e + \tau_c c_e(1-\tau_e) + e_e$$

$$T_u \equiv -(1-\tau_c c_u)(1-\tau_u)b$$

$$T_a \equiv pT_e + (1-p)T_u$$

Next, we calculate the derivatives of these functions with respect to X. We have:

$$(51)\quad G_p'(X_o) = -(1-\tau_c C'_p)(1-T_p')PB'e^{-vX}[f'(S_o)S'(X_o) - vf(S_o)] \equiv \Delta'_p e^{-vX}[f'(S_o)S'(X_o) - vf(S_o)]$$

$$(52)\ G'_e(X_o) = [T'_e + \tau_c C'_e(1-T'_e) + E'_e]e^{-vX}[f'(S_o)S'(X_o) - vf(S_o)] \equiv \Delta'_e e^{-vX}[f'(S_o)S'(X_o) - vf(S_o)]$$

$$(53)\ G'_u(X_o) = -(1-\tau_c C'_u)(1-T'_u)B'e^{-vX}[f'(S_o)S'(X_o) - vf(S_o)] \equiv \Delta'_u e^{-vX}[f'(S_o)S'(X_o) - vf(S_o)]$$

where we have defined

$$(54)\ \Delta'_p \equiv -(1-\tau_c C'_p)(1-T_p')PB'$$

$$(55)\ \Delta'_e \equiv T'_e + \tau_c C'_e(1-T'_e) + E'_e$$

$$(56)\ \Delta'_u \equiv -(1-\tau_c C'_u)(1-T'_u)B'$$

Finally,

$$\begin{aligned}(57)\ G'(X_o) &= q'S'[pG_e(X_o) + (1-p)G_u(X_o)] + q[p'S'G_e(X_o) + pG'_e(X_o) - p'S'G_u(X_o) + (1-p)G'_u(X_o)] \\ &= q'S'[pT_e + (1-p)T_u]e^{-vX}f(S_o) + q[G_e(X_o) - G_u(X_o)]p'S' + q[pG'_e(X_o) + (1-p)G'_u(X_o)] \\ &= q'S'T_a e^{-vX}f(S_o) + q(T_e - T_u)e^{-vX}f(S_o)p'S' + q\{p\Delta'_e + (1-p)\Delta'_u\}e^{-vX}[f'(S_o)S'(X_o) - vf(S_o)] \\ &\equiv q'S'T_a e^{-vX}f(S_o) + q(T_e - T_u)e^{-vX}f(S_o)p'S' + q\Delta'_a e^{-vX}[f'(S_o)S'(X_o) - vf(S_o)]\end{aligned}$$

where we have defined

$$(58)\ \Delta'_a \equiv p\Delta'_e + (1-p)\Delta'_u$$

Notice that T_p, T_u, Δ'_p and Δ'_u are negative.

Substituting these expressions into the rate of return formula given in (35) and dividing through by $qf(S_o)e^{-vX}$

$$\frac{R}{1-e^{-RH}} = \frac{G'(X_o) + \gamma(R)\left[q'S'(X_o)G_p(X_o) + qG_p{}'(X_o)\right]}{G(X_o) - G_s(X_o)e^{-vX}e^{vH_o/2} + \mu_g f(S_o)e^{-vX}e^{vH_o/2}}$$

$$= \frac{q'S'T_a e^{-vX} f(S_o) + q(T_e - T_u)e^{-vX} f(S_o)p'S' + q\Delta'_a e^{-vX}\left[f'(S_o)S'(X_o) - vf(S_o)\right]}{qT_a e^{-vX} f(S_o) - q\eta_q p_s T_s(1-\phi) f(S_o)e^{-vX}e^{vH_o/2} + \mu_g f(S_o)e^{-vX}e^{vH_o/2}}$$

$$+\gamma(R)\frac{q'S'(X_o)T_p e^{-vX} f(S_o) + q\Delta'_p e^{-vX}\left[f'(S_o)S'(X_o) - vf(S_o)\right]}{qT_a e^{-vX} f(S_o) - q\eta_q p_s T_s(1-\phi) f(S_o)e^{-vX}e^{vH_o/2} + \mu_g f(S_o)e^{-vX}e^{vH_o/2}}$$

$$= \frac{q'S'T_a + q(T_e - T_u)p'S' + q\Delta'_a\left[\theta S'(X_o) - v\right]}{qT_a - q\eta_q p_s T_s(1-\phi)e^{vH_o/2} + \mu_g e^{vH_o/2}} + \gamma(R)\frac{q'S'(X_o)T_p + q\Delta'_p\left[\theta S'(X_o) - v\right]}{qT_a - q\eta_q p_s T_s(1-\phi)e^{vH_o/2} + \mu_g e^{vH_o/2}}$$

$$= \frac{\frac{q'}{q}S'T_a + (T_e - T_u)p'S' + \Delta'_a\theta' + \gamma(R)\left[\frac{q'}{q}S'(X_o)T_p + \Delta'_p\theta'\right]}{T_a - \eta_q p_s T_s(1-\phi)e^{vH_o/2} + \frac{\mu_g}{q}e^{vH_o/2}}$$

or

$$(59)\quad \frac{R}{1-e^{-RH}} = \frac{\frac{q'}{q}S'T_a + (T_e - T_u)p'S' + \Delta'_a\theta' + \gamma(R)\left[\frac{q'}{q}S'(X_o)T_p + \Delta'_p\theta'\right]}{T_a - \eta_q p_s T_s(1-\phi)e^{vH_o/2} + \frac{\mu_g}{q}e^{vH_o/2}} \equiv \frac{N_1 + \gamma(R)N_2}{D}$$

Alternatively, we can fix the discount rate, r, and calculate the present value of the net benefits of schooling. It will be convenient to discount this quantity to the period students leave school (at time X) and to relate it to the wage of the average worker at that time, which is given by

$$W_o(X) = W(t, X_o, H_o/2) = A_o e^{gX} f(S_o)e^{vH_o/2}$$

From above, we have

$$V_g{}'(X) = A_o e^{vH_o/2}G_s(X)e^{-(R+v)X} - A_o e^{vH_o/2}\mu_g f(S_o)e^{-(R+v)X} - A_o e^{-RX}G(X)$$
$$+ A_o e^{-RX}G'(X)\frac{1-e^{-RH}}{R} + A_o e^{-R(X+H)}\left[q'S'G_p(X) + qG_p{}'(X)\right]\frac{1-e^{-(R+g+v-\omega)(Z-U)}}{R+g+v-\omega}$$

which can be written (recall that $R \equiv r - g - v$),

$$(60)\ V_g{}'(X)e^{rX}$$

$$=\left\{\begin{array}{l}\dfrac{e^{vH_o/2}G_s(X)e^{-(r-g)X} - e^{-(r-g-v)X}G(X)}{e^{gX}f(S_o)e^{vH_o/2}} - \dfrac{\mu_g e^{-(r-g)X}}{e^{gX}} \\ +e^{-(r-g-v)X}\dfrac{G'(X)}{e^{gX}f(S_o)e^{vH_o/2}}\dfrac{1-e^{-(r-g-v)H}}{r-g-v} + e^{-(r-g-v)(X+H)}\dfrac{q'S'G_p(X)+qG_p{}'(X)}{e^{gX}f(S_o)e^{vH_o/2}}\dfrac{1-e^{-(r-\omega)(Z-U)}}{r-\omega}\end{array}\right\} e^{rX}A_o e^{gX}f(S_o)e^{vH_o/2}$$

$$=\left\{\begin{array}{l}\dfrac{G_s(X)}{f(S_o)} - \dfrac{e^{vX}G(X)}{f(S_o)e^{vH_o/2}} - \mu_g + \dfrac{e^{vX}G'(X)}{f(S_o)e^{vH_o/2}}\dfrac{1-e^{-(r-g-v)H}}{r-g-v} \\ +e^{-(r-g-v)H}e^{vX}\dfrac{q'S'G_p(X)+qG_p{}'(X)}{f(S_o)e^{vH_o/2}}\dfrac{1-e^{-(r-\omega)(Z-U)}}{r-\omega}\end{array}\right\} A_o e^{gX}f(S_o)e^{vH_o/2}$$

Taking each of the terms inside the bracket at a time, we have

$$(61)\ \frac{G_s(X)}{f(S_o)} - \frac{e^{vX}G(X)}{f(S_o)e^{vH_o/2}} - \mu_g = q\eta_q p_s(1-\phi)T_s - qT_a e^{-vH_o/2} - \mu_g = -qe^{-vH_o/2}D$$

$$(62)\ \frac{e^{vX}G'(X)}{f(S_o)e^{vH_o/2}} = e^{vX}\frac{q'S'T_a e^{-vX}f(S_o) + q(T_e - T_u)e^{-vX}f(S_o)p'S' + q\Delta'_a e^{-vX}\left[f'(S_o)S'(X_o) - vf(S_o)\right]}{f(S_o)e^{vH_o/2}}$$

$$= \left[\frac{q'}{q}S'T_a + (T_e - T_u)p'S' + \Delta'_a\theta'\right]qe^{-vH_o/2} = qe^{-vH_o/2}N_1$$

$$(63)\ e^{-(r-g-v)H}e^{vX}\frac{q'S'G_p(X)+qG_p{}'(X)}{f(S_o)e^{vH_o/2}} = e^{-(r-g-v)H}e^{vX}\frac{q'S'T_p e^{-vX}f(S_o) + q\Delta'_p e^{-vX}\left[f'(S_o)S'(X_o) - vf(S_o)\right]}{f(S_o)e^{vH_o/2}}$$

$$= e^{-(r-g-v)H}\left[\frac{q'}{q}S'T_p + \Delta'_p\theta'\right]qe^{-vH_o/2} = N_2 e^{-(r-g-v)H}qe^{-vH_o/2}$$

Using these expressions, we have the following expression for the marginal NPV of schooling:

$$(64)\ V_g{}'(X)e^{rX} = \left\{-D + N_1\frac{1-e^{-(r-g-v)H}}{r-g-v} + N_2 e^{-(r-g-v)H}\frac{1-e^{-(r-\omega)(Z-U)}}{r-\omega}\right\}qe^{-vH_o/2}W_o$$

A special case

When unemployment benefits are linked to net-of-tax income in employment and are not taxed the above has to be modified as follows. We have then

$$(65)\ G_u(S) = -\beta\left[f(S) - T(f(S))\right] + \tau_c C\left[\beta\left(f(S) - T(f(S))\right)\right]$$

with

$$(66)\ G_u(S_o) = -\beta\left[f(S_o) - T(f(S_o))\right] + \tau_c C\left[\beta\left(f(S_o) - T(f(S_o))\right)\right]$$

$$= -\beta(1-\tau_e)f(S_o) + \tau_c c_u\beta(1-\tau_e)f(S_o) = -(1-\tau_c c_u)\beta(1-\tau_e)f(S_o)$$

$$\equiv T_u f(S_o)$$

and

$$(67)\ G_u{}'(S_o) = -\beta\left[f'(S_o) - T'\left(f(S_o)\right)f'(S_o)\right] + \tau_c C'()\beta\left[f'(S_o) - T'\left(f(S_o)\right)f'(S_o)\right]$$
$$= -\beta\left(1 - T_e{}'\right)f'(S_o) + \tau_c C_u{}'\,\beta\left(1 - T_e{}'\right)f'(S_o)$$
$$= -\left(1 - \tau_c C_u{}'\right)\beta\left(1 - T_e{}'\right)f'(S_o) \equiv \Delta'_u\, f'(S_o)$$

With this new definitions of T_u and Δ'_u, the equation derived above for the fiscal rate of return continues to hold as written, and so does the net present fiscal value formula.

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