Human capital in a global and knowledge-based economy, part II: assessment at the EU country level

FINAL REPORT

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Abstract

This report is an extension and partial update of de la Fuente and Ciccone (2002). It constructs estimates of the private and social rates of return on schooling for fourteen EU countries using microeconometric estimates of Mincerian wage equations, the results of cross-country growth regressions and OECD data on educational expenditures, tax rates and social benefits. The results are used to draw some tentative conclusions regarding the optimality of observed investment patterns and educational subsidy levels.

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EXECUTIVE SUMMARY

This document is an extension and partial update of a previous report on the role of investment in human capital as part of a growth-promoting strategy (de la Fuente and Ciccone (D&C), 2002). Its focus is narrower than that of the earlier study. It concentrates on the measurement of the economic returns to schooling in the member countries of the European Union, both from a private and from a social perspective. It also attempts to draw some conclusions regarding the adequacy of observed aggregate investment patterns and of private incentives for investing in education from a comparison of the estimated private and social rates of return to schooling with each other and with those available on alternative assets.

The results obtained in this study tend to confirm and strengthen the main conclusion of our previous report (D&C, 2002). I find, in particular, that i) educational attainment is a key determinant of individual earnings and aggregate productivity and has a significant effect on labour market outcomes and ii) that human capital appears as an attractive investment relative to alternative assets, both from the individual and from the aggregate perspectives.

Methodology

I calculate the private and social rates of return to education as the discount rates that equate the present value of the incremental cost and income streams generated by a marginal increase in the schooling of a representative individual for each country to whom I attribute the observed average levels of attainment and either wages or productivity. To quantify the contribution of schooling to individual wages and to aggregate productivity levels and growth rates, I use microeconometric estimates of Mincerian wage equations for EU countries and the results of cross-country growth regressions drawn from the literature.

While these calculations were carried out in D&C (2002) only for the case of a hypothetical average EU country, the present report extends the analysis to individual member states and introduces several refinements relative to the previous study. Estimates of the relevant rates of return are constructed for all current members of the European Union with the exception of Luxembourg (for which much of the required data are unavailable). The model has also been extended to take into account the positive effects of education on employment and the impact of taxes and social policies on the private return to schooling. These extensions have made it possible to draw on tax and benefit indicators provided by the OECD and on recent Labour Force Survey data from Eurostat to construct a more comprehensive measure of the economic benefits of education than the one provided in D&C (2002), and to undertake a detailed analysis of the impact of personal taxes, unemployment benefits and educational subsidies on the private incentive to invest in education.

Social returns to schooling and physical capital and the optimal investment pattern

Drawing on recent results in the literature, I estimate that an additional year of average school attainment raises productivity in the average EU country by 6.2% on impact and by a further 3.1% in the long run through its contribution to faster technological progress. The first of these effects is considerably higher in the cohesion countries and in Italy, reaching 9.2% in the case of Portugal, and drops to around 5% in the Scandinavian and German-speaking countries.

The social rate of return to schooling reflects, in addition to these productivity effects, the increase in participation and employment rates induced by a marginal increase in attainment and the direct and opportunity costs of school attendace born directly by individuals or by the public sector. My estimates of this rate of return for the EU countries range from 8.3% in Finland to 11.5% in Portugal, with an average value of 9.7%. For all the countries in the sample, the social return on human capital appears to be higher than the return on physical capital, suggesting that a marginal reallocation of investment resources in favour of education would be socially desirable. The social premium on human capital, defined as the difference between the estimated rates of return on human and physical capital, varies across member states reflecting the relative endowments of production factors and appears to be largest in Finland, Italy, Denmark, Greece, the Netherlands, Spain and Ireland, and smallest in the UK, Austria, France, Belgium and Portugal.

Private returns to schooling and the incentive to invest in education

The private rate of return to schooling measures the financial returns to a marginal increase in attainment that are available to individuals, taking into account only the privately born costs of education and the expected increase in net income after personal taxes and social benefits. Estimated private returns cluster between 8% and 10% for most European countries. The highest returns correspond to the UK and Portugal, followed by Austria, Germany and Ireland, and the lowest ones to Sweden, which is a clear outlier at the bottom of the distribution.

Various public policies have a significant impact on the private return to schooling. On average, direct subsidies to education raise private returns by around a third while personal taxes and social benefits reduce them by 10% and 8% respectively. In most countries, the combined effect of all these policies is a net subsidy to education. This subsidy exceeds 30% in Sweden, Portugal and Denmark and has an average value of 10% in the entire sample. The only countries where the net tax on schooling is positive (for an individual earning the wage of the average production worker) are Ireland and Germany, with effective tax rates of 15% and 4% respectively.

At the individual level, schooling seems to be a more attractive investment than the financial assets available to households. Taking as a reference a balanced portfolio of corporate shares and government bonds, the private premium on human capital ranges from 2.11% in Sweden to 9.87% in the UK with a mean value of 5.72%. For most countries, the private premium on schooling has the same sign as the social one and is significantly larger, suggesting that the combination of market forces and existing subsidies already provides more than sufficient financial incentives for individuals to modify their investment patterns in ways that are consistent with social needs. The only exception appear to be the Scandinavian countries, where slightly larger subsidies may be required to fully offset the disincentives created by rather flat payscales thay may not adequately capture education-induced productivity gains.

Policy implications

Although considerable caution is needed for a number of technical reasons that are discussed in detail in the report, I believe the results I have just summarized provide a reasonable assessment, given our current state of knowledge, of the private and social returns to investment in human capital. These results also reinforce the two main policy conclusions drawn in D&C (2002): First, that a modest increase in educational investment would almost certainly be beneficial from a social point of view in all EU countries. And second, that an increase in general subsidies for post-compulsory schooling would probably not be required to achieve this goal in most European countries.

The first of these conclusions follows essentially from a comparison between the estimated social rates of return on physical and human capital. My results suggest that the economic returns to schooling investment are at least comparable to, and very likely significantly higher than, those available from investment in physical capital. When a reasonable allowance is made for the non-market returns to education and for its benefits for social cohesion and for individual development, human capital appears as a rather attractive investment alternative from a social point of view for all the countries in the sample.

It must be kept in mind, however, that the data underlying my social return calculations refer to 1990, and that much of the required investment in education is probably under way already, as schooling levels for young cohorts are considerably higher than population averages in all EU countries. Hence, average attainment will rise sharply in the near future even without any changes in current policies. While it is impossible to know at this stage whether the social premium on human capital will remain positive in the future, the acceleration of the pace of technological change in recent decades and the secular trend towards an increasingly knowledge-intensive economy do make it likely that human capital will continue to be a strategic production factor, and hence an attractive investment alternative, in the foreseeable future.

Strictly speaking, all the results obtained in this report refer to the returns to a marginal increase in the *quantity* of education as measured by average years of school attainment.

There is still considerable room for improvement in this area, particularly in some of the poorer countries and regions of the Union, where enrollment in upper secondary training is still far from universal and tertiary accession rates remain relatively low. But there can be little doubt that in the long run the more relevant policy margin has to do with the *quality* of education, rather than with its quantity, as we must eventually run into sharply diminishing returns to futher increases in attainment.

My conclusion regarding subsidy levels is based both on the large private premium on schooling and on the fact that this premium generally exceeds its social counterpart. These findings suggest that the financial returns to investment in education reflect social needs more than adequately and that they are high enough that it is unlikely that insufficient pecuniary incentives can be seen as a real obstacle to higher enrollment rates in most EU countries. I suspect that other factors (and in particular liquidity constraints and low levels of basic skills for individuals from disadvantaged backgrounds) are far more important as barriers to access to advanced programmes. Hence, policies specifically targeted at these problems should be more effective in raising upper-level enrollments than further decreases in already low tuition charges that imply a large subsidy for relatively privileged groups. Indeed, higher tuition fees, coupled with a well designed loan programme and with an increase in means-tested grants, may be an efficient way to provide additional resources to increase the quality of post-secondary education while at the same time reducing the regressivity of its financing, ensuring equal access opportunities regardless of socieconomic background, and improving student motivation to take full advantage of educational opportunities.

1. Introduction

This document is an extension and partial update of a previous report on the role of investment in human capital as part of a growth-promoting strategy (de la Fuente and Ciccone (D&C), 2002). Its focus is narrower than that of the earlier study. It concentrates on the measurement of the economic returns to schooling in the member countries of the European Union, both from a private and from a social perspective. It also attempts to draw some conclusions regarding the adequacy of observed aggregate investment patterns and of private incentives for investing in education from a comparison of the estimated private and social rates of return to schooling with each other and with those available on alternative assets.

These issues were studied in D&C (2002) from the point of view of a hypothetical average EU country. The present report extends the analysis to individual member states and introduces several refinements relative to the previous study. Estimates of the relevant rates of return are constructed for all current members of the European Union with the exception of Luxembourg (for which much of the required data are unavailable). The model used for the calculation of the rates of return has been extended to take into account the positive effects of education on employment and the impact of tax and social policies on the private return to schooling. These extensions have made it possible to construct a more comprehensive measure of the economic benefits of education than the one provided in D&C (2002), and to undertake a detailed analysis of the impact of personal taxes, unemployment benefits and educational subsidies on the private incentive to invest in education.

In addition, I have updated or refined our previous estimates of some of the relevant cost and return variables. In particular, the calculations in this report make use of improved estimates of the rates of return on assets other than human capital and of the direct and opportunity costs of schooling. My current estimates of the direct costs of an additional year of schooling have been purged of research expenditure at the university level and take into account public subsidies for living expenses and other non-tuition costs, while those of the opportunity costs of education now allow for part-time work and for differential student unemployment and participation rates. Finally, I have also refined our former estimates of the parameters linking average attainment to aggregate productivity using the final results of a study by R. Doménech and myself (D&D, 2002) that was still in progress when the previous report was completed.

It should be noted that the attempt to enlarge the scope of the study so as to provide country-specific results and cover employment aspects introduces new margins for error and adds several items to the long list of reasons that require caution in the interpretation of my findings. As we emphasized in D&C (2002), there is considerable uncertainty concerning the values of the key parameters that measure the contribution of investment in human capital to individual wages and to aggregate productivity growth. This uncertainty is even greater in the case of some of the employment parameters that enter the calculations reported below, for which I have constructed a very tentative set of estimates that attempt only to capture the likely order of magnitude of the relevant effects.

An additional problem, to which I will return below, is that cross-country comparisons of social returns to schooling are much more sensitive to assumptions concerning functional forms and to other estimation issues than conclusions based on sample averages. Finally, concerns about data quality are also compounded by the cross-country dimension. The data underlying the calculations reported below are often incomplete and may not always provide an accurate picture of the situation in each member state. Since errors will tend to cancel out, I am fairly certain that sample averages are not far off the mark, but I am much less confident in the accuracy of the data for any individual country, particularly when, as is often the case, my estimates rely on rather ad-hoc assumptions to get around missing information. I have attempted throughout the text to alert the reader to particularly unreliable estimates. I would also welcome any information from national authorities or individual readers that may help improve these estimates.

These caveats notwithstanding, I believe the results presented below provide a reasonable assessment, given our current state of knowledge, of the private and social returns to investment in human capital. These results reinforce the conclusions of our previous report and suggest that they are valid for most, if not all, member states of the EU. According to my estimates, the social return to schooling is at least comparable to, and probably higher than, that on physical capital in all EU countries, suggesting that increased investment in education would be socially beneficial even if it comes at the expense of other capital expenditures. The social premium on human capital, however, varies significantly across member states reflecting the relative endowments of production factors and appears to be largest in Finland, Italy, Denmark, Greece, the Netherlands, Spain and Ireland, and smallest in the UK, Austria, France, Belgium and Portugal.

At the individual level, schooling seems to be a more attractive investment than the financial assets available to households. Private returns to schooling, moreover, incorporate an important public subsidy, even after taking into account the disincentives generated by progressive personal taxes and relatively generous social benefits. The overall effective tax rate on human capital (which summarizes the combined effect on net private returns of educational finance, taxation and unemployment protection) is negative in eleven out of the fourteen countries in the sample and has an average value of -10%. Finally, the premium on human capital relative to alternative assets appears to be higher at the private than at the social level in most countries, indicating that private incentives to invest in schooling reflect social needs more than adequately. The one exception to this are the Scandinavian countries.

As in D&C (2002), I draw two main policy conclusion from these results: First, that a modest increase in educational investment would almost certainly be beneficial from a social point of view in all EU countries. And second, that an increase in general subsidies for post-compulsory schooling would probably not be required to achieve this goal in most European countries because the main obstacle to higher enrollments does not lie in an insufficient financial reward.

The remainder of the report is divided into five sections. Section 2 describes the theoretical framework used for the calculation of the private and social rates of return to schooling, which includes a simple growth model specifying the links between average educational attainment and aggregate productivity. By necessity, this section is somewhat technical and, with the exception of its first two pages, can probably be skipped by the reader without seriouly impairing his or her ability to follow the rest of the discussion. Sections 3 and 4 deal with the quantification of the private and social costs and benefits of post-compulsory schooling. Each of these sections contains a description of the data and of the parameter values used in the calculations (with further details given in the Appendix), a discussion of the results and a comparison of the estimated returns on human capital with those on other assets. An important part of section 3 deals with the impact of public policies on private financial incentives for investing in education. In section 4 of the text and section 6 of the Appendix, a fair amount of space is devoted to justifying my choice of values for the parameters that measure the contribution of investment in human capital to aggregate productivity growth. Since this section draws heavily on recent work by R. Doménech and myself which may be somewhat controversial, I have attempted to give the reader enough information to judge by himself or herself the sensitivity of the results to changes in assumptions concerning these aggregate parameters. Section 5 attempts to draw some tentative conclusions regarding the adequacy of observed levels of educational subsidies on the basis of comparisons between the rates of return to schooling and the schooling premia at the private and social levels. Section 6 concludes with a summary of the main results and a discussion of their policy implications.

2. Theoretical framework: the rate of return to schooling

Any individual enrolled in an educational institution beyond the compulsory age 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). A similar but not identical trade-off arises from a social point of view, as the decision to devote additional resources to training can be expected to increase national output in the future by raising the skill level of the workforce.

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 I will discuss a set of formulas for the calculation of the private and social rates of return to schooling. These formulas will be used later on to obtain quantitative measures of the private and social returns to investment in education and to analyse the impact of various public policies on individual incentives.

Subsection a deals with the private return to education. For each country, I will consider a representative individual endowed with the average attainment level and earning average production worker (APW) wages and compute the expected private payoff to an additional year of schooling. The calculation will take into account the explicit costs of schooling actually born by the agent, his opportunity cost in the form of foregone labour income, and the expected increase in future net-of-tax labour earnings and unemployment benefits arising both from higher wages and from higher employment probabilities.

The logic will be very similar in subsection b, where I will analyse the social return to education. The main difference is that I will now be concerned with the total costs of training (rather than with their privately-born component) and with the total increase in output (rather than in after-tax wages) generated by an increase in average attainment. Hence, resource flows between the private and public sectors, such as taxes and subsidies, need not be considered in the calculations. On the other hand, to properly measure the social returns to educational investment, I will need to take into account its external effects. Since the main externality associated with rising attainment appears, on my reading of the literature, to take the form of an increase in the rate of technical progress, it will be necessary to specify a simple growth model linking these two variables in order to derive the desired formula.

To properly interpret the results that will be presented below, it is important to keep in mind that the rates of return I will calculate measure the return to educational investment in a rather specific and restrictive sense. They capture, in particular, the average payoff to an additional year of schooling holding its cost and quality constant at the existing level. They do not, however, tell us anything about the returns to additional spending on quality-improving policies. The problem here is empirical rather than conceptual. While it is straightforward to derive the appropriate rate of return formulas for investment in educational quality, we do not yet have reliable estimates of the impact of resource inputs on educational quality or of the effects of quality on wages and productivity that can be entered into these formulas. This is most unfortunate because this is without doubt the more relevant policy margin in the long run, and because we have reasons to suspect that the quality of education may be at least as important as its quantity. (See Appendix 3e in D&C, 2002).

When it comes to interpreting my estimates of the social rate of return to schooling there is an additional although related problem of which the reader should be aware. One of the key inputs for this calculation is an econometric estimate of the contribution of school attainment to productivity which essentially measures the strength of this connection in the case of a hypothetical average country.[1] Hence, my social rate of return estimates implicitly assume that the quality of a year of schooling is the same everywhere, irrespective of its cost or indeed of any other factor. This implies that my calcuations will understate the aggregate return to schooling in countries with educational systems of above-average quality. If quality is positively correlated with resource input (an issue that remains controversial, as discussed in our previous report), my results will also underestimate the returns to education in countries with high expenditure per student.

It should also be noted that my estimates of both private and social returns to schooling may be biased upward by the failure to take into account on-the-job training. As observed by Bassanini (2003), since more educated workers tend to receive more training, existing estimates of the Mincerian returns parameter at the individual level (and possibly at the country level as well) will tend to pick up not only the direct effects of schooling per se, but also the additional benefits that result from increased training. While this is not a problem per se, failure to take into account the cost of training will lead to the overestimation of the relevant rates of return. Although the data required for a correction are not available, I would expect that the resulting bias should not be very large because investment in training is likely to be much smaller than in formal schooling and, since it takes place later in life, it should be discounted more heavily.

A final source of bias that will work in the opposite direction and is likely to be considerably more important is that the rates of return computed below do not incorporate the non-market returns to schooling in home production and leisure (see section 3a.xi in D&C, 2002) and fail to take into account the direct consumption value of education and any "civic" externalities generated by it. As a result, I expect that my calculations will underestimate the true returns to schooling by an amount that may be large but is extremely difficult to measure with precision.

1 This problem does not arise in the calculation of the private returns to schooling because the relevant parameter is estimated separately for each country using individual data and can therefore pick up cross-country differences in the quality of education. We cannot follow a similar strategy to estimate the aggregate parameter because there are not enough data, and not enough variation in the available aggregate data, to obtain precise country-specific estimates.

a. The private rate of return to schooling

Consider an individual who goes to school the first S years of his adult life and retires at time U. I will assume that the direct cost to the agent of each year of schooling is a constant fraction μ_s of the earnings of a typical worker with the average level of schooling in the country as a whole, which will be denoted by S_0. The gross wage of the representative individual will be given by the product of a technical efficiency index $A_t = A_0 e^{gt}$ that grows over time at a constant exponential rate g, and a function $f(S)$ that increases with educational attainment. The probability of employment will also be assumed to be an increasing function of schooling. I will denote by $p(S)$ the function describing this relation for 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.[2]

I will allow for taxes and for unemployment and housing benefits. It will be assumed that tax rates are a function of relative rather than absolute incomes[3] (i.e. of $f(S)$ rather than of $Af(S)$), so the net-of-tax earnings at time t of a worker with S years of schooling who is employed full-time will be given by

$$(1)\quad \left[f(S) - T\left(f(S)\right)\right]A_t$$

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 I will write in net-of-tax terms. Since this benefit may or may not be linked to previous earnings, I will allow for both possibilities and write the worker's net income out of employment in the form

$$(2)\quad a\left[f(S) - T\left(f(S)\right)\right]A_t + b\left[f(S_o) - T\left(f(S_o)\right)\right]A_t$$

where a is the component of the net replacement ratio $(a+b)$ that is linked to previous earnings and b captures benefits that are independent of the agent's previous income (but are assumed to be indexed to average earnings, which are given by $Af(S_0)$).

I 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 full-time school attendance takes up a fraction ϕ of their time so that their potential labour supply is a fraction $1-\phi$ of the standard work-year. Under these assumptions, the expected earnings at time t of a student who has completed s years of training are given by

2 Notice that the model incorporates some rather strong simplifying assumptions about the behaviour of wages and employment rates over the lifecycle. It would be preferrable to work with observed wage and employment profiles following what Psacharopoulos (1995) has called the "full discounting method" for the calculation of the returns to schooling. This would, however, require much more detailed data than I had access to for all of the countries in the sample.

3 Otherwise, the tax rates faced by all agents would increase over time with productivity growth in a way that is probably not realistic and would considerably complicate the calculations. Since we are considering a horizon of over forty years, this effect would be important and is likely to distort the results.

$$(3)\quad \eta p(s)\left[(1-\phi)f(s)-T\left((1-\phi)f(s)\right)\right]A_t$$

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

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

$$(4)\quad V(S) = J(S) + I(S) - C(S)$$

where

$$(5)\quad J(S) = \int_0^S \eta p(t)\left[(1-\phi)f(t)-T\left((1-\phi)f(t)\right)\right]A_t e^{-rt}dt$$

$$(6)\quad I(S) = \int_S^U \left\{p(S)\left[f(S)-T\left(f(S)\right)\right]+(1-p(S))\left[a\left[f(S)-T\left(f(S)\right)\right]+b\left[f(S_o)-T\left(f(S_o)\right)\right]\right]\right\}A_t e^{-rt}dt$$

$$(7)\quad C(S) = \int_0^S \mu_S A_t f(S_0)e^{-rt}dt$$

and r is the discount rate. The term $J(S)$ denotes the present value of expected labour earnings while attending school and (potentially) working part-time a fraction $1\text{-}\phi$ of the standard work-year between times 0 and S, $I(S)$ the present value of labour income and unemployment benefits over the individual's post-school working life (between times S and U), and $C(S)$ the present value of the direct costs of schooling born by the agent (i.e. net of public subsidies). Notice that I am not taking into account retirement benefits. Since pensions are generally tied to previous earnings, their inclusion in the model will raise the estimated return to schooling, although the effect is not likely to be very large because benefits accrue far into the future and must be discounted accordingly.[4]

To obtain the required rate of return, I will compute the net marginal product of schooling, which will be given by the derivative of the net lifetime earnings function, $V'(S)$, and solve for the value of the discount rate, r, that makes this derivative equal to zero when $S = S_0$ (i.e. for an individual of average attainment).[5] This procedure yields the following expression for the (net) private rate of return on education:

$$(8)\quad r_p = R_p + g$$

where g is the exogenous growth rate of productivity and R_p is the value of R that solves the following equation

$$(9)\quad \frac{R}{1-e^{-RH}} = \frac{\left(\dfrac{p_o+(1-p_o)a}{p_o+(1-p_o)(a+b)}\right)\left(\dfrac{1-T'}{1-\tau_0}\right)\theta+\left(\dfrac{(1-a-b)p_o}{p_o+(1-p_o)(a+b)}\right)\varepsilon}{\left(1-\dfrac{1-\tau_S}{1-\tau_0}\dfrac{(1-\phi)\eta p_o}{p_o+(1-p_o)(a+b)}\right)+\dfrac{\mu_s}{(1-\tau_0)\left[p_o+(1-p_o)(a+b)\right]}} \equiv \frac{\theta_{net}+\varepsilon_{net}}{OPPC+DIRC}.$$

In this expression, p_0 stands for the probability of employment of an adult of average attainment, τ_0 and T' are the average and marginal tax rates applicable to the same worker,

[4] Notice also that I am not allowing for the possibility of death prior to retirement. As de la Croix (2003) observes, it would also be desirable to correct for this factor, but I doubt the error induced by this assumption is important. As he himself notes, the rough correction constructed by this author is likely to substantially overstate the importance of this factor because it is based on an assumption (that the probability of death is constant at each point in time) that will generate extremely unrealistic survival profiles.

[5] See de la Fuente (2003) for further details.

τ_S the average tax rate on income from part-time work for a student with schooling S_0, θ the Mincerian returns to schooling parameter, ε the curvature of the function that gives the probability of employment as a function of educational attainment, and $H = U\text{-}S$ the duration in years of the working life of the representative individual; that is,

$$(10)\qquad p_0 = p(S_0) \qquad \theta = \frac{f'(S_0)}{f(S_0)} \qquad \varepsilon = \frac{p'(S_0)}{p(S_0)}$$

$$\tau_0 = \frac{T\left(f(S_0)\right)}{f(S_0)} \qquad T' = T'\left(f(S_0)\right) \qquad \tau_S = \frac{T\left((1-\phi)f(S_0)\right)}{(1-\phi)f(S_0)}$$

To interpret equation (9), notice that its left-hand side is an increasing function of R where the term $1\text{-}e^{-RH}$ that appears in the denominator serves to adjust for the fact that the "useful life" of the asset (the working life of the individual) is finite. The right-hand side 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 the terms expressed as fractions of the expected net-of-tax earnings of an adult worker with average education. The first term in the numerator (θ_{net}) captures the expected increase in after-tax earnings and benefits holding the probability of employment constant, and the second one (ε_{net}) the increase in expected net earnings that comes from an increase in the probability of employment. 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 (foregone wages), and the second one $(DIRC)$ the direct costs of schooling born by the student himself.

Notice that public policies influence the private return to schooling in many ways. Educational subsidies or the direct public provision of educational services will raise the return to schooling by lowering its direct cost to the individual $(DIRC)$. The effect of taxation is more complicated. Notice that a flat-rate income tax (i.e. a tax system in which $\tau_0 = T' = \tau_S$) 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 three tax rates that enter the formula and from their interaction with the direct cost term, $DIRC$. Notice that θ_{net} depends only on the progressivity of the tax schedule at the average income level: as the tax system becomes more progressive (i.e. as the ratio $(1\text{-}T')/(1\text{-}\tau_0)$ declines), the incentive to invest in education falls. If we fix the degree of progressivity, an increase in τ_0 actually raises the return to schooling by lowering its opportunity cost, while an increase in the student tax rate, τ_S, has the opposite effect. Finally, tax rates interact with the direct cost of schooling term, $DIRC$. If $\mu_S > 0$, an increase in the average tax rate, τ_0, increases $DIRC$ (by lowering its denominator) thus lowering the return to schooling. If students receive a net subsidy, so that $\mu_S < 0$, the effect of τ_0 on r_p is the opposite one: higher taxes now raise the return to schooling by increasing the size of the subsidy when measured as a fraction of net adult earnings.

Unemployment benefits reduce the return to schooling by raising the expected income of adult workers, thereby increasing the opportunity cost of not being in the (full-time) labour market, and by reducing the loss of earnings associated with unemployment (i.e. by lowering ε_{net}). Notice that the size of this second effect will be proportional to the value of ε, for if schooling has no effect on employment probabilities the difference in earnings between employed and unemployed workers is irrelevant for the calculation. When unemployment benefits are linked to previous earnings (and therefore to education), these effects are partially offset by an increase in θ_{net} as additional schooling now translates into an increase in benefit levels.

b. The social rate of return to schooling

In this section I will apply the procedure developed above to a representative individual whose level of schooling determines, together with other factors to be specified below, the behaviour of aggregate productivity. The resulting rate of return formula must be regarded as an approximation because the computation implicitly assumes that a one-year increase in average attainment will be obtained by immediately sending the entire labour force to school for a year (rather than by gradually raising the attainment of younger cohorts).

To calculate the social return to education, I need to specify the connections between the educational attainment of the labour force and the level and growth rate of aggregate productivity. This is done in Box 1, where I outline a simple model of growth with human capital. As in our previous report, the model allows for two types of links between average schooling and aggregate output to which I will refer as "level" and "rate" effects. First, the *level* of output is assumed to be an increasing function of average attainment through a standard aggregate production function with human capital as an input.[6] And second, the model assumes that the rate of technical progress is also an increasing function of average schooling through an external effect that cannot be privately appropriated by individuals in the form of higher wages. The choice of values for the key parameters of the model, which is crucial for my calculations, will be discussed in detail below.

[6] The functional form of the production function is very important in cross-country comparisons. As shown in Box 1, the Cobb-Douglas function in years of schooling that underlies my calculations (equation (1) in Box 1) forces the aggregate Mincerian returns parameter *(ρ)* for each country to be inversely proportional to its average attainment. An alternative ("Mincerian") specification that has often been used in the recent literature, by contrast, imposes a common value of ρ for the whole sample (see Box 2 in section 3b.ii of D&C (2002)). This makes little difference when we are interested in drawing conclusions for a hypothetical average country but becomes crucial when we want to compare rates of return across territories. While I find the Cobb-Douglas specification intuitively more appealing than the Mincerian functional form and have found that it fits the OECD data better, it may still be too restrictive. If this is the case, cross-country results may be distorted in a way that will depend on the true sensitivity of ρ to average attainment.

Box 1: A simple model of human capital and growth

My estimates of the social return to schooling will be based on a simple model of human capital and growth with two components: an aggregate production function and a technical progress function. The production function will be assumed to be of the Cobb-Douglas type:

$$(1)\ Y_{it} = A_{it} K_{it}^{\alpha_k} S_{it}^{\alpha_S} L_{it}^{\alpha_l}$$

where Y_{it} denotes the aggregate output of country i at time t, L_{it} is the level of employment, K_{it} the stock of physical capital, S_{it} the average stock of human capital per worker, measured by the average years of schooling of the adult population, and A_{it} an index of technical efficiency or total factor productivity (TFP) which summarizes the current state of the technology and, possibly, omitted factors such as geographical location, climate, institutions and endowments of natural resources. The coefficients α_i (with $i = k, s, l$) measure the elasticity of output with respect to the stocks of the different factors. An increase of 1% in the stock of human capital per worker, for instance, would increase output by α_S%, holding constant the stocks of the other factors and the level of technical efficiency.

Under the standard assumption that (1) displays constant returns to scale in capital, labour and total human capital, LS, (i.e. that $\alpha_k + \alpha_l = 1$) we can define a per capita production function that will relate average productivity to average schooling and the stock of capital per worker. Letting $Q = Y/L$ denote output per worker, $Z = K/L$ the stock of capital per worker, and dividing both sides of (1) by total employment, L, we have:

$$(2)\ Q = f(S) = AZ^{\alpha_k} S^{\alpha_S}$$

The aggregate Mincerian returns parameter that appears in the rate of return calculation is given by

$$(3)\ \rho = \frac{f'(S)}{f(S)} = \frac{AZ^{\alpha_k}\alpha_S S^{\alpha_S - 1}}{AZ^{\alpha_k} S^{\alpha_S}} = \frac{\alpha_S}{S}$$

The technical progress function describes the determinants of the growth rate of total factor productivity. I will assume that country *i*'s TFP level can be written in the form:

$$(4)\ A_{it} = B_t X_{it}$$

where B_t denotes the world "technological frontier" (i.e. the maximum attainable level of efficiency in production given the current state of scientific and technological knowledge) and $X_{it} = A_{it}/B_t$ the "technological gap" between country i and the world frontier. It will be assumed that B_t grows at a constant and exogenous rate, g, and that the growth rate of X_{it} is given by

$$(5)\ \Delta x_{it} = \gamma_{io} - \lambda x_{it} + \gamma S_{it}$$

where x_{it} is the log of X_{it} and γ_{io} a country fixed effect that helps control for omitted variables such as R&D investment. Notice that this specification incorporates a technological diffusion or catch-up effect. If $\lambda > 0$, countries that are closer to the technological frontier will experience lower rates of TFP growth. As a result, relative TFP levels will tend to stabilize and their steady-state values will be partly determined by the level of schooling.

The derivation of the rate of return formula is very similar to the one in the previous section. The main differences are that we must now consider the full direct costs of training (rather than the component that is born by private individuals) and the total increase in output generated by additional schooling (rather than the increase in after-tax individual earnings). This second difference has several implications. First, taxes and social benefits are now irrelevant, as they are transfers between the private and public sectors that do not directly change total output. Second, the function *f(S)* introduced in the previous section to describe the response of gross wages to educational attainment will now be interpreted as a per capita production function. Accordingly, the microeconomic Mincerian parameter derived from the wage function, θ, will now be replaced by its aggregate counterpart, ρ, which measures the percentage increase in output resulting from a one-year increase in average attainment. And third, we need to extend the previous formula to take into account the externality effect that works through the rate of technological progress.

Under the assumptions listed above, the social rate of return to schooling, r_S, is given by

$$(11)\quad r_S = R_S + g$$

where g is the rate of exogenous productivity growth at the world frontier (see Box 1) and R_S the value of R that solves the following equation:

$$(12)\quad \frac{R}{1-e^{-RH}} = \frac{\varepsilon + \rho + \frac{\gamma}{R+\lambda}}{(1-(1-\phi)\eta) + \frac{\mu}{p_o}} \equiv \frac{\rho + \varepsilon + EXT}{OPPC + DIRC}$$

where μ is the total direct cost of a year of schooling measured as a fraction of average output per worker, ρ is the aggregate Mincerian returns coefficient, γ the rate effects parameter that captures the contribution of schooling to technical progress and λ the rate of technological diffusion (see Box 1). The remaining parameters have the same interpretation as in the previous section. Notice that equation (12) has the same form as equation (9) above, except for the absence of tax and benefit parameters and for the inclusion of a new term (EXT) that captures the externality or rate effects of human capital. Aside from this, the interpretation of the formula remains unchanged: the rate of return to schooling is the ratio of its marginal benefits to its marginal costs, adjusted for the finite life of the asset.

3. The private return to schooling and the incentive to invest in education

In this section I will present estimates of the private return to post-compulsory schooling in the member countries of the European Union. These rates of return will be calculated by applying equation (9) to a representative individual for each country endowed with average school attainment. I will assume that this representative agent's income, when employed, is equal to the gross earnings of the average production worker (APW).[7] It will also be assumed that the agent is active throughout his working life (i.e. that he is active while attending school at post-compulsory levels and remains a member of the labour force until the standard retirement age) and that he wants to work (but may not succeed in doing so) 20% of a standard

7 This assumption is made for convenience, as it allows me 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.

work-year while enrolled in school.[8] Hence, the employment probabilities and related parameters used in the calculation are conditional on labour force participation. As suggested by de la Croix (2003), I will allow retirement ages to vary across countries. I will also take into account cross-country differences in school-leaving ages, and set the expected duration of the (post-school) working life of the representative individual for each country as the difference between these two variables.

The calculations will also allow for the taxes on labour income to which the representative individual would be subject in each country (including national and regional income taxes and employee social security contributions) and for the unemployment and housing benefits for which he would be eligible, working under the assumptions 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 exahust contributive benefits.

a. Data and sources

Table 1 describes the different variables and parameters used in the computation of the private rate of return to schooling and gives the sources of these data. The details of the construction of the different variables are discussed in the Appendix.

The expected length of the working life of the representative individual for each country is calculated as the difference between the estimated average age of retirement 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 attainment is taken from de la Fuente and Doménech (2001).

A key input to my calculations is a set of estimates of the individual-level Mincerian returns to schooling parameter (θ) that has been constructed using the results of microeconometric wage regressions reported in Harmon, Walker and Westergaard-Nielsen (2001).[9] These authors provide separate estimates of this coefficient for men and women in most EU countries using relatively homogeneous data for 1995 or a nearby year and a common econometric specification. I have averaged these estimates across sexes using their shares in total employment, and introduced some corrections (using information reported in the relevant country chapters of the same study) in those cases in which the original estimates seemed to

8 This figure of 20% may be too low when interpreted strictly as a measure of potential labour supply, but it is probably realistic as an estimate of potential student earnings relative to those of full-time adult workers with similar attainment levels.

9 Harmon et al's estimates of θ are obtained by OLS and are therefore potentially subject to biases arising from measurement error and the omission of ability. Our reading of the relevant literature suggests that the net bias is unlikely to be large (see D&C (2002), sections 3ai and ii and Appendix 1).

be based on data referring to net rather than gross wages. (See Section 2 of the Appendix for details).

Table 1: Variables and parameters used in the calculation of the private rate of return on schooling and sources of the data

parameters

g = 1.5%, rate of exogenous productivity growth. Source: Jones (2002).

ϕ = 0.8, fraction of time taken up by (full-time) school attendance; $1-\phi$ is the potential labour supply while in school.

variables

U = Average retirement age in 1995, constructed by averaging separate estimates for men and women, weighted in proportion to their shares in total employment. Source: Blöndal and Scarpetta (1999).

S_o = average years of school attainment of the adult (over 25) population in 1990. Source: de la Fuente and Doménech (2001).

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

θ = microeconomic Mincerian returns to schooling parameter. It measures the average (log) increase in gross wages (wages before income taxes and employee social security contributions are witheld) resulting from an additional year of schooling. Source: constructed using estimates for 1995 taken from Harmon, Walker and Westergaard-Nielsen (2001). See section 2 of the Appendix for details.

μ_s = direct cost of schooling born by the individual, measured as a fraction of APW gross earnings (weighted average of secondary and tertiary levels with weights 2/3 and 1/3 respectively). Average costs are shown net of direct public subsidies to students for living costs and other non-tuition expenses and will be negative when these subsidies exceed tuition charges. Source: constructed using data in various issues of *Education at a Glance*. See section 1 of the Appendix.

μ = total cost (private + public) of schooling per student measured as a fraction APW gross earnings (weighted average of secondary and tertiary levels with weights 2/3 and 1/3 respectively). It excludes an estimate of research expenditure by universities. Direct subsidies to students for living and non-tuition expenses are not considered a net cost from the point of view of society as a whole (I consider them a transfer to the private sector). Source: constructed using data in various issues of *Education at a Glance*. See section 1 of the Appendix.

p_o = probability of employment after leaving school, conditional on participation in the labour force. Source: Eurostat, Spring 2000 Labor Force Survey. I use one minus the unemployment rate for the 35-44 population.

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

Table 1: Variables and parameters used in the calculation of the private rate of return on schooling and sources of the data -- continued

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 the Appendix.

$\varepsilon = p'(S)/p(S)$ measures the responsiveness of the probability of employment of active workers to their level of schooling. Source: estimated using data from Eurostat's Spring 2000 Labor Force Survey. See section 3 of the Appendix.

τ_o = average tax rate on labour income (including national and regional income taxes and employee social security contributions) applicable to the average production worker in 2000. Source: OECD tax database with data from *Taxing Wages*.

T' = marginal tax rate on labour income (including national and regional income taxes and employee social security contributions) applicable to the average production worker in 2000. Source: OECD tax database with data from *Taxing Wages*.

τ_s = average tax rate on labour income (including national and regional income taxes and employee social security contributions) applicable to a worker earning 20% of the APW salary in 2000. Source: calculated using the description of national tax systems given in *Taxing Wages 2000-2001*.

a = first component of the net replacement ratio (ratio of net after-tax earnings out of work to net after-tax earnings while employed) for a single individual with no children whose previous earnings were equal to the average production worker's salary. This parameter captures the effects of unemployment benefits that are linked to previous earnings. Source: estimated using the description of national social protection systems given in the country chapters of *Benefit systems and work incentives 1999*.

b = second component of the net replacement ratio, calculated under the same assumptions as a. It captures the effects of unemployment and housing benefits whose amount is not linked to previous earnings. Source: same as for a.

My estimates of the direct costs of schooling (μ and μ_s) are based on data on private and government 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 and private) cost per student of a marginal increase in enrollments, which would have to come at the upper secondary and university levels since attendance at lower levels is already compulsory in the EU. The cost of higher education is purged of research expenditure by universities, and private costs are shown net of direct government transfers to households for living and other non-tuition expenses (which makes them negative in quite a few European countries).[10] Both direct cost variables 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. I 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. (See section 1 of the Appendix).

The probability of employment of adult workers (p_o) has been taken from Eurostat's Spring 2000 Labour Force Survey. It is calculated as *1-u* where *u* is the unemployment rate of the 35-44 age group.[11] The same data, which are disaggregated into three educational levels, have been used to calculate the sensitivity of the probability of employment to educational attainment (captured by $\varepsilon = p'(S_o)/p(S_o)$). For each country, I approximate $p'(S_o)$ by the average increase in the probability of employment induced by an additional year of schooling. Dividing this figure by p_o, I obtain a preliminary estimate of ε. Since this estimate is likely to be biased upward due to the impossibility of controlling for relevant individual characteristics with aggregate data, I reduce it by 1/3 before using it in the calculations discussed in this section. The correction factor for differential student unemployment is obtained using data from *Education at a Glance 2000* on the unemployment rates of the in-school and out-of-school population between ages 20 and 24.

The tax and benefit parameters are taken from various OECD sources and refer to single individuals with no children.[12] The average and marginal tax rates on adult workers (τ_o and T') are taken directly from the OECD Tax Database (and originally from *Taxing Wages*). They refer to the year 2000 and 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. The average tax rate on student income (τ_s) has been constructed using the description of the 2000 tax systems of European countries given in *Taxing Wages 2000-2001*. This rate has been calculated under the assumption that the income of an employed student is 20% of APW earnings. All tax rates incorporate personal income taxes and employee (but not employer) social security contributions, so as to be consistent with the

[10] In the case of Germany, the bulk of private expenditure on secondary education corresponds to enterprise contributions to apprenticeship programmes. (Thanks to L. Wössman for pointing this out). Since I am concerned with the return to individuals, I treat this item as public expenditure.

[11] The choice of the unemployment rate for prime-age individuals is probably an optimistic assumption, as unemployment rates are generally higher in early post-school years and for older individuals. The resulting bias is at leat partially offset by two factors: the fact that I am using unemployment rates for the entire population (and not for relatively skilled individuals, which are the group of intersest) and the use of estimated retirement ages which incorporate information about early exit from the labour market. In any event, the rate of return is not very sensitive to the choice of unemployment rate. Notice that, if we assume there are no unemployment benefits (i.e. $a = b = 0$), p_o drops out of equation (9) except for the denominator of the *DIRC* term. As will be shown later, this term has only a minor impact on the estimated rate of return.

[12] As several discussants have noted, it would be interesting to relax this assumption and analyze the impact of family-related benefits and tax deductions. The required calculations are, however, fairly complex and could not be completed within the time available for the preparation of this report.

definition of gross wages that seems to have been used in the wage equation estimates I am using.

Table 2: Data used in the calculation of the private rate of return on schooling

	U	H	θ	μ_s	μ	p_o	p_s
Austria	57.7	40.4	8.60%	-1.40%	***35.33%***	96.35%	**96.35%**
Belgium	56.1	40.0	**7.24%**	0.32%	21.46%	94.63%	83.27%
Denmark	61.2	43.4	5.71%	-4.44%	21.38%	96.29%	90.03%
Finland	59.0	42.0	8.69%	-1.84%	22.91%	92.67%	62.64%
France	58.8	42.3	7.77%	1.94%	32.76%	91.27%	**61.79%**
Germany	59.6	40.6	8.73%	0.00%	21.29%	93.11%	93.11%
Greece	61.5	47.5	8.21%	***0.98%***	21.56%	92.37%	67.52%
Ireland	62.1	46.7	10.90%	0.73%	27.20%	93.16%	**93.16%**
Italy	59.4	45.3	7.90%	0.74%	**25.28%**	97.76%	31.97%
Netherlands	57.3	40.4	6.70%	-1.34%	21.40%	97.06%	93.47%
Portugal	62.3	48.3	9.70%	***-0.33%***	**39.51%**	95.23%	87.80%
Spain	60.5	46.5	8.23%	4.05%	25.64%	88.62%	60.00%
Sweden	62.7	46.1	3.96%	-5.80%	29.84%	95.74%	75.35%
UK	61.4	44.8	10.34%	0.94%	20.34%	94.17%	94.26%
average EU14	59.97	43.89	*8.05%*	-0.39%	26.14%	*94.17%*	*77.31%*

	η *	ε	τ_o	T'	τ_s	a	b
Austria	**1**	0.51%	0.279	0.429	18.20%	59.56%	0.00%
Belgium	0.880	0.86%	0.419	0.555	13.07%	0.00%	64.47%
Denmark	0.935	0.40%	0.441	0.507	20.04%	0.00%	62.71%
Finland	0.676	0.77%	0.336	0.480	23.20%	33.74%	31.16%
France	**0.677**	1.23%	0.268	0.335	18.01%	70.52%	0.00%
Germany	1	1.14%	0.420	0.579	20.50%	59.69%	0.51%
Greece	0.731	0.36%	0.181	0.285	15.90%	46.59%	0.00%
Ireland	**1**	**0.91%**	0.203	0.525	2.00%	0.00%	31.18%
Italy	0.327	0.51%	0.285	0.404	9.19%	39.28%	2.29%
Netherlands	0.963	0.35%	0.362	0.531	10.52%	77.27%	4.72%
Portugal	0.922	0.03%	0.177	0.260	11.00%	78.89%	0.00%
Spain	0.677	0.66%	0.185	0.288	6.35%	74.45%	0.00%
Sweden	0.787	0.49%	0.329	0.352	24.21%	0.00%	70.62%
UK	1	0.91%	0.236	0.320	0.00%	0.00%	46.32%
average EU14	*0.821*	0.65%	*0.294*	*0.418*	*13.73%*	*38.57%*	*22.43%*

Notes:
Entries in bold type indicate very unreliable estimates. For the sake of completeness, I generally estimate missing data by assuming that a country is similar to its neighbours.
θ : No estimates are available for Belgium. I assign to this country the average of the values for France and Holland.
ε: I assume Ireland is the same as the UK.
η : I assume Austria is the same as Germany, France the same as Spain, and Ireland the same as the UK.
(*) When the value of η given in Table A.10 of the Appendix exceeds 1, I use a value of 1.

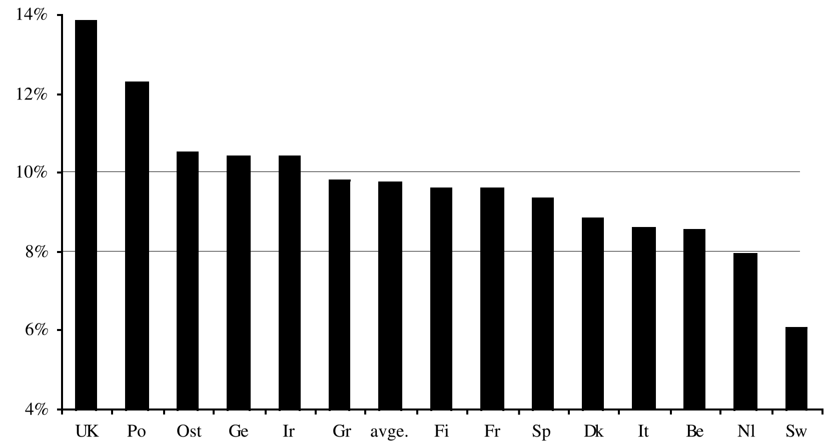
Finally, my estimates of the benefit parameters (i.e. of the two components of the net replacement ratio for unemployed workers) have been constructed using the description of the existing benefit schemes given in the country chapters of the OECD's *Benefit Systems and Work Incentives 1999*, assuming 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. For this calculation, I have assumed that any unemployment spells experienced by this representative worker are sufficiently brief that he does not exhaust the contributive benefits to which he is entitled.

Table 2 shows the actual data used in the rate of return calculations (except for S_o, which is shown in Table 7 below). As noted in the introduction, missing data have been a problem in some countries. Throughout the text, I will use bold type to identify particularly unreliable observations. More specifically, bold entries in a table indicate that the required data or some key parameter for its calculation are unavailable and have been filled in by imputing to problem countries the values of the same variable observed in close neighbours or in countries with similar income levels, whenever this problem can have an important effect on the calculations. Bold italics will be used in cases when there is partially incomplete data or when the missing data is not expected to have an important effect on the final estimates. For purposes of this section, the first of these problems affects four countries (Belgium, Ireland, Austria and France) and is particularly worrisome in the case of Belgium as the missing piece of information for this country is the Mincerian returns parameter. Hence, all the estimates for this country given in this section should be interpreted with extreme caution and are reported only because comparisons among estimated returns under different assumptions do contain useful information about the impact of Belgian policies on private incentives. 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 the Appendix).

b. Basic results

Figure 1 displays my estimates of the private rate of return *(r_p)* to schooling in fourteen European countries.[13] For most countries, the value of r_p lies between 8 and 10%, with an average value of 9.75%. Sweden is a clear outlier. The rate of return estimated for this country (6.06%) is almost two 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_p exceeds 12% in the UK and Portugal and is over 10% in Austria, Germany and Ireland.

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



- *Note:* the estimate for Belgium is based on seriously incomplete data and is included for illustrative purposes only.

The upper panel of Table 3 shows the numerical values behind Figure 1 and the four cost and benefit "components" of the rate of return. As above, bold entries identify estimates that are based on incomplete information. The estimate of r_p for Belgium is shown in bold type because, as noted above, I am missing a crucial piece of information for its calculation. The entries for Ireland, Austria and France appear in bold italics because the error induced by the missing data for these countries is likely to be relatively minor. The same convention is used in the remaining columns of Table 3.

To interpret this table, recall the rate of return formula derived in Section 2a,

$$(9')\; R' \equiv \frac{R}{1-e^{-RH}} = \frac{\theta_{net}+\varepsilon_{net}}{OPPC+DIRC} \equiv \frac{NUM}{DENOM}$$

In this expression, θ_{net} and ε_{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 *OPPC* and *DIRC* measure 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} and ε_{net} are normalized by the average value of their sum, *NUM*, and *OPPC* and *DIRC* are normalized by the average value of *DENOM*).

[13] In this figure, and elsewhere in the report, the rates of return for the average country are obtained by entering average parameter values in the relevant formula, not by averaging the rates of return across countries.

Table 3: Private rate of return to schooling and its components

a. Observed values

	r_p	*NUM*	θ_{net}	ε_{net}	*DENOM*	*OPPC*	*DIRC*
UK	13.87%	9.42%	8.94%	0.47%	75.82%	74.55%	1.27%
Portugal	12.29%	8.73%	8.72%	0.01%	80.41%	80.81%	***-0.41%***
Austria	**10.50%**	7.01%	6.81%	0.20%	**75.84%**	**77.81%**	-1.97%
Germany	10.43%	6.77%	6.33%	0.43%	73.76%	73.75%	0.01%
Ireland	**10.41%**	**6.96%**	6.35%	**0.61%**	**76.91%**	**75.96%**	0.96%
Greece	9.81%	7.35%	7.16%	0.18%	86.78%	85.54%	**1.24%**
Finland	9.62%	6.91%	6.65%	0.26%	82.29%	85.13%	-2.84%
France	**9.59%**	7.40%	7.06%	0.34%	**88.50%**	**85.79%**	2.71%
Spain	9.36%	7.34%	7.19%	0.15%	90.92%	85.80%	5.12%
Denmark	8.87%	5.06%	4.91%	0.14%	65.83%	73.88%	-8.05%
Italy	8.61%	6.88%	6.58%	0.29%	92.81%	91.76%	1.05%
Belgium	**8.56%**	**5.64%**	**5.35%**	0.29%	75.14%	74.59%	0.56%
Netherlands	7.95%	4.98%	4.92%	0.06%	71.54%	73.65%	-2.11%
Sweden	6.06%	3.84%	3.70%	0.14%	74.01%	82.76%	-8.75%
avge. EU14	*9.75%*	*6.78%*	*6.53%*	*0.24%*	*79.95%*	*80.52%*	*-0.56%*

b. Normalized values

	r_p	*NUM*	θ_{net}	ε_{net}	*DENOM*	*OPPC*	*DIRC*
UK	142.3	*138.9*	131.9	7.0	*94.8*	93.2	1.6
Portugal	126.1	*128.7*	128.7	0.1	*100.6*	101.1	-0.5
Austria	**107.7**	*103.5*	100.5	3.0	*94.9*	97.3	-2.5
Germany	106.9	*99.8*	93.4	6.4	*92.3*	92.2	0.0
Ireland	**106.7**	*102.7*	93.7	9.0	*96.2*	95.0	1.2
Greece	100.6	*108.4*	105.7	2.7	*108.5*	107.0	1.6
Finland	98.6	*101.9*	98.1	3.8	*102.9*	106.5	-3.5
France	**98.3**	*109.2*	104.1	5.0	*110.7*	107.3	3.4
Spain	96.0	*108.3*	106.0	2.3	*113.7*	107.3	6.4
Denmark	91.0	*74.6*	72.5	2.1	*82.3*	92.4	-10.1
Italy	88.3	*101.4*	97.1	4.3	*116.1*	114.8	1.3
Belgium	**87.8**	*83.2*	78.9	4.3	*94.0*	93.3	0.7
Netherlands	81.5	*73.5*	72.6	0.9	*89.5*	92.1	-2.6
Sweden	62.1	*56.7*	54.6	2.1	*92.6*	103.5	-10.9
avge. EU14	100.0	*100.0*	96.4	3.6	*100.0*	100.7	-0.7

- *Note:* entries in bold or bold italics are based on incomplete information. See the text and the notes to Table 2 for further details.

Inspection of Table 3 shows that the return to schooling is primarily determined by its wage-related benefits and its opportunity cost, with employment-related effects and direct costs playing a secondary role. For the average country in the sample, 96.4% of the payoff to schooling comes from its impact on earnings and over 100% of its costs take the form of foregone wages. This implies that the direct costs of schooling are in fact negative in the average

country as a result of government subsidies in excess of private costs.[14] There is considerable variation across countries in this respect, however. Subsidies are particularly generous in the Scandinavian countries, although not enough to compensate low earnings effects in Denmark and Sweden, 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.

c. The impact of public policies and student unemployment

This section analyzes the effects on the private return to schooling of various forms of government intervention and of youth unemployment. To quantify the contribution of each of these factors to the net private return to schooling, I will recalculate the rate of return under a set of different counterfactual assumptions or *scenarios*. In the *baseline* scenario [1] I assume there is no government intervention, i.e. that private agents pay the full costs of education and there are no taxes or social benefits. In scenario [2] I introduce *subsidies* to education respecting the remaining assumptions. In [3] I introduce *taxes* and in [4] social benefits to obtain an estimate that includes the effects of all relevant public policies *(GOVT)*. In these four scenarios I assume $\eta = 1$, i.e. that the probability of finding part-time work while in school is the same as the probability of finding full-time work after graduation. Scenario [5], finally, corresponds to the observed returns to education *(OBS)* as measured by the estimates given in the previous subsection. It differs from scenario [4] only in that it makes use of the estimated value of η to correct for the added difficulty of finding part-time work in many countries (*difstU* correction).[15] Table 4 summarizes these assumptions.

Table 4: Assumptions underlying the scenarios

	baseline [1]	*subsidies* [2]	*taxes* [3]	*GOVT* [4]	*OBS* [5]
direct costs	total	private	private	private	private
taxes	none	none	observed	observed	observed
benefits	none	none	none	observed	observed
diffstU correct.	no	no	no	no	yes

The detailed results of the calculations are shown in Table A.12 in section 5 of the Appendix. Figure 2 summarizes graphically the main results by comparing each country's relative rate of return (with the sample average normalized to 100 in each case) under the *baseline*, *GOVT* and *OBS* scenarios. Notice that changes in relative positions as we go from

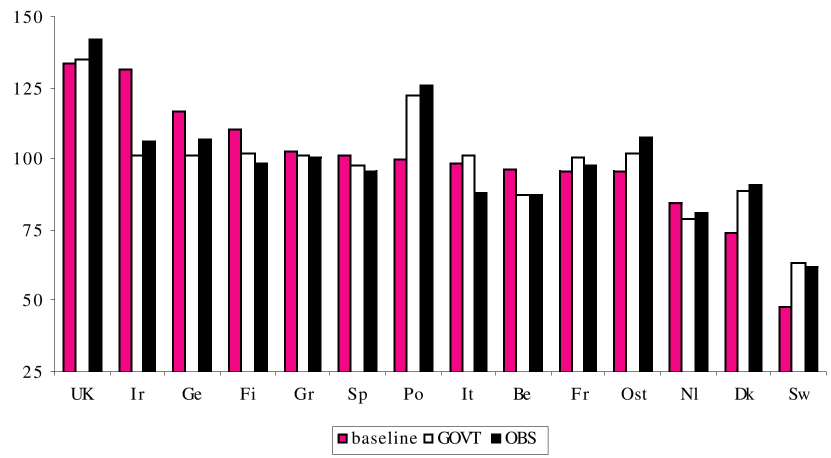
14 This may be somewhat misleading as our cost estimates do not take into account the purchase of books and other classroom materials or other school-related expenses such as transport.

15 I carry out this correction last partly in order to isolate the effects of differential student unemployment, and partly because the data on student unemployment is incomplete and I have some doubts about its quality, as I suspect that, at least in some countries, labour force surveys do not target this group carefully.

the first to the second scenario are due to cross-country differences in tax and benefit systems and in educational finance, and those that arise as we go from the second to the third scenario reflect differences in student unemployment differentials relative to adult workers.

The figure suggests that student unemployment has a relatively low impact on the relative rate of return to schooling except in the case of Italy, and that government policies make a big difference in many countries. The combination of the different policies we are considering, in particular, greatly raises the relative return to schooling in Denmark, Sweden and Portugal, and reduces it in Ireland and Germany.

Figure 2: Normalized rate of return to schooling under different scenarios



- *Note:* All estimates for Belgium are based on seriously incomplete data. Differences across scenarios, however, should contain useful information.

To obtain more precise measures of the impact of different policies on the private return to schooling, I will construct an *effective tax rate* on human capital ($etr_{gov@}$) and decompose it into a series of factors by comparing the returns obtained under different scenarios. Letting r_i denote the estimated private rate of return to schooling under scenario *i*, I will define $etr_{gov@}$ by

$$(13)\ 1 - etr_{gov@} = \frac{r_{gov@}}{r_{baseline}}.$$

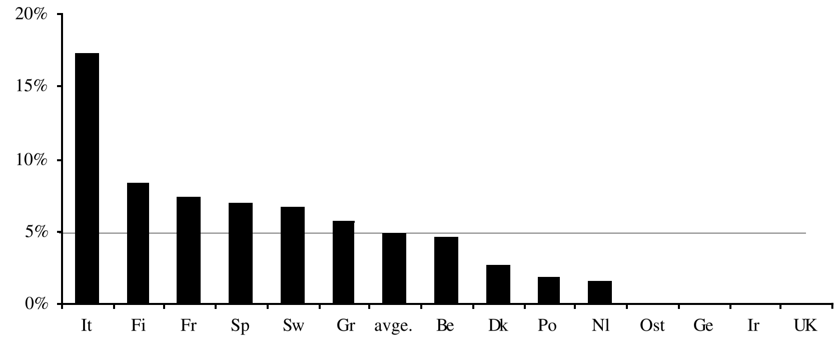
Hence, $etr_{gov@}$ captures the joint effect of all the relevant public policies. Notice that this tax rate can be decomposed into three factors that isolate the impact of educational subsidies, personal taxes and social benefits using the following identity:

$$(14)\ 1 - etr_{gov@} = \frac{r_{gov@}}{r_{baseline}} = \frac{r_{subsidies}}{r_{baseline}} \frac{r_{taxes}}{r_{subsidies}} \frac{r_{gov@}}{r_{taxes}} = (1+subs)(1-etr_{tax})(1-etr_{ben}).$$

Finally, I will construct in a similar way the effective tax rate implicit in the student unemployment differential, which is given by

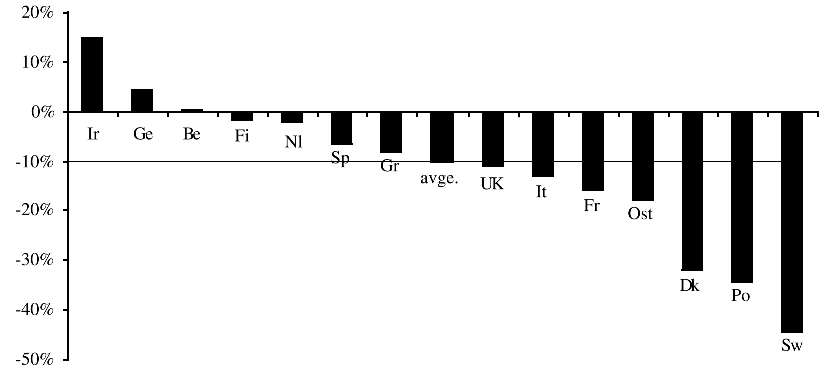
$$(15)\ 1 - etr_{stU} = \frac{r_{obs}}{r_{gov@}}$$

Figure 3: Tax rate implicit in differential student unemployment (etr_{stU})



- *Note:* Estimates for Ireland, Austria and France are based on seriously incomplete data.

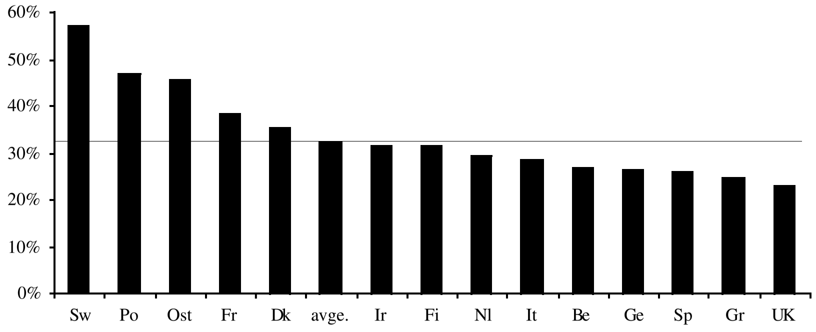
Figure 4: Effective tax rate on human capital ($etr_{gov@}$)



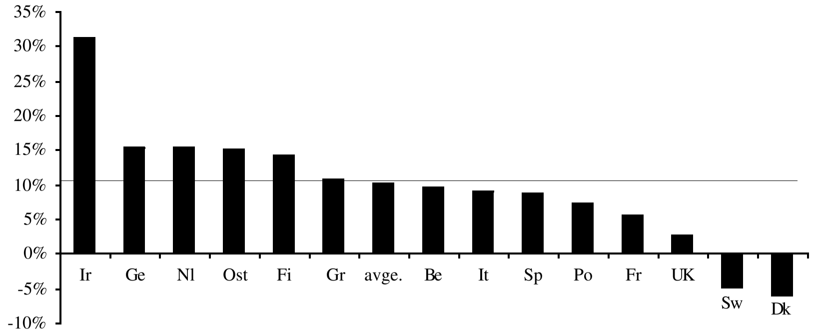
The results of these calculations are shown in Table A.14 in section 5 of the Appendix and in Figures 3-5. As noted above, the difficulty of finding part-time work while attending schoool reduces the expected return of schooling by over 15% in Italy and is also a problem in Finland, France, Spain, Sweden, Greece and Belgium (Figure 3). Taken together, public policies imply a net *subsidy* to human capital at a rate of 10% in the average European country. (Notice in Figure 4 that the average value of $etr_{gov@}$ is negative). Hence, educational subsidies more than offset the disincentive effects generated by personal taxes and social benefits. The average subsidy rate *(subs)* is over 30% when we consider only the effects of

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

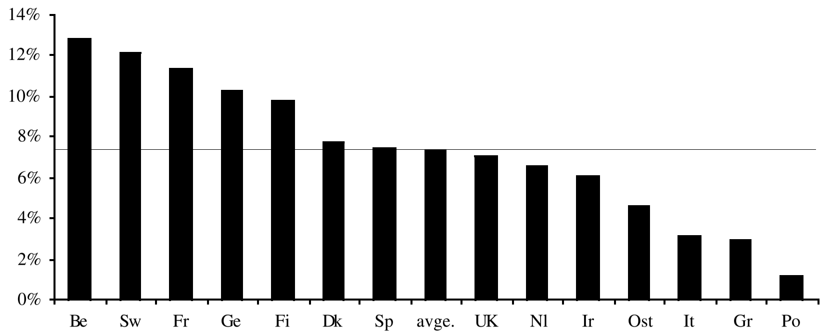
a. Educational subsidies (*subs*)



b. Taxes (etr_{tax})



c. Social benefits (etr_{ben})



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 10.1% and 7.4% respectively (Figures 5b and 5c).

There are very important differences across countries in terms of both the total tax burden on human capital and the sources of this burden. Ireland and Germany are the only two countries where the effective tax rate on schooling is significantly positive. In the case of Ireland, the main disincentive has to do with the very high progressivity of personal taxes at APW income levels. In Germany, the high effective tax rate arises from the combination of high tax progressivity and a fairly low rate of direct subsidies. At the other end of the scale, the overall subsidy rate exceeds 30% in Sweden, Portugal and Denmark. In these three cases, the direct subsidy rate is high (although this result is somewhat suspect in the case of Portugal for reasons already discussed) and the disincentive effects of personal taxes are low. In Portugal, moreover, the tax rate implied by social benefits is very low, mostly as a result of the low sensitivity of the probability of employment to attainment (i.e. because of the low estimated value of ε).[16] 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 relatively low progressivity ratios and the interaction between a negative private cost ($\mu_S < 0$) and a high average tax rate on adult workers.

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

Table 5 compares the private *after-tax* return to education (under the all-in scenario, *OBS*) to the *before-tax* real return on debt and equity. The real returns on bonds and stocks are averages for the period 1950-1989 and are taken from Dimson, Marsh and Staunton (2002).[17] Since these authors provide no data for Austria, Greece, Finland and Portugal, I have imputed to these countries the average returns in the remainder of the sample. As usual, the corresponding entries are shown in bold type in Table 5. Column [5] of Table 5 shows what I will call the *private premium on human capital*. This variable is defined as the difference between the private 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]).

16 See the discussion of the impact of unemployment benefits at the end of section 2a. Because the rate of return formula is highly non-linear, interaction effects are important. As a result, effective tax rates are not necessarily proportional to tax or benefit levels -- i.e. it is not necessarily true, for instance, that the disincentive effects of unemployment benefits are highest in countries where those benefits are most generous.

17 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 of writing this report, many Western stock market indices have lost around 50% of their value relative to their 2000 peaks. The average return on the equal weights portfolio I use as a reference, were 1 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 affect our conclusions.

Table 5: Net *after-tax* rate of return on schooling vs. *before-tax* real return on financial assets, and private premium on human capital

	[1] *schooling* r_p	[2] *equity*	[3] *bonds*	[4] *avge. portfolio*	[5] *premium on h. capital*
Austria	***10.50%***	**6.93%**	**1.12%**	**4.03%**	**6.48%**
Belgium	**8.56%**	6.50%	1.90%	4.20%	**4.36%**
Denmark	8.87%	6.20%	2.60%	4.40%	4.47%
Finland	9.62%	**6.93%**	**1.12%**	**4.03%**	**5.59%**
France	***9.59%***	7.70%	3.70%	5.70%	***3.89%***
Germany	10.43%	9.50%	3.40%	6.45%	3.98%
Greece	9.81%	**6.93%**	**1.12%**	**4.03%**	**5.78%**
Ireland	***10.41%***	6.90%	0.30%	3.60%	***6.81%***
Italy	8.61%	4.90%	0.20%	2.55%	6.06%
Netherlands	7.95%	7.50%	-0.30%	3.60%	4.35%
Portugal	12.29%	**6.93%**	**1.12%**	**4.03%**	**8.27%**
Spain	9.36%	4.50%	-0.90%	1.80%	7.56%
Sweden	6.06%	8.70%	-0.80%	3.95%	2.11%
UK	13.87%	8.30%	-0.30%	4.00%	9.87%
avge. EU14	*9.75%*	*6.93%*	*1.12%*	*4.03%*	*5.72%*

- *Note:* No data are available on the returns to bonds and shares in Austria, Finland, Greece and Portugal. I impute to these countries the average return in the rest of the sample.

These data reinforce our conclusion in D&C (2002) that schooling is a rather attractive investment from an individual point of view.[18] For the average country, the real return to schooling exceeds the return on bonds by 8.6 points and that on equity by 2.8 points. When allowance is made for taxes on capital income (a complicated matter that I 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 5.9 points (which is the value corresponding to France). The before-tax return to equity, however, is above the rate of return on schooling 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 2.11% in Sweden to 9.87% in the UK with a mean value of 5.72%.[19]

[18] As noted in D&C (2002), 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. I am not aware of any refined measures of earnings risk that can be used to draw valid comparisons with other assets.

On a 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).

[19] The absence of data on financial returns makes my estimates of the private premium on schooling rather uncertain for four countries (Austria, Greece, Finland and Portugal). Notice, however, that the human capital premium in these countries would remain over three percentage points if we assigned to them the highest rate of return on financial assets observed in the sample. The premium on schooling would also remain positive in all cases if we used financial returns over the period 1950-2000 to calculate it.

4. The social return to schooling and the optimal investment pattern

In this section I will focus on the social return to investment in education. As in the previous section, the relevant rate of return will be calculated by applying the formula derived in section 2 (equation (12)) to a hypothetical representative individual for each country. The only difference is that we will now be concerned with the social, rather than private, costs and benefits of an additional year of schooling. As a result, we need to consider the effects of education on aggregate output rather than on individual income, and its contribution to faster technological progress. On the other hand, taxes and social benefits are no longer relevant, as we are not interested in flows of resources between the public and private sectors.

a. Data and sources

Table 6 defines the variables that enter the social rate of return formula and Table 7 shows the relevant data. As usual, bold entries indicate missing or incomplete data. The cost and employment parameters have been taken from the same sources as those used in the private return calculations, and their construction is discussed in the Appendix.

Table 6: Variables used in the calculation of the social rate of return on schooling and sources of the data

ρ, ρ_{min} = macroeconomic Mincerian returns to schooling parameter. It measures the average (log) increase in output per employed worker resulting from an additional year of schooling of the adult population. It is obtained by dividing the estimated elasticity of output with respect to the stock of human capital (α_S) by average attainment in each country, using the results in D&D (2002). My baseline estimates of ρ are based on an estimate of α_S that is corrected for measurement error bias, but I also use an uncorrected estimate to obtain a lower bound on the value of ρ, which is denoted by ρ_{min}.

U = Average retirement age in 1995. See Tables 1 and 2.

S_0 = average years of school attainment of the adult (over 25) population in 1990. Source: de la Fuente and Doménech (2001).

$H = U - Max(6+S_0, 14)$ = estimated length of the (post-school) working life of the representative individual. See Tables 1 and 2.

μ = total costs of schooling per student measured as a fraction of GDP per employed worker. Calculated as described in Table 1. See section 1 of the Appendix for details.

p_0 = total probability of employment after leaving school (i.e. ratio of employment to the total population of working age). Source: Eurostat, Spring 2000 Labor Force Survey. I use values for the 35-44 population.

Table 6-- continued

η = correction factor capturing lower student labour force participation and employment rates. Source: calculated as the ratio between the total probability of employment of those enrolled in education and those not enrolled in education among workers aged 20 to 24, using data for 1998 from *Education at a Glance 2000*. See section 3 of the Appendix.

$\varepsilon = p'(S)/p(S)$ = sensitivity of the total probability of employment to the level of schooling. Source: estimated using data from Eurostat's Spring 2000 Labor Force Survey. See section 3 of the Appendix.

Table 7: Data used in the calculation of the social rate of return to schooling

	So	ρ	ρ_{min}	μ	p_o	ε	η
Austria	11.31	5.19%	3.48%	***14.59%***	84.73%	1.17%	**61.95%**
Belgium	10.08	5.82%	3.91%	9.69%	80.95%	1.53%	13.10%
Denmark	11.73	5.00%	3.36%	13.04%	87.66%	0.87%	88.66%
Finland	10.97	5.35%	3.59%	9.90%	83.65%	0.71%	41.05%
France	10.45	5.62%	3.77%	11.77%	80.41%	1.49%	16.46%
Germany	12.95	4.53%	3.04%	12.02%	81.62%	1.64%	61.95%
Greece	7.91	7.42%	4.98%	7.29%	74.05%	1.29%	8.58%
Ireland	9.41	6.24%	4.19%	7.98%	73.54%	**2.46%**	**57.86%**
Italy	8.04	7.30%	4.90%	***9.29%***	82.90%	1.24%	1.67%
Netherlands	10.95	5.36%	3.60%	10.70%	83.97%	2.07%	65.19%
Portugal	6.41	9.16%	6.15%	***11.98%***	84.57%	0.65%	25.06%
Spain	7.10	8.27%	5.55%	8.16%	70.61%	1.36%	15.37%
Sweden	10.62	5.53%	3.71%	13.16%	81.74%	1.25%	27.77%
UK	10.52	5.58%	3.75%	10.41%	80.80%	2.46%	57.86%
average EU14	9.89	*6.17%*	*4.14%*	*10.71%*	*80.80%*	*1.44%*	*38.75%*

- *Note*. Incomplete data on ε and η: Ireland is assumed to be equal to the UK and Austria equal to Germany.

An important difference with the calculations presented in the previous section is that I will now consider the total effect of education on employment, rather than just the increase in the probability of employment of active workers. That is, I will consider as part of the social benefits of education the induced increase in the rate of labour force participation. Hence, the values of p_o, ε and η used in this section are based on data on the absolute probability of employment (i.e. the fraction of the adult population that is employed) rather than on the probability of employment conditional on labour force participation, as was the case in the previous section.[20] A second difference is that the variable that measures the cost of

[20] As in the previous section, the raw estimate of ε described in section 3 of the Appendix is reduced (now by two thirds) to try to correct for its likely bias.

education, μ, now refers to total rather than private expenditure, and is normalized by average labour productivity rather than by APW earnings.

For the calculation of the social rate of return, the microeconomic Mincerian returns parameter (θ) used in the previous section must be replaced by its macroeconomic or aggregate counterpart (ρ), which measures the contribution of an additional year of schooling to aggregate productivity rather than to labour earnings. This variable is constructed by dividing the estimated coefficient of human capital in the aggregate production function (α_S) by average attainment in each country, as indicated in Box 1. The estimate of α_S comes from a single cross-country growth regression with panel data rather than from wage equations estimated separately for each country with individual-level wage data. The choice of baseline values for α_S will be discussed in greater detail in the following section.

b. Parameter values and the effects of human capital on aggregate productivity

Table 8 lists the values or ranges of values of the parameters that will be used below to compute the social return on investment in human and physical capital, with my baseline estimates shown in italics. As in the previous section, I assume an exogenous (steady-state) rate of productivity growth of 1.5% per annum and a value of ϕ equal to 0.8.

Table 8: Parameter values used in the calculations

human capital:	
level effects: α_S	0.394-*0.587*
rate effects: γ	*0*-0.20%
others:	
physical capital: α_k	*0.345*
technological diffusion: λ	*0.074*
s.s. rate of tech. progress: g	*0.015*
time used in school: ϕ	*0.80*

- *Note:* The reported values of α_k, λ and the first value given for α_S are taken from de la Fuente and Doménech (D&D 2002), Table 9e, equation [e8]. The second value for α_S is taken from D&D (2002), Table 11a, equation [4].

The remaining coefficients shown in the table are the key parameters of the growth model outlined in section 2b (see Box 1). The first two are the elasticities of aggregate output with respect to average educational attainment (α_S) and to the stock of physical capital (α_k). These parameters measure the percentage increase in output that would result from a 1% increase in the stocks of human or physical capital. The third coefficient (γ) captures the intensity of rate effects, i.e. the contribution of one additional year of schooling to the growth rate of total factor productivity (TFP). The last parameter of interest (λ) can be interpreted as the rate of technological diffusion across countries. Notice that the technological diffusion process assumed in the model implies that increases in schooling have only transitory effects on the growth rate of TFP and, in the long run, affect only the level of this variable. The percentage increase in steady-state TFP induced by a one-year increase in average attainment is given by γ/λ.

The values of α_k and λ shown in Table 8 and the lower bound on the level effects parameter (α_S = 0.394) come from de la Fuente and Doménech's (D&D 2000) estimation (without correcting for measurement error) of a model similar to the one described in Box 1 except in that it does not include rate effects.[21]

The baseline estimates of α_S and γ are constructed drawing on the results of D&D (2002) and other papers in the manner discussed in detail in section 6 of the Appendix. I take from the literature a number of estimates of the effect of an additional year of schooling on the level of output and use results from D&D (2002) to correct them for measurement error bias. The corrected estimates obtained in this manner imply Mincerian returns to schooling at the individual level that are well above existing microeconometric estimates.[22] If we take these results at face value, they indicate that the externalities associated with the accumulation of human capital are potentially very large. We need to be careful, however, because as noted in D&C (2002), these estimates may also contain a positive bias arising from endogeneity (reverse causation) problems.

The corrected estimates of the human capital coefficient constructed in the Appendix may be seen as the sum of three components: the first one measures the direct contribution of schooling to productivity that is directly appropiable by individuals through higher wages, the second one captures externalities linked to investment in human capital, and the third is the potential endogeneity bias. To try to separate these three factors, I will set the first component approximately equal to the value of α_S that would be implied by existing microeconometric estimates of the Mincerian returns parameter for our EU sample. I will then interpret the difference between each of the corrected estimates and this baseline value of α_S as a potentially biased measure of the size of externalities. Finally, I attempt to narrow down the range of possible values of the externality parameter by examining the implications of different assumptions about its value for the importance of externalities from human capital as a source of cross-country differentials in relative levels of total factor productivity (TFP) in an OECD sample. My baseline value of the externalities coefficient will be based on the

[21] As is often the case in the literature, attempts to estimate level and rate effects jointly produced unsatisfactory results. There is some discussion in D&C (2002) of why it may be difficult to disentangle these two effects.

[22] As discussed in D&C (2002), estimates of the micro and macroeconomic Mincerian returns parameter (θ and ρ) cannot be compared directly because the latter hold the stock of physical capital constant and the former do not. Under some assumptions (see section 8 of the Appendix), the relationship between these two parameters is given by $\rho = (1-\alpha_k)\theta$, where α_k is the elasticity of aggregate output with respect to the stock of physical capital. I will use this formula below, with the value of α_k given in Table 8, to calculate the value of θ implied by different estimates of ρ.

assumption that the external effects of human capital account for one third of observed TFP differentials across OECD countries in 1990.

To implement this approach, I will assume that the externalities linked to the accumulation of human capital take the form of what I have called rate effects, i.e. that they affect the rate of technical progress in the manner described in Box 1. I make this assumption for two reasons. The first one is that I believe this is the most plausible source of human capital externalities identified in the literature. The second reason is that this is actually a rather conservative assumption, for it implies that externalities materialize only gradually over time and must therefore be discounted. This makes the contribution of externalities to the social rate of return on schooling considerably lower than it would be under the alternative assumption that they have an immediate effect on output levels.

To be more precise, my baseline value for α_S is the lowest of all the meta-estimates of this parameter obtained by D&D (2002) after correcting for measurement error bias.[23] This value of α_S implies a value of θ (the individual-level Mincerian returns parameter) equal to 9.06% for the average EU country, which is half-way between Harmon et al's (2001) mean estimate of 8.06% for our EU sample and their average estimate of 10.62% for the Anglo-Saxon countries (see Table 2 above) where estimates of θ presumably best capture productivity effects due to labour market flexibility. After correcting for measurement error bias, practically all the other estimates of the human capital parameter considered in the Appendix imply considerably larger values of θ for the average EU country. D&D's average meta-estimate, for instance, implies a value of 17.2% for this parameter, and estimates taken from other papers in the literature imply values of θ ranging from 11.7% (Cohen and Soto, 2001) to 32.9% (Jones, 1996).

To obtain an estimate of the rate effects parameter, γ, I reinterpret the corrected estimates of the human capital coefficient discussed above as capturing the total contribution of schooling to steady-state output levels within the framework of the model sketched in Box 1, and solve for the implied value of γ given the assumed baseline value of the level effects parameter α_S . Since the resulting interval of estimates of the rate effects parameter is rather broad and includes implausibly high values of γ that are likely to suffer from reverse-causation bias, I set γ by assuming that rate effects account for a bit over one third of observed TFP differentials across OECD countries. This assumption yields a baseline value of 0.20% for γ, which implies that a one-year increase in average attainment will raise productivity by 3.1% in the medium or long-run through its contribution to faster technological progress. This

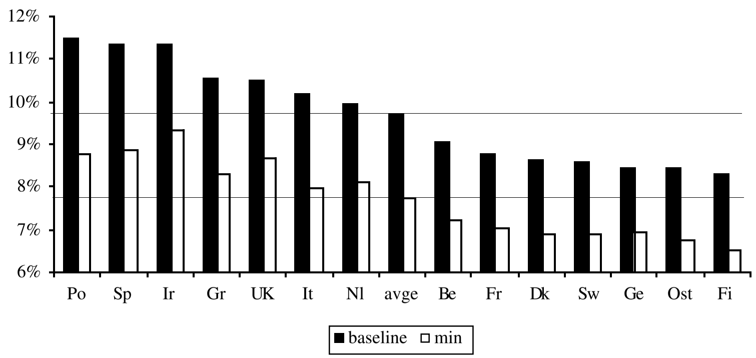
[23] These authors construct nine different meta-estimates of α_S by combining three different specifications of the production function (in levels, with fixed effects and in differences) with three different assumptions about the nature of measurement error. The estimated values of α_S range from 0.587 to 2.606, with a mean of 1.11.

delayed effect must be added to the immediate contribution of attainment to productivity through the level effect, which stands at 6.2% for the average EU country.[24]

c. Results

Figure 6 shows two alternative estimates of the social rate of return to schooling *(r_s)* in our sample of EU member countries. Both sets of figures are all-in estimates that take into account rate effects (using our baseline estimate of 0.20% for γ) and induced changes in employment and correct for differential student employment probabilities. The only difference between them has to do with the assumed value of the level effects parameter *(α_S)*, which is corrected for measurement error bias in one case (labeled *baseline* in the figure) but not in the other *(min)*.

Figure 6: Social rate of return to schooling in the EU



According to my baseline estimates, the social rate of return to schooling in the EU ranges from 8.3% in Finland to 11.5% in Portugal, with an average value of 9.7%. Under the more pessimistic *(min)* assumption on the size of the level effects, the average return drops to 7.75% and the lowest value of r_s to 6.5%. Under both assumptions, estimated returns to human capital are highest in the cohesion countries and the UK, and lowest in the Scandinavian and German-speaking countries.

Table 9 gives the normalized values of the baseline estimate of r_s and of its various cost and benefit components (see equation (12) in section 2b). As in the case of the private rate of

24 Notice that the values of the productivity parameters used here are somewhat different from those assumed in our previous report. My new baseline estimates are based on the final results of de la Fuente and Doménech (2002), which was still in progress when D&C (2002) was completed and differ from the previous ones mostly because an improved correction for measurement error bias has raised my estimate of the level parameters. Since this reduces the unexplained or TFP component of cross-country productivity disparities, our original estimate of the rate effects parameter has been reduced to keep human capital's contribution to TFP differences within prudent bounds. When these parameters are translated into the long-term contributions to output growth of an additional year of schooling, the total figure drops somewhat (from 5 + 5 = 10% to 6.2 + 3.1 = 9.3%). Because most of the impact is now immediate, however, the estimated social rate of return to schooling will tend to be higher than under our earlier parameter estimates, as will be seen in the next section.

return, productivity effects and opportunity costs are the dominant determinants of the social rate of return to schooling. In the average country, level effects on productivity *(ρ)* account for 65% of the total benefits of schooling and rate effects *(EXT)* for an additional 20%, while opportunity costs *(OPPC)* make up almost 90% of total costs.

Table 9: Social rate of return to schooling (baseline estimate) and its components, normalized values

	r_p	*NUM*	ρ	*EXT*	ε	*DENOM*	*OPPC*	*DIRC*
Portugal	116.3	121.4	96.7	17.7	6.9	103.4	90.0	***13.4***
Ireland	***115.5***	109.7	65.9	17.8	**26.0**	94.1	***83.8***	10.3
Spain	115.3	119.6	87.3	17.9	14.4	102.8	91.9	11.0
Greece	107.8	110.6	78.4	18.7	13.6	102.5	93.2	9.3
UK	107.5	103.7	58.9	18.7	26.0	96.0	83.8	12.2
Italy	103.9	109.3	77.1	19.1	13.1	105.1	94.5	***10.6***
Netherlands	102.5	97.8	56.6	19.3	21.9	94.5	82.4	12.1
Belgium	94.0	98.0	61.5	20.4	16.1	103.6	92.3	11.3
France	91.0	95.9	59.3	20.8	15.8	105.5	91.7	13.9
Denmark	90.6	82.9	52.9	20.8	9.2	92.1	78.0	14.1
Sweden	89.5	92.6	58.4	21.0	13.2	104.8	89.5	15.3
Germany	88.8	86.4	47.9	21.1	17.4	97.0	83.0	14.0
Austria	***88.5***	88.3	54.8	21.1	12.4	99.4	***83.0***	***16.3***
Finland	87.1	85.4	56.5	21.3	7.5	98.2	87.0	11.2
avge. EU14	*100.0*	*100.0*	*65.2*	*19.6*	*15.2*	*100.0*	*87.4*	*12.6*

- *Note:* entries in bold or bold italics are based on incomplete information. See the text, Appendix 1 and the notes to Table 10 for further details.

Table 10: Net social rates of return to schooling under different scenarios

	level effects		*+ empl. eff.*		*+ rate effects*		*+ diffstE corr.*	
	min	*baseline*	*min*	*baseline*	*min*	*baseline*	*min*	*baseline*
Austria	3.46%	5.95%	5.22%	7.45%	7.22%	9.04%	***6.73%***	***8.45%***
Belgium	4.44%	7.18%	6.66%	9.11%	8.47%	10.57%	7.22%	9.06%
Denmark	3.65%	6.04%	4.98%	7.17%	7.04%	8.81%	6.89%	8.63%
Finland	4.10%	6.66%	5.19%	7.59%	7.28%	9.23%	6.51%	8.30%
France	4.23%	6.81%	6.35%	8.65%	8.14%	10.10%	7.03%	8.76%
Germany	2.87%	5.24%	5.46%	7.44%	7.45%	9.07%	6.93%	8.46%
Greece	6.54%	9.58%	8.18%	11.09%	9.73%	12.35%	8.32%	10.55%
Ireland	5.34%	8.04%	***8.55%***	***10.96%***	***10.04%***	***12.22%***	***9.31%***	***11.33%***
Italy	6.25%	9.27%	7.85%	10.72%	9.43%	11.99%	7.97%	10.15%
Netherlands	3.92%	6.52%	6.93%	9.15%	8.67%	10.58%	8.13%	9.93%
Portugal	7.70%	11.13%	8.47%	11.85%	9.92%	13.00%	8.75%	11.46%
Spain	7.12%	10.39%	8.79%	11.94%	10.25%	13.11%	8.87%	11.34%
Sweden	4.30%	6.74%	6.01%	8.23%	7.81%	9.69%	6.91%	8.60%
UK	4.47%	7.00%	7.78%	9.96%	9.35%	11.29%	8.68%	10.48%
avge. EU14	*4.97%*	*7.68%*	*6.94%*	*9.41%*	*8.64%*	*10.79%*	*7.75%*	*9.70%*

- *Note:* Bold italics indicate estimates based on incomplete data (whose impact on the estimated rate of return is not likely to be very large). The values of η in Austria and Ireland are assumed to be the same as those for Germany and the UK respectively. The value of ε in Ireland is assumed to be the same as in the UK.

As in the previous section, it will be convenient to recalculate the rate of return to schooling under a variety of assumptions or scenarios in order to isolate the contribution of different factors to this return and to check the sensitivity of the results to various assumptions. Using the two alternative assumptions about the size of level effects discussed above, I will construct *baseline* and *min* estimates of the return to schooling under four different scenarios. The first one *(level)* considers only the direct level effects of human capital on average productivity. In the second one *(employment)*, I introduce employment effects and in the third one *(rate)* I add rate effects under the assumption that $\gamma = 0.20\%$. In these three scenarios I assume that $\eta = 1$ (i.e. that the probability of employment for young people is the same in and out of school). In the last scenario *(OBS)*, which corresponds to Figure 6, I use the estimated value of η to correct for the low participation and employment rates of students in many countries (*diffstE* correction).

Table 10 shows the results of the calculations. As noted above, the bulk of the return to human capital can be traced back to its direct (level) effects on productivity. Considering only this factor, the baseline estimate of r_s goes from 5.95% in Austria to 11.13% in Portugal with a sample average of 7.68%. For the average country, the sequential introduction of employment and rate effects adds 1.73 and 1.38 percentage points respectively to the baseline returns arising from level effects, and the correction for differential student employment probabilities lowers the average value of r_s by 1.09 points. Employment effects add over two points to the rate of return in the UK, Netherlands and Germany (as well as in Ireland, under the assumption that the relevant parameter is the same as in the UK), and the student correction is largest in the Mediterranean countries.

d. The relative returns to investment in schooling and in physical capital

Table 11 compares the estimated social return to schooling (using the baseline estimates under the last, all-in scenario) with two alternative estimates of the return to physical capital (r_k). The "direct" estimate of the rate of return on physical capital shown in the second column of the table is calculated as $r_k = MP_k - \delta + g$ where MP_k is the marginal product of this factor, δ the rate of depreciation and g the rate of technical progress.[25] My estimate of MP_k is the marginal product of capital in 1990 computed using the production function estimated in de la Fuente and Doménech (2002) and the data used by these authors, which includes an estimate of the stock of physical capital. I assume a depreciation rate of 5% and a value of g of 1.5% (as in the calculations of the rate of return to education).

[25] This formula comes out of a calculation analogous to the one described in section 2, which is much simpler in the case of physical capital because of the absence of delays and rate effects.

Table 11: Net social rate of return on schooling vs. real return on physical capital

	r_s *schooling*	*max* r_k *(direct)*	*baseline* r_k *(adjusted)*
Austria	***8.45%***	9.68%	7.27%
Belgium	9.06%	9.94%	7.46%
Denmark	8.63%	6.76%	5.08%
Finland	8.30%	5.78%	4.34%
France	8.76%	9.54%	7.16%
Germany	8.46%	8.46%	6.35%
Greece	10.55%	9.50%	7.14%
Ireland	***11.33%***	11.43%	8.58%
Italy	10.15%	8.65%	6.50%
Netherlands	9.93%	9.30%	6.99%
Portugal	11.46%	12.90%	9.69%
Spain	11.34%	11.29%	8.48%
Sweden	8.60%	8.59%	6.45%
UK	10.48%	12.64%	9.49%
average	*9.70%*	*9.60%*	*7.21%*

In Section 7 of the Appendix I compare these estimates with those taken from other sources that make use of national accounts data on capital income and alternative estimates of the stock of capital. On the basis of this discussion, I conclude that my direct estimates of r_k are likely to be biased upward and construct an alternative or adjusted estimate that I will use as a baseline. This series, which is denoted by r_k *adjusted* in Table 11, is constructed by multiplying the previous one by a correction factor that is the ratio of my direct estimate of r_k for the US (not shown in the table) and Poterba's (1997) estimate of the average rate of return on corporate capital, which is in turn based on revised BEA data.

Figure 7 summarizes the information in Tables 10 and 11 for the case of the average EU country. If we exclude the lowest bound scenario (my *min* estimate when only level effects are considered), my calculations suggest that the economic returns on human capital are probably higher than those on physical capital, as the most comprehensive baseline estimate of the rate of return to schooling is 2.5 points higher than my best estimate of the rate of return on physical capital and lies a bit above my upper bound ("direct" estimate) for this magnitude.

Figure 8 shows the situation in each of the countries in the sample. It displays the *social premium on human capital*, defined as he difference between my baseline all-in estimate of the social rate of return to schooling and each of the alternative estimates of the return to physical capital. In all cases, my baseline estimate of the social premium on human capital is positive, suggesting that human capital should be favoured over physical capital as an investment alternative. This continues to be the case for half the countries in the sample when I use as a reference the upper bound on the rate of return on physical capital. Under this "pessimistic" assumption, the return on physical capital would clearly exceed that on human capital in the UK, Portugal, Austria, Belgium and France.

Figure 7: Social rate of return to schooling under different scenarios and returns on physical capital in the average EU country

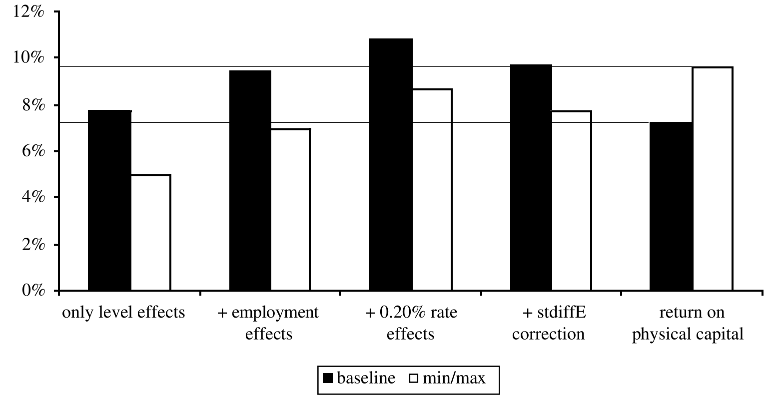
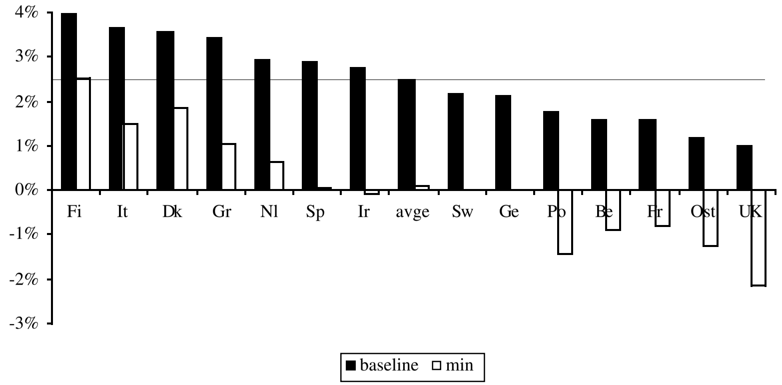


Figure 8: Social premium on human capital



5. Comparing private and public returns and implications for the financing of education

Comparisons between the private and social rates of return to schooling are potentially of considerable interest because they can alert us to discrepancies between social priorities and private incentives that may call for corrective policy action. For instance, the finding that the return to education is higher at the social than at the individual level may be interpreted as an indication that existing educational subsidies and other policy measures such as compulsory schooling laws have been insufficient to fully correct for the externalities

associated with educational investment. Hence, additional public resources may be needed to bring private incentives back in line with social returns and to raise investment in education to its socially optimal level.

Such comparisons, however, must be made with extreme care for a number of reasons. The first one is that, as I have emphasized repeatedly, there is considerable uncertainty regarding the values of practically all the relevant variables. Part of this uncertainty can be traced back to incomplete or imperfect data and to statistical and specification problems that may yield biased estimates of some key parameters. Second, it should be kept in mind that, even abstracting from these problems, the private and social rates of return to schooling presented in previous sections measure different things. One minor difference, which will be corrected shortly, is that the private returns I have calculated are conditional on labour force participation while social returns are not. A more important difference is that the private returns calculated above capture the financial rewards available to an individual acting alone (i.e. in "partial equilibrium"), while the social rates of return measure the payoff to a marginal increase in average schooling at the aggregate level (in "general equilibrium"). Hence, private rates of return implicitly hold constant factor prices and the economy-wide average level of education, whereas social rates of return allow for changes in these variables but hold the aggregate stock of physical capital constant. While it is not difficult to adjust private returns for general equilibrium effects,[26] it is not entirely clear whether social rates of return should be compared to raw or to adjusted private returns in order to asses the potential misalignment between private incentives and social needs.

A third problem is that wage scales may not exactly reflect marginal productivities because of distortions introduced by labour market institutions. In societies with a high aversion to inequality, for instance, collective bargaining may lead to relatively flat payscales ("wage compression"). This will reduce private incentives to invest in education, thereby increasing the wedge between the social and private returns to schooling in the same way as positive externalities, and may call for educational subsidies as a second-best remedial measure.

A final consideration is that a straightforward comparison between the private and social rates of return to schooling may not be very informative in a world in which the externalities associated with educational investment are not the only distortion that may affect the allocation of investment across alternative assets. Such a comparison implicitly assumes that agents get the full social marginal product when they invest in assets other than schooling. For most individuals, however, the relevant alternative to schooling investment involves standard financial assets, and our data suggest that the returns on these claims are considerably lower than the marginal social product of capital, probably as a result of

26 Under reasonable assumptions, the required correction involves reducing the microeconomic Mincerian returns parameter, θ, by around one third. See footnote 22 and section 8 of the Appendix.

intermediation costs and capital taxes. Hence, the wedge between the private and social returns to human capital may be matched by similar distortions affecting other types of investment and it may be expected that, to a first approximation, these different distortions will tend to offset each other. This suggests that, for purposes of determining whether market signals are channeling resources to the most socially desirable investment alternatives, the more relevant comparison will be the one between what I have called above the social and private *premia* on schooling, rather than between the social and private returns to education per se.

In the remainder of this section I will carry out both sets of comparisons in an attempt to draw some tentative conclusions regarding the adequacy of observed educational subsidy rates. I will start by constructing two new sets of estimates of the private rate of return that are more directly comparable to social returns than those presented above. Then, I will examine the difference between the private and social premia on schooling.

a. Private returns allowing for participation effects in partial and in general equilibrium

As I have already noted, the estimates of the private and social rates of return to schooling presented in previous sections are not fully comparable because they are based on different assumptions concerning labour force participation. In particular, the private return calculations assumed that the agent of reference would remain active throughout his student and adult life, while the social return calculations applied to a representative individual who may or may not be active with probabilities based on observed labour force participation rates. To make both sets of returns more comparable, in this section I will construct estimates of the private rate of return to schooling that will be based on the same participation assumption as the social returns presented above. I will consider an agent who does not yet know whether or not he or she will be active in the future and assume that the relevant probabilities are given by the observed labour force participation rates.

As described in Box 2, this change in assumptions requires three adjustments in the private rate of return formula. The first of these adjustments tends to raise the rate of return and takes the form of an additional term in the numerator (ε_{part}) that captures the positive effect of additional schooling on expected earnings acting through an increase in the activity rate. The other two adjustments involve the cost terms in the denominator of the rate of return formula and tend to reduce its value. Allowing for the possibility of inactivity increases the direct cost of schooling, which is measured as a fraction of the expected earnings of an adult worker, because the denominator of this ratio drops whenever the participation rate is less than one. Intuitively, direct costs become more important because they are incurred in any event but generate a positive revenue stream only if the agent joins the labour force. The opportunity cost of schooling, *1-B*, also rises if $\eta_q < 1$, that is, whenever activity rates are lower for

Box 2: Allowing for participation effects

It will be useful to go back to the private rate of return formula given in equation (9) and write the opportunity cost term in the form *OPPC = 1 - B*. With this notational change, the equation takes the following form:

$$(9') \quad \frac{R}{1-e^{-RH}} = \frac{\theta_{net} + \varepsilon_{net}}{(1-B) + DIRC}$$

where all the terms have been defined in section 2a.

Consider now how the calculations described above change from the point of view of an individual who does not yet know whether he will be active in the future. I will use $q(S)$ and $q_S(S) = \eta_q q(S)$ for the labour force participation rates of adult workers and students, respectively, and assume that these rates are increasing functions of educational attainment. The agent's expected income both as an adult worker and as a student can be obtained by multiplying the expressions derived in section 2a (equations (2) and (3)) by the relevant participation probabilities, given by $q(S)$ and $q_S(S)$. It is easy to show that, under these assumptions, the rate of return formula becomes

$$(9'') \quad \frac{R}{1-e^{-RH}} = \frac{\theta_{net} + \varepsilon_{net} + \varepsilon_{part}}{(1-\eta_q B) + \dfrac{DIRC}{q(S_o)}}$$

where $\varepsilon_{part} = q'(S_o)/q(S_o)$ measures the sensitivity of the labour force participation rate to educational attainment.

For the calculations reported below ε_{part} and η_q have been estimated with the same data and following the same procedure I have used above for calculating ε and η (see section 3 of the Appendix). Due to the lack of information, I assign to Ireland the British values of both variables, and to Austria the German value of η_q.

Table 12: New variables used in the calculation of the private rate of return allowing for participation effects

	q	η_q	ε_{part} *part. eq.*	ε_{part} *gen. eq.*
Austria	87.94%	**0.550**	1.87%	0.94%
Belgium	85.54%	0.149	2.23%	1.12%
Denmark	91.04%	0.948	1.37%	0.69%
Finland	90.27%	0.607	0.68%	0.34%
France	88.11%	0.119	1.80%	0.90%
Germany	87.66%	0.550	2.25%	1.13%
Greece	80.16%	0.117	2.19%	1.10%
Ireland	78.03%	**0.578**	**4.13%**	**2.07%**
Italy	78.94%	0.051	2.23%	1.12%
Netherlands	84.80%	0.677	3.88%	1.94%
Portugal	86.52%	0.272	1.28%	0.64%
Spain	79.68%	0.227	2.05%	1.03%
Sweden	88.81%	0.353	1.96%	0.98%
UK	85.38%	0.578	4.13%	2.07%
avge. EU14	*85.20%*	*0.413*	*2.29%*	*1.15%*

students than for adults, because the participation correction reduces expected student earnings by more than those of adult workers, thereby lowering *B*.

Table 12 displays the values of the new variables used in the rate of return calculation, including two different estimates of ε_{part} (one in partial and one in general equilibrium) whose use will become clear below. Column [2] of Table 13 shows the partial equilibrium estimates of the private rate of return to schooling obtained under the new participation assumptions, while column [1] reproduces my previous estimates from section 3b. Notice that, since participation rates are generally quite sensitive to attainment, for most countries the effect of the correction is to increase the estimated rate of return.

Table 13: Alternative estimates of the private rate of return to schooling

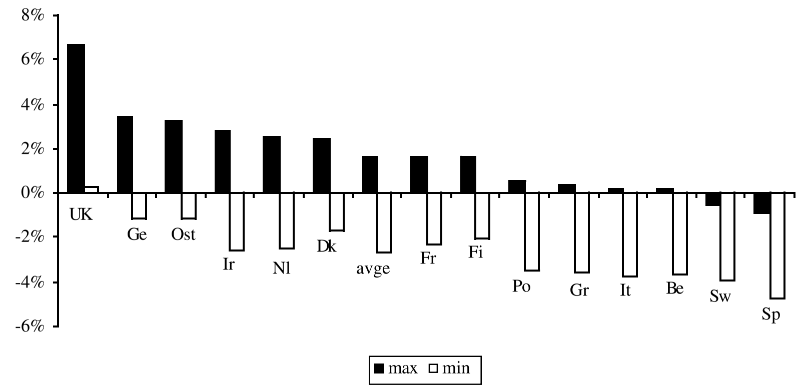
	[1]	[2]	[3]	[4]
	r_p section 3b	r_p part. eq	r_p gen. eq.	r_s social
Austria	***10.50%***	***11.72%***	***7.31%***	***8.45%***
Belgium	**8.56%**	**9.27%**	**5.38%**	9.06%
Denmark	8.87%	11.03%	6.92%	8.63%
Finland	9.62%	9.88%	6.24%	8.30%
France	***9.59%***	***10.36%***	***6.41%***	8.76%
Germany	10.43%	11.89%	7.31%	8.46%
Greece	9.81%	10.95%	6.95%	10.55%
Ireland	***10.41%***	***14.17%***	***8.72%***	***11.33%***
Italy	8.61%	10.37%	6.43%	10.15%
Netherlands	7.95%	12.49%	7.42%	9.93%
Portugal	12.29%	12.05%	7.94%	11.46%
Spain	9.36%	10.46%	6.61%	11.34%
Sweden	6.06%	8.07%	4.68%	8.60%
UK	13.87%	17.10%	10.76%	10.48%
avge. EU14	*9.75%*	*11.30%*	*7.04%*	*9.70%*
cond. on particip.	yes	no	no	no

Column [3] of Table 13 contains a set of "general equilibrium" estimates of the private return to schooling under the same participation assumptions used in column [2] for the "partial equilibrium" calculations. To obtain the general equilibrium estimates, I have scaled down the microeconomic Mincerian returns parameters by a factor of $1-\alpha_k$ so as to hold the stock of capital constant (see footnote 22 and section 8 of the Appendix), and reduced the estimates of the employment and participation parameters ε and ε_{part} used in column [2] by 50% (which is the same correction factor used in the calculation of the social rate of return). Notice that these adjustments substantially reduces the estimated rate of return to schooling. This difference reflects the fact that the payoff to increased attainment is considerably larger for an individual acting alone than for society as a whole, essentially because factor

prices will remain constant in the first case, giving the agent access to complementary inputs whose use will raise the return to educational investment.

A comparison between private and social returns can potentially tell us to what extent private and social incentives may be misaligned in Europe. One problem is that it is not entirely clear what specific rates of return should be used in the comparison. It may be argued that private incentives are best captured by the unadjusted or partial equilibrium private rates of return given in column [2] of Table 13, as these reflect the expected benefits that are available to individuals. But it is also true that these expected benefits will partially fail to materialize if aggregate attainment rises as a sufficient number of individuals stay longer in school. Hence, it is probably best to take columns [2] and [3] of Table 13 as defining an interval of potentially relevant rates of return for each country that should be compared with the social rate of return given in column [4] of the same table.

Figure 9: Difference between the private and social rates of return on schooling



- *Note:* Referring to Table 13, *max* is given by [2] - [4] and *min* by [3]- [4].

Figure 9 shows the difference between the private and social rates of return on schooling using both the partial and general equilibrium estimates of the first magnitude. When this variable is positive, private returns exceed social returns and, assuming there are no distortions in the economy aside from those that affect educational investment, we may conclude that existing educational subsidies should be reduced, for they more than compensate for the relevant externalities and for the disincentives created by wage compression.

Inspection of Figure 9 suggests a classification of EU countries into five different groups. The UK is the only country where both measures of private returns exceed the social return on schooling, suggesting that observed subsidy levels are higher than required. Spain and Sweden are in the opposite situation, with private returns clearly below social returns according to both estimates of the first variable. A fairly clear case for cutting subsidies can be made for Germany, Austria and Denmark, and the opposite is true in Italy, Greece and Portugal. In the remaining countries (Ireland, Netherlands, France and Finland, as well as in Belgium due to data limitations), the results are inconclusive as the two estimates of private returns yield very different implications about the optimality of observed net subsidy levels.

b. Private vs. social premia on schooling

I have argued that a comparison between the private and social premia on schooling is likely to be more informative than the one carried out in the previous section for purposes of identifiying potential discrepancies between market signals and social needs. Table 14 contains the information required for this comparison.[27] Its left-hand block shows the social premium on schooling as calculated in section 4 together with two alternative estimates of the private premium. The first one (labeled *private 1* in the table) is based on the partial equilibrium results obtained in Section 3d (see Table 5), and the second one corresponds to the general equilibrium calculations carried out in the previous subsection (column [3] in Table 12). The right-hand block of the table shows the ratio between the private and social premia, using both estimates of the first variable, and the average value of this ratio for each country.

For the average country, both estimates of the private to social premium ratio (hereater the premium ratio) are greater than one and their mean value is 1.76. This result suggests that, for the average European country, market signals and existing public interventions do reflect the relative scarcity of human capital and provide incentives for additional investment in schooling that appear to be more than correct. In fact, and with all due caution, this result suggests that educational subsidies should probably be reduced. The case for cutting subsidies appears to be quite strong in the UK (with an average premium ratio exceeding 8), and also in Austria, Portugal, Ireland and Spain (all of which have premium ratios over two). At the other end of the scale, the pemium ratio drops below one in the Scandinavian countries, and especially in Sweden where large subsidies appear to be required in order to compensate for the disincentive effects created by particularly flat payscales.

27 One factor that may distort this comparison is that, as noted in section 2, my estimates of social returns (and hence of the social premium) are likely to be biased against countries with educational systems of high quality. While there is no generally accepted measure of educational quality, the results of the standardized tests of student achievement conducted as part of the PISA project suggest that Finland, the UK and Ireland perform significantly above the OECD average (in terms of mean scores), while Portugal, Greece, Italy, Germany and Spain display below-average performance.

Table 14: social vs. private premium on schooling

	premium on schooling			ratio private/social premium		
	social	*private1*	*private2*	*ratio 1*	*ratio 2*	*avge.*
UK	0.99%	9.87%	6.76%	10.00	6.85	8.43
Austria	***1.18%***	**6.47%**	**3.28%**	5.48	2.78	4.13
Portugal	1.77%	**8.26%**	**3.91%**	4.66	2.20	3.43
Ireland	***2.75%***	***6.81%***	***5.12%***	2.48	1.86	2.17
Spain	2.87%	7.56%	4.81%	2.64	1.68	2.16
Belgium	1.59%	**4.36%**	**1.18%**	2.74	0.74	1.74
France	1.59%	***3.89%***	***0.71%***	2.44	0.45	1.44
Netherlands	2.94%	4.35%	3.82%	1.48	1.30	1.39
Italy	3.65%	6.06%	3.88%	1.66	1.06	1.36
Greece	3.42%	**5.77%**	**2.92%**	1.69	0.85	1.27
Germany	2.11%	3.98%	0.86%	1.88	0.41	1.15
Finland	3.96%	**5.58%**	**2.21%**	1.41	0.56	0.99
Denmark	3.55%	4.47%	2.52%	1.26	0.71	0.98
Sweden	2.14%	2.11%	0.73%	0.98	0.34	0.66
avge. EU14	*2.49%*	*5.72%*	*3.01%*	*2.30*	*1.21*	*1.76*

Notes:
- The social premium on human capital is defined as the difference between the baseline all-in estimate of the social rate of return to schooling and the baseline (adjusted) estimate of the social rate of return on human capital.
- The private premium on human capital is constructed as the difference between the estimated private rate of return on schooling and the real return on an equal-weight portfolio of shares and government bonds. As noted above, this last piece of information is not available for Austria, Finland, Greece and Portugal, so I have imputed them the average return over the rest of the sample. As a result, the private premia for these countries are shown in bold type.

6. Conclusion and policy implications

The results obtained in this study tend to confirm and strengthen the main conclusion of our previous report (D&C, 2002). I find that i) educational attainment is a key determinant of individual earnings and aggregate productivity and has a significant effect on labour market outcomes and ii) that human capital appears as an attractive investment relative to alternative assets, both from the individual and from the aggregate perspectives.

Drawing on recent results from D&D (2002) and other papers in the literature, I estimate that an additional year of average school attainment raises productivity in the average EU country by 6.2% on impact and by a further 3.1% in the long run through its contribution to faster technological progress. The first of these effects is considerably higher in the cohesion countries and in Italy, reaching 9.2% in the case of Portugal, and drops to around 5% in the Scandinavian and German-speaking countries. Productivity effects account for the bulk of the social returns to human capital (85% of the total in the case of the average country) and the remainder reflects induced increases in participation and employment rates.

The social rate of return to schooling in the EU ranges from 8.3% in Finland to 11.5% in Portugal, with an average value of 9.7%. For all the countries in the sample, the social return on human capital is higher than my preferred estimate of the return to physical capital, suggesting that a marginal reallocation of investment resources in favour of human capital would be desirable from a social point of view. The social premium on human capital, however, varies significantly across member states reflecting the relative endowments of production factors and appears to be largest in Finland, Italy, Denmark, Greece, the Netherlands, Spain and Ireland, and smallest in the UK, Austria, France, Belgium and Portugal.

Private returns to schooling cluster between 8 and 10% for most European countries. 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 Portugal, followed by Austria, Germany and Ireland. Private rates of return on schooling are heavily influenced by various government policies. On average, direct subsidies to education raise the private rate of return by around a third while personal taxes and social benefits reduce it by 10 and 8% respectively. In most countries, the combined effect of all these policies is a net subsidy to education. This subsidy exceeds 30% in Sweden, Portugal and Denmark and has an average value of 10%. The only countries where the net tax on schooling is positive are Ireland and Germany, with effective tax rates of 15% and 4% respectively.

At the individual level, schooling seems to be a more attractive investment than the financial assets available to households. Taking as a reference a balanced portfolio of corporate shares and government bonds, the private premium on human capital ranges from 2.11% in Sweden to 9.87% in the UK and has an average value of 5.72%. For most countries, the private premium on schooling is significantly larger than the social one, suggesting that the combination of market forces and existing subsidies already provides more than sufficient financial incentives for individuals to modify their investment patterns in ways that are consistent with social needs. The only exception appear to be the Scandinavian countries, where larger subsidies may be required to fully offset the disincentives created by rather flat payscales thay may not adequately capture education-induced productivity gains.

Although caution is clearly needed for a number of reasons that have already been discussed, I believe these results reinforce the two main policy conclusions drawn in D&C (2002): First, that a modest increase in educational investment would almost certainly be beneficial from a social point of view in all EU countries. And second, that an increase in general subsidies for post-compulsory schooling would probably not be required to achieve this goal in most European countries.

The first of these conclusions follows essentially from a comparison between the estimated social rates of return on physical and human capital. My results suggest that the economic returns to schooling investment are at least comparable to, and very likely significanly

higher than, those available from investment in physical capital. When a reasonable allowance is made for the non-market returns to education and for its benefits for social cohesion and for personal development, human capital appears as a rather attractive investment alternative from a social point of view for all the countries in the sample.

It must be kept in mind, however, that the data underlying my social return calculations refer to 1990, and that much of the required investment in education is probably under way already, as schooling levels for young cohorts are considerably higher than population means in all EU countries. Hence, average attainment will rise sharply in the near future even without any changes in current policies. While it is impossible to know at this stage whether the social premium on human capital will remain positive in the future, the acceleration of the pace of technological change in recent decades and the secular trend towards an increasingly knowledge-intensive economy do make it likely that human capital will continue to be a strategic production factor, and hence an attractive investment alternative, over the foreseeable future.[28]

Strictly speaking, all the results derived above refer to the returns to a marginal increase in the *quantity* of education. There is still considerable room for improvement in this area, particularly in some of the poorer countries and regions of the Union, where enrollment in upper secondary training is still far from universal and tertiary accession rates remain relatively low. But there can be little doubt that in the long run the more relevant policy margin has to do with the *quality* of education, rather than with its quantity, as we must eventually run into sharply diminishing returns to futher increases in attainment. One reason for this is that, given the finiteness of human lives, longer schooling periods will eventually cease to pay off, as they imply increasingly shorter working lives over which to recoup the required investment. A second reason is that the marginal cost of human capital, unlike that of physical assets, rises with the accumulated per capita stock because of its opportunity cost component.

Turning now to the implications of the analysis for educational finance, my conclusion regarding subsidy levels is based both on the large private premium on schooling and on the fact that this premium generally exceeds its social counterpart. These findings suggest that the financial returns to investment in education reflect social needs more than adequately and that they are high enough that it is unlikely that insufficient pecuniary incentives can be a real obstacle to higher enrollment rates in most EU countries. I suspect that other factors (and in particular liquidity constraints and low levels of basic skills for individuals from disadvantaged backgrounds) are far more important as barriers to access to advanced programmes. Hence, policies specifically targeted at these problems should be more effective in raising upper-level enrollments than further decreases in already low tuition charges that

28 See section 2 of D&C (2002).

imply a large subsidy for relatively privileged groups.[29] Indeed, higher tuition fees, coupled with a well designed loan programme and with an increase in means-tested grants, may be an efficient way to provide additional resources to increase the quantity and quality of post-secondary education while at the same time reducing the regressivity of its financing, ensuring equal access opportunities regardless of socioeconomic background, and improving student motivation to take full advantage of educational opportunities.

[29] See for instance OECD (2001b).

APPENDIX

1. The direct costs of schooling

This section describes the construction of the direct cost of schooling variables (μ and μ_s). As noted in the text, these variables are weighted averages of total and private costs per student at the secondary and tertiary levels measured as a fraction of either output per employed worker or APW earnings. The primary data are taken from various recent issues of the OECD's *Education at a Glance* report, to which I 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

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). I 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 I use the second category. The main source is EAG 2000 (Table B2.1 with data for 1997). For this year, the data refer to initial sources of the relevant 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.

data refer mostly to 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, I 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 I 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, I use bold italics for this country in columns [3] and [4]. As in the text, I will use this type to identify results that are based on incomplete information when this is not expected to be asource of substantial errors, and plain bold type to identify results where the error caused by incomplete data is potentially important for the rate of return 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).[30] Since I am interested in the cost of education to households, I will treat enterprise contributions as public expenditure. As no specific figure is given for enterprise contributions, I 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]. 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 my implicit assumption that such transfers are zero is small.

[30] Thanks to L. Wössmann (2003) for pointing this out to me.

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 initial sources of the relevant 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 (our preliminary public expenditure figures already incorporate the "tuition" costs that are included in government expenditure on 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.

As usual, bold entries in the table indicate missing observations that have been estimated in various ways. I 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 fes when available. The bold entries in coumn [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 for Table A.3*

[5] EAG 2002 (Table B6.2 with data for tertiary education in 1999). Since no data are available for Austria, Italy and Portugal, I 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. I 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. I 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, I 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.

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*
Austria	***26.64%***	-6.06%	***32.70%***
Belgium	20.90%	-2.32%	23.22%
Denmark	21.10%	-17.13%	38.23%
Finland	22.54%	-6.11%	28.66%
France	28.68%	2.26%	26.42%
Germany	26.64%	-1.66%	28.30%
Greece	22.41%	-0.99%	23.40%
Ireland	32.61%	0.75%	31.86%
Italy	***21.25%***	2.31%	***18.94%***
Netherlands	27.33%	-6.43%	33.76%
Portugal	***21.64%***	-0.72%	***22.36%***
Spain	24.28%	5.90%	18.39%
Sweden	33.27%	-16.96%	50.23%
UK	25.62%	-2.12%	27.75%
avge. EU14	*25.35%*	*-3.52%*	*28.87%*

- *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]

c. Total expenditure

I 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 social rate of return calculations I will want to express total expenditure per student as a fraction of output per employed worker. Hence, I multiply the original figures shown in columns [1] by the ratio of employment to the total population in 1990, taken from an updated version of Doménech and Boscá (1996), which is shown in column [4]. For the private rate of return calculations, the appropriate denominator is the gross earnings of an average production worker (APW). The adjustment factor is therefore the ratio between GDP per capita and APW gross earnings, which is given 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 [3] are carried over from previous tables. The entry for Portugal in column [5] 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. This will have some effect on the private return calculations.

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] jobs per capita	[5] GDPpc/AP Wearngs
Austria	**32.88%**	-1.30%	***34.18%***	0.444	1.075
Belgium	26.30%	0.39%	25.91%	0.369	0.816
Denmark	25.70%	-5.34%	31.04%	0.507	0.832
Finland	24.18%	-1.94%	26.12%	0.410	0.947
France	30.23%	1.79%	28.44%	0.389	1.084
Germany	27.55%	0.01%	27.54%	0.436	0.773
Greece	20.14%	***0.91%***	***19.23%***	0.362	1.071
Ireland	23.54%	0.63%	22.91%	0.339	1.156
Italy	**26.42%**	0.77%	***25.65%***	0.352	0.957
Netherlands	24.44%	-1.53%	25.97%	0.438	0.876
Portugal	**26.55%**	-0.22%	***26.77%***	0.451	**1.488**
Spain	26.09%	4.13%	21.97%	0.313	0.983
Sweden	29.09%	-5.65%	34.74%	0.452	1.026
UK	23.87%	1.10%	22.77%	0.436	0.852
avge. EU14	*26.21%*	*-0.45%*	*26.66%*	*0.407*	*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.

2. Mincerian returns to schooling at the individual level

In this section I construct estimates of the individual-level Mincerian returns to schooling parameter in most EU countries. For this, I will rely on 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 recently sponsored by the European Commission.

In their introduction to a collective volume summarizing the results of the PURE project, Harmon, Walker and Westergaard-Nielsen (HW&W 2001) use data provided by the project's national teams to obtain estimates of the Mincerian returns parameter *(θ)* for men and women in each of a number of European countries around 1995. They estimate by OLS a common wage equation specification for all countries using data on hourly wages and controlling for potential experience (i.e. time since the completion of education) and the square of this variable. Their results are shown in columns [1] and [2] of Table A.6. Using these estimates I construct a measure of the average return to schooling for the entire population by weighting the male and female estimates by the corresponding shares in total employment (using data from the 2000 Labour Force Survey provided by Eurostat). This average is shown in column [4].

Table A.6: Harmon et al's results on the individual Mincerian returns to schooling and adjusted estimates

	[1] men	[2] women	[3] weight women	[4] weighted average	[5] adjusted estimate
*Austria**	6.9%	6.7%	0.437	6.81%	8.60%
*Belgium ***			0.422		**7.24%**
Denmark	6.4%	4.9%	0.463	5.71%	5.71%
Finland	8.6%	8.8%	0.474	8.69%	8.69%
France	7.5%	8.1%	0.450	7.77%	7.77%
Germany	7.9%	9.8%	0.435	8.73%	8.73%
*Greece**	6.3%	8.6%	0.376	7.16%	8.21%
Ireland	9.0%	13.7%	0.404	10.90%	10.90%
*Italy**	6.2%	7.7%	0.365	6.75%	7.90%
*Netherlands**	6.3%	5.1%	0.419	5.80%	6.70%
Portugal	9.7%	9.7%	0.457	9.70%	9.70%
*Spain**	7.2%	8.4%	0.361	7.63%	8.23%
Sweden	4.1%	3.8%	0.481	3.96%	3.96%
UK	9.4%	11.5%	0.446	10.34%	10.34%
average	*7.3%*	*8.2%*	*0.428*	*7.69%*	*8.05%*

Notes:
(*) Original estimates are based on data on net (rather than gross) wages.
(**) Harmon et al report no results for Belgium. The value shown in column [5] for this country is the average of the French and Dutch estimates.

One problem with Harmon et al's estimates is that they are not entirely comparable across countries. The authors report that their estimates are based on data on gross wages except in the cases of Austria, Greece, Italy, Netherlands and Spain, where the data refer to net wages (i.e. wages after personal income taxes and employee social security contributions have been witheld). Hence, for some countries we have a measure of the before-tax Mincerian return and for the rest an indicator of the after-tax return, which will be lower if the witholding rate rises with income.

I have attempted to correct this problem by constructing estimates of the gross (before-tax) return to schooling for the relevant countries (shown with an asterisk in Table A.6) in the manner explained below. These adjusted figures replace Harmon et al's estimates in column [5], where I show the values that were finally used in the rate of return calculations reported in the text. Notice that his column includes an entry for Belgium even though Harmon et al report no results for this country.[31] This value is obtained as the average of the estimates for France and Holland. Hence, my results for Belgium should be interpreted with extreme caution and are included in the report only because they contain information of interest about

31 In fact, I have been unable to locate any estimates of the Mincerian parameter for Belgium, even in a recent and rather comprehensive compilation of results due to Psacharopoulos and Patrinos (2002).

the effects of educational subsidies, taxes and social benefits on private returns to schooling in this country.

The adjusted estimates of the Mincerian returns parameter have been constructed as follows. In two cases (Netherlands and Spain), I have found in the corresponding country chapters of the PURE volume estimates of male and female returns to schooling based on gross wages for 1995 or nearby years that are obtained with a specification similar (but not identical) to the one used by Harmon et al. The Dutch estimate is taken from Smits et al (2001, p. 183, Table 10.3 for 1996). The specification used by these authors (unlike Harmon et al's) includes a dummy for part-time workers in the female equation, but its estimated coefficient is zero. The Spanish estimate is taken from Barceinas et al (2001, p. 238, Table 13.1, results for WSS-95). In this case, the female sample is restricted to full-time workers. In the case of Italy, the country chapter provides comparable estimates based on both net and gross wages in 1989 (Brunello et al, 1991, p. 162, Table 9.3). Since the net returns are very different from those reported by Harmon et al for 1995, I cannot use the net estimate directly, but I use the ratio of net to gross returns in 1989 (0.833 for men and 0.885 for women) to adjust the 1995 net returns.

For Austria and Greece, I could not find sufficient data in the country chapters to carry out a similar adjustment so I have based the correction on the theoretical relationship between net and gross returns and on OECD data on average and marginal tax rates on labour income. The procedure is as follows. Let $f(S)$ be the gross wage rate written as a function of years of schooling, S. Then, the net or after-tax wage rate is given by

$$(1)\ F(S) = f(S) - T[f(s)] = (1-\tau)f(S)$$

where $T(y)$ is the total tax due on income y (which I assume coincides with the tax witheld at pay time) and

$$(2)\ \tau = T[f(S)]/f(S)$$

is the average tax rate. We are interested in the relationship between the gross returns to schooling $\theta = f'(S)/f(S)$ and the net returns, $\theta_n = F'(S)/F(S)$. Notice that

$$(3)\ \theta_n = \frac{F'(S)}{F(S)} = \frac{(1-T')f'(S)}{(1-\tau)f(S)} = \frac{1-T'}{1-\tau}\theta$$

where T' is the marginal tax rate. I have used this formula to estimate the gross return to schooling given Harmon et al'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*. 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.

3. Employment probabilities and employment effects of schooling

It is well documented that increased educational attainment goes hand in had with greater rates of labour force participation (particularly in the female population) and lower unemployment rates. Both of these effects will in turn increase lifetime income and raise the expected return on schooling above the level implied by wage regressions that use samples of employed workers. Although there are some attempts in the literature to incorporate these effects into calculations of the rate of return to schooling (see for instance Barceinas et al (2001) and the references therein), I have not found a set of homogeneous estimates of the relevant parameters for EU countries that can be used to make the required adjustments. To fill in this gap and try to get some feeling for the potential impact of these factors, in this section I report a (rather crude) estimate of the impact of schooling on the probability of employment using data from the Spring 2000 Labour Force Survey provided by Eurostat.

Table A.7: Probability of employment by attainment level population 35-44

	*total = (1-u)*LFPR*			*conditional on partic. = 1-u*		
	low	*medium*	*high*	*low*	*medium*	*high*
Austria	71.5%	86.7%	91.9%	92.8%	96.9%	97.5%
Belgium	70.1%	83.8%	91.6%	90.8%	95.3%	98.0%
Germany	67.0%	81.9%	90.5%	87.1%	92.9%	96.5%
Denmark	77.5%	90.3%	92.3%	93.7%	96.2%	98.2%
Spain	62.3%	74.9%	86.8%	85.7%	89.0%	93.8%
Finland	76.7%	82.5%	89.9%	88.1%	91.6%	96.0%
France	70.0%	84.4%	89.1%	86.2%	92.7%	95.6%
Greece	66.8%	73.1%	90.6%	91.0%	91.3%	96.3%
Italy	63.7%	81.5%	92.1%	90.6%	94.6%	97.7%
Netherlands	71.4%	85.9%	91.7%	96.6%	98.0%	98.5%
Portugal	83.3%	91.4%	94.9%	97.0%	96.6%	97.8%
Sweden	73.5%	85.3%	90.4%	92.6%	94.5%	97.9%
UK	59.8%	84.1%	90.8%	91.0%	95.9%	98.2%
avge. EU14	70.3%	83.5%	91.0%	91.0%	94.3%	97.1%

- *Source*: Eurostat, Labour Force Survey, Spring 2000.
- The data refer to the population aged 35 to 44. The data for Ireland are not broken down by attainment categories.

For each EU country (with the exception of Ireland), Eurostat provides information on labour force participation and unemployment rates disaggregated by age group and by three levels of educational attainment (low, medium and high).[32] Table A.7 shows the "total" and conditional probabilities of employment for the population aged 35 to 44 implied by these data, broken down by three attainment levels (low, medium and high). The total probability

32 *Low* attainment includes primary and lower secondary education and elementary vocational training (ISCED levels 1 and 2); *medium* refers to higher secondary education and vocational programmes (ISCED 3 and 4); and *high* to post-secondary training (ISCED level 5 or higher).

of employment is defined as $(1-u)*LFPR$ where u is the unemployment rate and $LFPR$ the rate of labour force participation. The "conditional" probability of employment is simply $1-u$.

Table A.8 shows the cumulative years of schooling associated with each of the three attainment categories in the Eurostat data. I will used the data in these two tables to calculate the increase in the probability of employment associated with a one-year increase in educational attainment ($p'(S)$). Let $p(n)$ be the (total or conditional) probability of employment of the the population that has achieved the n-th attainment level (with n = 1, 2 or 3 for low, medium and high attainment) and $S(n)$ the cumulative years of schooling assigned to the same group. I calculate the marginal increase in the probability of employment brought about by moving from group n to $n+1$ by

$$d(n) = \frac{p(n+1) - p(n)}{S(n+1) - S(n)}$$

for n = 1 and 2. The desired variable, $p'(S)$ is then constructed as a weighted average of $d(1)$ and $d(2)$ with weights of 2/3 and 1/3 respectively. A (preliminary) estimate of ε is then obtained by dividing $p'(S)$ by the average probability of employment in the entire (35 to 44) population, $p(S)$.

Table A.8: Cumulative years of schooling for each educational level

	low	*medium*	*high*
Austria	9	13	17
Belgium	9	12	16
Germany	10	13	17
Denmark	9	13	17
Spain	8	12	17
Finland	9	12	17
France	9	12	16
Greece	9	12	16
Italy	8	13	18
Netherlands	10	12	17
Portugal	8	12	16
Sweden	9	12	16
UK	9	12	16

- *Source*: de la Fuente and Doménech (2002), Table 4, using these authors' L2.1 for low, L2.2 for medium and L3.2 for high.

Table A.9 summarizes the results of the exercise. The left-hand side block of the table refers to the "total" probability of employment, taking into account both labour force participation and unemployment rates, and the right-hand side block refers to employment probabilities conditional on labour force participation (i.e. one minus the unemployment rate as conventionally defined). In both cases, $p(S)$ stands for probability of employment (i.e. the fraction of the relevant group that is employed), $p'(S)$ is the marginal increase in this probability associated with an additional year of schooling, and $\varepsilon = p'(S)/p(S)$ is the

coefficient which enters the rate of return calculation. As noted above, since the data for Ireland are not broken down by attainment level, it is not possible to calculate $p'(S)$. I have assumed that the value of ε in this country is the same as in the UK.

Table A.9: Marginal contribution of schooling to the probability of employment population 35-44

	total probability of employment			*conditional on participation*		
	$p(S)$	$p'(S)$	$\varepsilon = p'/p$	$p(S)$	$p'(S)$	$\varepsilon = p'/p$
Austria	84.73%	2.97%	3.51%	96.35%	0.74%	0.77%
Belgium	80.95%	3.71%	4.58%	94.63%	1.22%	1.29%
Germany	81.62%	4.03%	4.93%	93.11%	1.59%	1.71%
Denmark	87.66%	2.30%	2.62%	96.29%	0.57%	0.60%
Spain	70.61%	2.88%	4.09%	88.62%	0.87%	0.99%
Finland	83.65%	1.79%	2.14%	92.67%	1.07%	1.15%
France	80.41%	3.60%	4.47%	91.27%	1.69%	1.85%
Greece	74.05%	2.86%	3.86%	92.37%	0.50%	0.54%
*Ireland**	73.54%		**7.39%**	93.16%		**1.36%**
Italy	82.90%	3.07%	3.71%	97.76%	0.74%	0.76%
Netherlands	83.97%	5.22%	6.21%	97.06%	0.51%	0.52%
Portugal	84.57%	1.65%	1.96%	95.23%	0.04%	0.04%
Sweden	81.74%	3.06%	3.74%	95.74%	0.70%	0.73%
UK	80.80%	5.97%	7.39%	94.17%	1.28%	1.36%
avge. EU14	*80.80%*	*3.32%*	*4.33%*	*94.17%*	*0.89%*	*0.98%*

(*) For lack of data, Ireland is imputed the same value of ε as the UK.

The procedure I have just described is clearly far from the ideal way to estimate the value of ε and may be subject to a very large upward bias because it does not control for many relevant individual and social characteristics that may generate a "spurious" correlation between school attainment and employment. Age is one such characteristic, particularly in the case of females. Older female cohorts tend to be less educated than younger ones and are also much less likely to be employed. But it is highly unlikely that lower employment probabilities are only the result of lower attainment levels. Undoubtedly, social norms are also an important factor, as these women grew up in a society where they were not expected to stay long in school or work outside the home. Failing to control for this factor will tend to overstate the effects of education on employment. Similarly, it may be expected that individuals who, for whatever reason, do not plan to participate actively in the labour market will demand less education than those who do.

The upshot of this discussion is that it is extremely dangerous to interpret observed differences in average employment rates across educational levels as an indication of the causal effect of schooling on employment probabilities. To try to mitigate the resulting bias, I have taken two precautions. First, in an attempt to minimize the age bias reflecting changes in social values, I have based all my calculations on data for a relatively young cohort (those aged 35 to 44) rather for the adult population as a whole.[33] And second, I will assume that only a fraction of the calculated effect can be properly attributed to education itself. Thus, the preliminary estimates of ε given in Table A.9 will be multiplied by a factor of either 1/3 or 2/3 before inserting them in the appropriate rate of return formula. I will use the larger coefficient for calculating the individual level payoff to increased schooling, and the smaller one for estimating the social rate of return to education. The size of the adjustment is certainly arbitrary, but it seems clear that it should be larger at the aggregate than at the individual level because the expected gain in terms of employment prospects from an additional year of schooling will be greater if you are the only one raising your qualifications than if everybody else is doing it too.

Correction for differential student employment probabilities

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 and social rates of return, they should be taken into account in the rate of return calculations.

Table A.10: Probability of employment, population 20-24 in and out of school

	in education		*not in education*		η = *ratio in/not in edu.*	
	total [1]	*active* [2]	*total* [3]	*active* [4]	*total* [5]	*active* [6]
Austria						
Belgium	9.36%	73.08%	71.43%	83.01%	0.131	0.880
Denmark	65.91%	85.86%	74.34%	91.82%	0.887	0.935
Finland	26.72%	54.55%	65.09%	80.68%	0.411	0.676
France	10.25%		62.26%	72.54%	0.165	
Germany	47.38%	98.29%	76.49%	87.30%	0.619	1.126
Greece	4.70%	51.72%	54.79%	70.73%	0.086	0.731
Ireland						
Italy	0.93%	23.08%	55.47%	70.49%	0.017	0.327
Netherlands	56.49%	91.74%	86.66%	95.29%	0.652	0.963
Portugal	20.88%	84.52%	83.33%	91.67%	0.251	0.922
Spain	9.73%	46.81%	63.32%	69.12%	0.154	0.677
Sweden	19.95%	66.94%	71.84%	85.03%	0.278	0.787
UK	45.12%	89.93%	77.98%	89.85%	0.579	1.001
average EU14	**26.45%**	**69.68%**	**70.25%**	**82.29%**	**0.352**	**0.821**

- *Source:* EAG 2000 (Table E2.1 p. 280) with data for 1998.

33 This reduces the estimated effect by around one third. For instance, the average value of ε for the 25-64 population is 6.62% (rather than 4.33% as in Table A.9).

To calculate the required correction factor (η), I will use data on the probability of employment of the 20 to 24 age group in 1998 taken from the 2000 edition of *Education at a Glance*. Columns [1] to [4] of Table A.10 show the total probability of employment of this group and its probability of employment conditional on participation in the labour force,[34] distinguishing between those enrolled in educational institutions and those who have completed their formal schooling. Columns [5] and [6] show preliminary estimates of the correction factor, η. This variable is constructed by dividing the relevant employment probability for those attending scool by its counterpart for those out of school. Column [5] refers to the total population (and therefore takes into account differences across these groups in participation rates), while column [6] refers only to active students and non-students.

To go from Table A.10 to Table 2 in the text (which shows the values of the correction factor, η, that are used in the rate of return calculations), I assign a value of 1 to countries where the preliminary estimate shown here exceeds that value (i.e. assume that, other things equal, it is never easier to find part-time employment as a student than a full-time job). I also fill in the missing cells in columns [5] and [6] by assigning to Austria, France and Ireland the values of observed in Germany, Spain and the UK respectively.

4. Tax and benefit parameters

As noted in the text, the average tax rate on student income (τ_s) has been constructed using the information given in *Taxing Wages 2000-2001* about national income tax and social security systems. Students are assumed to be single individuals with no descendants with labour income equal to 20% of APW earnings. In most countries existing tax allowances or zero-rate brackets are such that individuals with these characteristics will pay no income tax. The exceptions are the Nordic countries, where they would be subject to proportional local taxes, and the Netherlands, where some social contributions are levied on taxable income rather than on gross wages. 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, I have assumed that young part-time workers opt out of certain unemployment and pension schemes that appear to be voluntary.

My estimates of the benefit parameters (*a* and *b*) have been constructed using the description of the existing benefit schemes given in the country chapters of the OECD's *Benefit Systems and Work Incentives 1999*. I have worked under the assumptions that i) we are dealing with a single individual with no children whose wage prior to the loss of

34 As above, the first of these figures is simply the ratio of employment to the total population, and the second one the ratio of employment to the labour force.

employment was equal to average production worker (APW) earnings and ii) that any unemployment spells experienced by our representative worker are sufficiently brief that he does not exhaust the contributory benefits to which he is entitled.

Table A.11 contains the relevant information. Column [1] shows the total net replacement ratio *(a+b)* for the reference individual, defined as the ratio of his after-tax income when unemployed to his after-tax income when employed at a wage equal to APW earnings. Column [2] tells us whether the unemployment benefit (which in all cases accounts for the bulk of out-of-work income) is linked to previous earnings or not. While most countries tie benefit levels to previous wages, some of them also establish ceilings that may be binding for our reference individual, and others pay a fixed rate or use a mixed system. I use *PW* to indicate that benefits are an increasing function of previous wages, *FR* for a fixed rate system, *FR** for the case where the benefit is in practice fixed for our reference individual (because the benefit ceiling applies to him) and *mixed* for the case of Finland, where benefit levels include both a fixed base rate and a second component that rises with previous earnings. Column [3] shows the share of housing benefits *(HB)* in total after-tax income out of work in those countries where our reference individual would be eligible for such a subsidy (which is non-taxable and not tied to previous earnings in all cases).

Table A.11: Benefit parameters

	[1] *a+b* *net replacement ratio*	[2] *type of UI scheme*	[3] *weight of housing benefits*	[4] *a* *linked to prev. earns*	[5] *b* *not so linked*
Austria	59.56%	PW		59.56%	0.00%
Belgium	64.47%	FR*		0.00%	64.47%
Denmark	62.71%	FR*	0.016	0.00%	62.71%
Finland	64.90%	mixed	0.097	33.74%	31.16%
France	70.52%	PW		70.52%	0.00%
Germany	60.20%	PW	0.008	59.69%	0.51%
Greece	46.59%	PW		46.59%	0.00%
Ireland	31.18%	FR		0.00%	31.18%
Italy	41.57%	PW	0.055	39.28%	2.29%
Netherlands	81.98%	PW	0.058	77.27%	4.72%
Portugal	78.89%	PW		78.89%	0.00%
Spain	74.45%	PW		74.45%	0.00%
Sweden	70.62%	FR*		0.00%	70.62%
UK	46.32%	FR	0.571	0.00%	46.32%
avge. EU14	*61.00%*			*38.57%*	*22.43%*

Using this information, I split the total replacement rate given in column [1] into the two components shown in columns [4] and [5]. The first of these parameters, *a*, captures benefits that are linked to previous earnings, and the second one, *b*, fixed-rate unemployment and

housing benefits. Hence, we have $a = 0$ and $b = a+b$ for systems of type FR or FR*. For countries of type *PW*, we set $b = 0$ and $a = a+b$ whenever no (fixed rate) housing benefits are available. If housing benefits are provided, then *b* is equal to the total replacement ratio *(a+b)* times the share of housing benefits in after-tax income, and the remainder is assigned to *a*. In the case of Finland, we follow the same procedure to split *a+b* into its housing and unemployment components and then allocate the latter between *a* and *b* in proportion to the variable and fixed parts of the benefit.

5. The private return to schooling: detailed results

Table A.12 shows estimates of the private rate of return to schooling under each of the scenarios discussed in section 3.c of the text. The first block of the table gives the actual rates of return, and the second one a set of normalized rates of return that are obtained by setting the average value for each scenario to 100. Table A.13 shows the change in the rate of return as we move across scenarios and Table A.14 converts these changes into the implied subsidy (when positive) or tax rate (when negative) by dividing the total changes shown in Table A.13 by the initial rate of return (before the contemplated change) shown in Table A.12.

As usual bold and bold italic entries in Table A.12 identify estimates based on incomplete data. Belgian estimates are particularly unreliable in all scenarios (because the missing piece of information is the Mincerian returns parameter, which is used in all scenarios), whereas in the remaining countries data problems affect only the calculations in the last column through the student unemployment correction, except in the case of Portugal where the main potential problem has to do with the total direct costs of education.

Table A.12: Net private rates of return to schooling under different scenarios

	baseline [1]	*+subsidies* [2]	*+ taxes* [3]	*GOV'T + benefits* [4]	*OBS +diffstU* [5]
Austria	8.92%	12.99%	11.02%	10.50%	***10.50%***
Belgium	**8.99%**	**11.38%**	**10.29%**	**8.97%**	**8.56%**
Denmark	6.90%	9.33%	9.87%	9.11%	8.87%
Finland	10.31%	13.55%	11.61%	10.48%	9.62%
France	8.93%	12.35%	11.66%	10.34%	9.59%
Germany	10.88%	13.75%	11.63%	10.43%	10.43%
Greece	9.61%	11.99%	10.70%	10.39%	9.81%
Ireland	***12.24%***	***16.10%***	***11.08%***	***10.41%***	***10.41%***
Italy	9.20%	11.81%	10.73%	10.40%	8.61%
Netherlands	7.88%	10.20%	8.64%	8.07%	7.95%
Portugal	**9.33%**	13.68%	12.67%	12.52%	12.29%
Spain	9.45%	11.92%	10.87%	10.06%	9.36%
Sweden	4.49%	7.05%	7.38%	6.49%	6.06%
UK	12.49%	15.36%	14.92%	13.87%	13.87%
avge. EU14	*9.31%*	*12.30%*	*11.06%*	*10.24%*	*9.75%*
	baseline [1]	*+ subsidies* [2]	*+ taxes* [3]	*+ benefits* [4]	*OBS* [5]
Austria	95.8	105.6	99.6	102.6	107.7
Belgium	96.6	92.5	93.1	87.6	87.8
Denmark	74.1	75.8	89.3	89.0	91.0
Finland	110.8	110.2	105.0	102.3	98.6
France	95.9	100.4	105.4	101.0	98.3
Germany	116.8	111.7	105.1	101.8	106.9
Greece	103.3	97.5	96.7	101.4	100.6
Ireland	131.5	130.9	100.2	101.6	106.7
Italy	98.8	96.0	97.1	101.6	88.3
Netherlands	84.7	82.9	78.1	78.8	81.5
Portugal	100.2	111.2	114.6	122.3	126.1
Spain	101.5	96.9	98.3	98.2	96.0
Sweden	48.3	57.3	66.8	63.3	62.1
UK	134.1	124.8	134.9	135.5	142.3
avge	100.0	100.0	100.0	100.0	100.0

- Note: bold entries denote estimates based on incomplete or suspicious data.

Table A.13: change in the net private rates of return to schooling induced by various public interventions and by differential student unemployment

	educational subsidies [2]-[1]	*personal taxes* [3]-[2]	*social benefits* [4]-[3]	*all gov't* [4]-[1]	*student unempl.* [5]-[4]	*total* [5]-[1]
Austria	4.07%	-1.97%	-0.51%	1.58%	0.00%	1.58%
Belgium	2.39%	-1.09%	-1.32%	-0.02%	-0.41%	-0.43%
Denmark	2.43%	0.55%	-0.76%	2.21%	-0.24%	1.97%
Finland	3.24%	-1.94%	-1.13%	0.16%	-0.86%	-0.70%
France	3.42%	-0.69%	-1.32%	1.41%	-0.75%	0.65%
Germany	2.87%	-2.12%	-1.20%	-0.45%	0.00%	-0.45%
Greece	2.38%	-1.30%	-0.31%	0.78%	-0.58%	0.19%
Ireland	3.86%	-5.02%	-0.67%	-1.83%	0.00%	-1.83%
Italy	2.61%	-1.08%	-0.33%	1.20%	-1.79%	-0.59%
Netherlands	2.32%	-1.57%	-0.57%	0.18%	-0.12%	0.06%
Portugal	4.35%	-1.00%	-0.15%	3.20%	-0.23%	2.97%
Spain	2.47%	-1.05%	-0.81%	0.61%	-0.70%	-0.09%
Sweden	2.55%	0.34%	-0.90%	1.99%	-0.43%	1.57%
UK	2.87%	-0.43%	-1.05%	1.39%	0.00%	1.39%
avge. EU14	*2.99%*	*-1.24%*	*-0.82%*	*0.93%*	*-0.49%*	*0.44%*

Table A.14: Net implicit subsidy (+) or tax (-) rate induced by various public interventions and by differential student unemployment

	educational subsidies [2]-[1]	*personal taxes* [3]-[2]	*social benefits* [4]-[3]	*all gov't* [4]-[1]	*student unempl.* [5]-[4]	*total* [5]-[1]
Austria	45.62%	-15.18%	-4.65%	17.77%	0.00%	17.77%
Belgium	26.61%	-9.59%	-12.80%	-0.18%	-4.58%	-4.75%
Denmark	35.15%	5.87%	-7.70%	32.05%	-2.64%	28.56%
Finland	31.41%	-14.34%	-9.76%	1.58%	-8.23%	-6.78%
France	38.25%	-5.59%	-11.33%	15.73%	-7.26%	7.33%
Germany	26.36%	-15.42%	-10.30%	-4.13%	0.00%	-4.13%
Greece	24.78%	-10.81%	-2.89%	8.07%	-5.62%	2.00%
Ireland	31.53%	-31.17%	-6.07%	-14.96%	0.00%	-14.96%
Italy	28.42%	-9.16%	-3.09%	13.05%	-17.18%	-6.37%
Netherlands	29.38%	-15.35%	-6.59%	2.31%	-1.46%	0.82%
Portugal	46.69%	-7.35%	-1.19%	34.29%	-1.82%	31.85%
Spain	26.11%	-8.81%	-7.47%	6.41%	-6.91%	-0.94%
Sweden	56.83%	4.81%	-12.17%	44.36%	-6.59%	34.85%
UK	22.96%	-2.82%	-7.03%	11.09%	0.00%	11.09%
avge. EU14	*32.14%*	*-10.11%*	*-7.39%*	*10.00%*	*-4.78%*	*4.74%*

6. A plausible range of macroeconomic parameter estimates[35]

In this section I will try to extract from D&D (2002) and from the review of the literature in the Appendix to our previous report (D&C, 2002) a plausible range of values for the parameters that describe the relationship between human capital and the level and growth rate of aggregate productivity. The coefficients of interest are two alternative measures of level effects and one measure of rate effects. The level parameters are the elasticity of output with respect to average schooling, α_S, and the aggregate Mincerian return on schooling, ρ, that measures the percentage increase in output resulting from a one-year increase in average attainment. As the reader will recall (see Box 1 in section 2b the text), ρ can be obtained by dividing α_S by average attainment in years, and vice versa. The rate effects parameter is the coefficient of educational attainment *(S)* in the technical progress function, γ, and measures the contribution of an additional year of schooling to the rate of TFP growth holding other things (and in particular the gap with the world technological frontier) constant.

The first block of Table A.15 shows a number of selected coefficient estimates taken from the empirical literature reviewed in D&C (2002). The first row of the table gives the source of the estimate, the second shows the specific form in which years of schooling enters the equation,[36] the third and fourth rows display the estimated value of the "raw" regression coefficient and the associated *t* statistic, and the fifth row lists the source of the schooling data. To increase the comparability of the coefficients and to facilitate their interpretation, I have selected only estimates obtained using data on average years of schooling (rather than on enrollment rates). I have focused mostly on recent studies that make use of the latest available data sets and use specifications that produce "respectable" signal to noise ratios for an OECD data set. Implicitly, then, I am accepting Krueger and Lindhal's (2001) argument that failure to find significant productivity effects is most likely due to poor data, and not taking into account the negative findings of some of the studies we have reviewed in the Appendix to the previous report.

35 This section is based on de la Fuente (2003). It is also an update of material that was included in sections 5a and 5b of the text and in section 3f of the Appendix of D&C (2002). The main difference with the previous version has to do with the adjustment for measurement error. As noted in the text, in the first column of Table A.15 I use a direct meta-estimate taken from D&D's (2002) to correct these authors' raw estimate of the human capital coefficient. For the remaining columns, I use what D&D (2002) call SUR estimates of the relevant reliability ratios rather than those originally computed in C&D (2002) because the former should be more precise. These reliability ratios are derived from OECD data (rather than from the larger country samples used in some of the relevant studies). As noted in Appendix 2a of C&D (2002), reliability ratio estimates for broader samples tend to be larger than those based on OECD data, but this is likely to give a misleading impression of data quality.

36 The notation is the standard one in this report: *S* denotes years of schooling, *s* the log of this variable and Δs its annual growth rate, computed as the average annual log change over the relevant period. C&S stands for Cohen and Soto, D&D and for de la Fuente and Doménech, and Bas&Scarp for Bassanini and Scarpetta.

Table A.15: Selected estimates, corrections for measurement error bias and tentative estimates of rate effects

	1. original coefficient estimates:				
source:	*D&D (2002)*	*C&S (2001)*	*Bas&Scarp*	*Barro (2000)*	*Jones (1996)*
regressor:	Δs	*S*	*s*	*S**	*S*
raw coefficient	0.394	0.085	0.95	0.0044	0.159
(t)	(4.57)	(4.00)	(3.96)	(2.44)	(2.48)
data from:	D&D (2001)	C&S (2001)	D&D (2001)	B&L (2000)	B&L (1993)
	2. implied values of the level parameters:				
coefficient interpreted as	α_S	$\frac{\rho}{1-\alpha_k}$	$\frac{\alpha_S}{1-\alpha_k}$	$\beta\frac{\rho}{1-\alpha_k}$	$\frac{\rho}{1-\alpha_k}$
implied ρ	**3.70%**	5.67%	7.76%	11.73%	11.75%
implied α_S	0.394	0.603	0.826	1.248	1.250
	3. level parameters after correcting for measurement error:				
*reliab. ratio***	meta-est.	0.793	0.859	0.768	0.587
corrected coeff.	0.587	0.107	1.106	0.006	0.271
implied ρ	**5.52%**	7.15%	9.04%	15.28%	20.02%
implied α_S	0.587	0.760	0.962	1.626	2.130
implied θ	8.42%	10.72%	10.39%	22.92%	27.09%
	4. implied value of γ_h *under the assumption that* $\alpha_{YS} = 0.587/\rho = 5.52\%$				
corrected coeff. interpreted as:	α_S	$\frac{\rho}{1-\alpha_k}+\frac{\gamma}{\lambda}$	$\frac{\alpha_S}{1-\alpha_k}+\frac{\gamma}{\lambda}$	$\frac{\beta\rho}{1-\alpha_k}+\frac{\beta\gamma}{\lambda}$	$\frac{\rho}{1-\alpha_k}+\frac{\gamma}{\lambda}$
implied γ	**0.00%**	0.18%	0.30%	1.08%	1.45%
	5. other parameter values used in the calculations:				
avge. S	10.64	10.64	10.64	10.64	10.64
λ	0.074	0.074	0.074	0.074	0.074
α_k	0.345	0.333	0.130	0.333	0.261
β				0.025	

(*) The regressor is some transformation of the average years of total schooling of the adult population, except in Barro (2000), where it is the average years of secondary and higher schooling of the adult male population.
(**) SUR reliability ratios for the appropriate data set and data transformation from D&D (2002), Table 8. I use panel a of this table (reliability ratios for the raw data) for C&S (2001), Barro (2000) and Jones (1996), and panel b (reliability ratios for the data after removing fixed time effects) for Bassanini and Scarpetta (2001).

The second block of the table shows the values of α_S and ρ implied by the original coefficients when these are interpreted as capturing level effects only. In most cases, the values of these parameters are not given directly by the estimated coefficients displayed in the first block of the table but can be recovered from them using either the explicit structural model that underlies the estimated equation, or a model that generates the same reduced form specification. For instance, Jones (1996) interprets the coefficient of *S* in the steady-state equation he estimates as capturing rate effects in a world with technological diffusion. I will do something like this below, but for now I interpret this coefficient as capturing a level effect within the framework of a Mincerian version of the model of Mankiw, Romer and Weil (MRW, 1992), which yields exactly the same steady-state specification. In the case of Barro (2000), the estimated convergence equation is not explicitly derived from a structural model, but it can be interpreted as such because the functional form is similar to the one that would be implied by the same Mincerian MRW model when we allow for transitional dynamics.[37] To recover the values of α_S and ρ I typically need an estimate of α_k. When possible, this is taken from the original equation (as in Jones (1996) or in Bassanini and Scarpetta (2001)); otherwise, a value of 0.333 is assumed for this parameter.

The calculations I have just sketched will produce an estimate of α_S when the underlying production function is Cobb-Douglas in years of schooling (i.e. when we assume that the stock of human capital, H, is given by $H = S$), and an estimate of $\rho = \theta\alpha_h$ when a Mincerian specification (with $H = Exp\ (\theta S)$) is adopted. To compute ρ given α_S, I will divide the latter parameter by 10.64, which is the average years of schooling in 1990 in a sample of OECD countries using D&D's (2001) data set.[38] The reverse procedure will be used to compute α_S given the value of ρ. The values of the auxiliary parameters used in these computations are shown in the last block of the table.

I will use as a lower bound on the level effects parameters the smallest of the estimates shown in Block 2 of the Table, which is taken from D&D (2002). I expect that this coefficient will underestimate the true return to schooling because it is not corrected for measurement error bias and is obtained working with growth rates computed over five-year periods, which can make it difficult to detect productivity effects that may involve considerable lags -- as is likely to be the case with the technology-related rate effects.

The third block of Table A.15 shows the effects on parameter estimates of correcting for measurement error bias. In the case of D&D (2002), I will use a direct *meta-estimate* of α_S provided by the same authors that should be free of attenuation bias.[39] In the remaining

37 Within this model, the coefficient of years of schooling will provide an estimate of $\beta\frac{\rho}{1-\alpha_k}$, where β (the rate of convergence) is the coefficient of log initial income per capita. Barro's equation includes both this variable and its square, but the author reports that the average rate of convergence in the sample is 2.5%. This is the value of β used in my calculations and is shown in the last block of the table. Barro's equation controls for investment in physical capital, but the investment ratio does not enter the equation in a way that allows me to recover an estimate of α_k. Hence, I assume a value of 1/3 for this parameter.

38 Hence, the values of ρ and θ given in Table A.15 refer to this sample and are therefore different from those used for the average EU country in the rate of return calculations in the text, which focuses on a subset of the OECD sample comprised by 14 EU members.

39 To construct this meta-estimate, D&D (2002) rely on an extension of the classical error-in-variables model. Their procedure works roughly as follows. First, the authors construct an independent measure of the signal-to-noise ratio in eight different schooling data sets by exploiting the covariance across the different series. Second, a common growth specification is estimated with each of the different data sets. The meta-estimate is then constructed essentially by extrapolating the observed relationship between the index of data quality and the estimated human capital coefficient to the case where the data contain no measurement error. This procedure is repeated using different econometric specifications and different assumptions about the nature of measurement error to obtain a number of different meta-estimates of α_S. The

columns, the correction is based on the reliability ratio (data quality index) estimated by D&D (2002) for the relevant data set. Notice that the correction is only a partial one because it ignores the increase in the attenuation bias that will result from the introduction of additional regressors when these are correlated with schooling (see Section 2b.iii of D&C (2002)). The corrected estimates of the raw coefficients are obtained by dividing their original values (in the first block of the table) by the reliability ratios shown in the first row of the third block. The implied values of α_S and ρ are then recovered in the manner explained above, working with the corrected raw coefficients. Finally, the last row of block 3 shows the value of the individual-level Mincerian returns parameter *(θ)* implied by the corrected values of ρ for the case of the average OECD country (and not for the average EU country, which is the reference used in section 4b of the text). The value of θ is estimated as $\rho/(1-\alpha_k)$, as discussed in section 8 of the Appendix.

The corrected parameter values displayed in the third block of Table A.15 are rather high. Notice that the lowest value of α_S is 0.587, which corresponds to D&D's lowest meta-estimate. Since this figure implies a value of θ that is consistent with Harmon et al's estimates of the individual returns to schooling in the EU, I will use it as my baseline value for the level effects parameter. Hence, the larger estimates of α_S that are implied by the other studies listed in the table and by the rest of D&D's (2002) meta-estimates (which range from 0.843 to 2.606 with an average value of 1.11) must be picking up something different from the direct productivity or level effects that are likely to translate into higher wages.

There are essentially two possibilities: one is the upward bias from reverse causation (see D&C, 2002), and the other what we have called rate effects, i.e. the indirect contribution of human capital to growth via faster technical progress that constitutes the most plausible source of externalities linked to education. The pattern of results in the studies that produce large estimates of α_S suggests that both factors are at work. Schooling coefficients are generally larger when they come from steady-state level equations (where reverse causation can be a serious problem if we do not control for differences in TFP levels across countries) or from differenced specifications that use growth rates computed over long periods (where again there is greater danger of reverse causation bias as there is time for changes in enrollments to affect schooling stocks). On the other hand, these specifications are also more likely to pick up productivity effects that involve long gestation lags, and there are reasons to expect that not all of the observed increase in the coefficients is due to reverse causation. In particular, some of the relevant studies that estimate steady-state equations do include proxies for TFP or other control variables that should at least reduce the endogeneity bias (e.g. Cohen and Soto (2001) and Barro (2000)), and one of them (Bassanini and Scarpetta (2001)) estimates very high schooling coefficients with annual data using an error correction

corrected values shown in Block 3 of Table A.15 for D&D (2002) correspond to the lowest of all such meta-estimates. The average value of the meta-estimates of α_S is 1.11.

specification that probably permits a better characterization of long-term relationships by allowing short-term deviations from them.

Thus, I conjecture that, as may be expected from the discussion in D&C (2002) about the difficulty of empirically separating level and rate effects, the coefficient estimates shown in Table A.15 are picking up both of them. To get some feeling for the likely size of the rate effects, I will take as given the value of the level parameters implied by D&D's lowest meta-estimate and solve for the value of the rate effects coefficient, γ, that is consistent with the raw coefficient of schooling. To do this, I will reinterpret the reported raw coefficients within the framework of an enlarged model with rate effects and technological diffusion as described in Box 1 in the text. In this context, and under the further assumption that countries are reasonably close to their "technological steady states" relative to the world frontier, the coefficient of the schooling variables will reflect both the standard level effect and an additional term of the form γ/λ, where λ is the rate of technological diffusion.[40] The fourth block of the table shows the results of this calculation, which uses the value of λ estimated by de la Fuente and Doménech (2002).

Table A.16: Immediate sources of cross country productivity differentials 1990, 21 OECD countries

contribution of:	
physical capital	38.02%
schooling (level effect)	29.09%
total k + sch. level	67.11%
rest = due to TFP	32.89%

- *Note:* Shares of different factors in observed relative productivity in a typical OECD country as defined in Box 4 of D&C (2002). Relative productivity is output per employed worker in log differences with its (geometric) sample average.

40 The details of the required calculations are as follows. Let x be the relevant "raw coefficient" corrected for measurement error and assume for concreteness that we are interpreting this coefficient as

$$x = \frac{\rho}{1-\alpha_k} + \frac{\gamma}{\lambda}$$

Given the assumed values of λ, ρ and α_k, we can solve for γ as

$$\gamma = \lambda\left(x - \frac{\rho}{1-\alpha_k}\right)$$

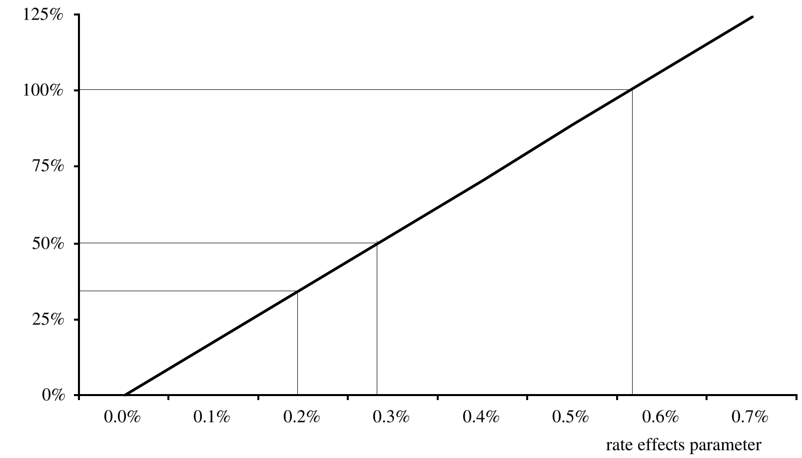
In the case of Basanini and Scarpetta (2001), an additional step is necessary. Since these authors use years of schooling in logs rather than in levels (ie. $s = ln\ S$), the calculation just described will yield an estimate of the change in the rate of technical progress (g) induced by a unit increase in log schooling, i.e. of $\frac{\partial g}{\partial lnS}$ rather than of γ which is defined as $\frac{\partial g}{\partial S}$. To recover the parameter of interest, notice that

$$\frac{\partial g}{\partial S} = \frac{\partial g}{\partial lnS}\frac{dlnS}{dS} = \frac{\partial g}{\partial lnS}\frac{1}{S}$$

so we have to divide the result of the first calculation by average years of schooling to recover γ.

The value of γ obtained in this manner ranges from 0.18% in Cohen and Soto (2001) to over 1% in Jones (1996) and Barro (2000) and is equal to 0.37% for D&D's (2002) average meta-estimate of the human capital coefficient (not shown in the table). Since some of these values are implausibly high, I will attempt to narrow down this range of estimates by examining the implications of different parameter values for the importance of rate effects from human capital as a source of cross-country differentials in relative levels of total factor productivity (TFP) in an OECD sample.

Figure A.1: Cumulative impact of the rate effects from human capital as a % of the total contribution of TFP to relative productivity



Subtracting from observed relative productivity the contribution of physical capital and (the baseline estimate of) the level effects from human capital, I obtain the share of TFP in relative productivity for an average OECD country which, as shown in Table A.16, is around one third. Figure A.1 then plots the contribution of rate effects to relative productivity as a fraction of the estimated TFP share.[41] A "large" value of this ratio will render the underlying rate effects coefficient suspect. For instance, the finding that rate effects are greater than observed total TFP differences would imply that the component of TFP levels not related to human capital (e.g. that arising from differences in R&D investment) would have to be negatively correlated with labour productivity which seems unlikely. Turning to Figure A.16, the exercise suggests that we should rule out estimates of γ greater than 0.55%, and that values of this parameter over 0.30% are unlikely because they would imply that more than half of the observed cross-country TFP differentials are induced by human capital. My choice

41 See Box 4 in C&D (2002) for the details of this calculation.

of 0.20% as the baseline value for γ implies that rate effects account for a bit over a third of observed TFP differentials across OECD countries.

7. The rate of return on physical capital

The OECD publishes annual estimates of the rate of return to physical capital in the business sector that are based on data from its National Accounts and (either national or OECD) estimates of the gross stock of non-residential fixed capital. The rate of return is calculated as the ratio of the gross operating surplus of enterprises (i.e. value added minus labour costs) to the stock of capital valued at replacement cost.

The OECD warns that its rate of return estimates suffer from a number of shortcomings. First, the data are not comparable across countries because there are important differences in the assumptions used to construct the capital stock series, particularly in regard to the useful lives of different types of assets.[42] Second, these estimates are likely to be biased upward because the numerator includes the operating surplus of the housing sector, whereas residential capital is excluded from the denominator. According to the OECD (see the notes to Annex Tables 24 and 25 in the *1998 Economic Outlook*), the available data suggest that the required correction would lower the estimated rate of return by around three percentage points. In addition, I suspect that there may be an additional problem that will increase this upward bias and also contribute to reduce cross-country comparability. In principle, the measure of labour income that is used to calculate the gross operating surplus of enterprises includes the imputed income of self-employed persons, which is calculated by multiplying the number of self-employed (excluding unpaid family workers) by an estimate of the average wage. For some countries, however, there does not seem to be any data on self-employment until very recent years (see Volume II of the OECD's *National Accounts*). I suspect, therefore, that the gross operating surplus is significantly overstated in some countries (e.g. Greece), but not in others.

Given these problems, it seems clear that the OECD series on the rate of return on capital are not suitable for our purposes here. Nonetheless, a comparison of its average value across countries with that of our production-function estimates may still be informative. Table A.17 shows the average rate of return in the OECD series, calculated over different periods, together with my own estimates of the marginal product of capital. (Notice that since this is a gross rate of return in which no allowance is made for depreciation, it is roughly comparable to my production-function based estimate of the marginal product of capital, rather than with my measure of net returns).

[42] For instance, Keese, Salou and Richardson (1991) report that for the 1980's the assumed useful life of structures ranged from 30 to 72 years and that of plant and equipment from 10 to 24 years in a set of 10 countries that constructed capital stock estimates.

Since the average values of the two series are very similar, I conclude that my own direct estimates of the rate of return on physical capital are also likely to be biased upward. I construct a rough measure of the likely bias by relying on a careful study by Poterba (1987) which makes use of revised BEA data for the US. His estimate of the aveage pre-tax net rate of return on non-financial corporate capital over the period 1959-86 is 8.5% (with some oscillations but without a clear trend). Dividing this number by my original estimate of the rate of return to physical capital in the US (which is 11.32% after correcting for depreciation and technical progress) I obtain an adjustment coefficient of 0.751 which is used to construct the adjusted estimate of the return on physical capital that is used in section 4d of the text.

Table A.17: Alternative estimates of the gross return on physical capital

	[1]	[2]	[3]	[4]
source:	*OECD*	*OECD*	*OECD*	*D&D (2002)*
period:	*1981-97*	*1985-97*	*1988-97*	*1990*
Austria		13.71%	13.84%	13.18%
Belgium	13.19%	13.71%	13.85%	13.44%
Denmark			7.90%	10.26%
Finland	8.52%	8.52%	8.57%	9.28%
France	14.25%	15.00%	15.41%	13.04%
Germany	12.56%	12.95%	13.15%	11.96%
Greece	22.83%	22.78%	23.41%	13.00%
Ireland	9.57%	10.72%	11.81%	14.93%
Italy	13.73%	14.33%	14.54%	12.15%
Netherlands			17.96%	12.80%
Portugal				16.40%
Spain	16.45%	17.64%	18.28%	14.79%
Sweden	11.04%	11.38%	11.60%	12.09%
UK	9.24%	9.43%	9.44%	16.14%
avge. EU14	13.14%	13.65%	13.83%	13.10%
period:	1981-96	1985-96	1988-96	1990
US	16.56%	17.36%	17.74%	14.82%

- *Sources:* the OECD series are taken from the 1998 Economic Outlook except for the case of the US, as the series for this country had been discontinued by then due to changes in the methodology used by the BEA to construct the underlying data. For the US I use the OECD series as reported in Poterba (1997). Column [4] is the marginal product of capital calculated using the production function estimated in de la Fuente and Doménech (2002) and their output and capital stock series.

8. Reconciling micro and macro estimates of the returns to schooling: a simple model[43]

Assume all firms in a given country have access to a constant returns production function of the form

$$(1)\quad Y = AK^{\alpha_k}E^{\alpha_h}L^{1-\alpha_k-\alpha_h}$$

[43] This section is taken from de la Fuente (2003). It owes a lot to my conversations with Antonio Ciccone. The derivation of the wage schedule, in particular, is his.

where E is the total stock of human capital of the relevant production unit and L its total employment, given respectively by

(2) $E = \Sigma L_i H_i$

(3) $L = \Sigma L_i$

where L_i is the number of workers with a stock of human capital equal to H_i. Since the production function displays constant returns to scale, firm size will be indeterminate (as in most growth models), but all firms will produce in equilibrium using the same factor ratios, which will coincide with aggregate factor ratios and thus make for direct and easy aggregation. I will follow the standard procedure and work with a "representative firm" that behaves competitively, (that is, I will implicitly assume that there is a large number of such firms in the economy and that they all behave as price-takers).

Let us first consider the response of aggregate productivity to an increase in the average stock of human capital, which is what our macroeconomic growth equations presumably capture. Let H denote the average stock of human capital and Z the capital/labour ratio, ie.

(4) $H = \frac{E}{L} = \frac{\Sigma L_i H_i}{L}$ and $Z = \frac{K}{L}$

and observe that average labour productivity $Q = Y/L$ can be written in the form

(5) $Q = AZ^{\alpha_k} H^{\alpha_h}$

or, in logarithms

(6) $q = a + \alpha_k z + \alpha_h h.$

Hence, the elasticity of aggregate labour productivity with respect to the average stock of human capital is given, as we already knew, by α_h.

Consider now a representative firm, say f, and write its production function (which is identical to the aggregate one) in the form

(7) $Y_f = AK_f^{\alpha_k} E_f^{\alpha_h} L_f^{1-\alpha_k-\alpha_h} = L_f A Z_f^{\alpha_k} H_f^{\alpha_h} = L_f Q_f$

We will assume that physical capital is traded in a competitive market. Setting the marginal product of capital equal to its rental rate, R, it is easy to check that the optimal capital/labour ratio for the firm is given by

(8) $Z_f^* = \left(\frac{\alpha A}{R}\right)^{1/(1-\alpha_k)} H_f^{\alpha_h/(1-\alpha_k)}$

Substituting this back into the firm's production function written in intentive form, we see that the firm's average productivity is given by

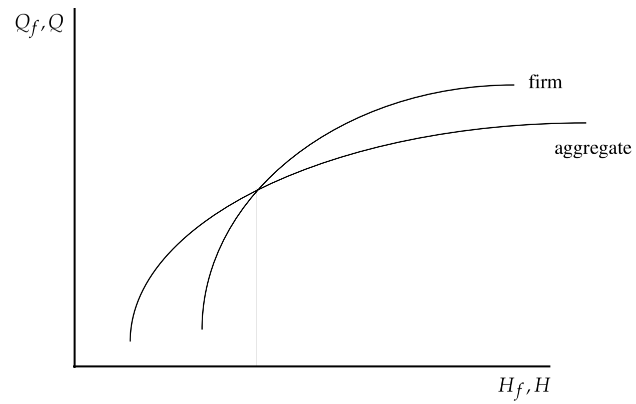
(9) $Q_f = A\left(\frac{\alpha A}{R}\right)^{\alpha_k/(1-\alpha_k)} H_f^{\alpha_k\alpha_h/(1-\alpha_k)} H_f^{\alpha_h} = \Gamma(R, A) H_f^{\alpha_h/(1-\alpha_k)}$

where $\Gamma(R, A)$ is an exogenous constant from the point of view of the firm but depends on the equilibrium rental rate of capital. In logs, we have

(10) $q_f = \gamma(R, A) + \frac{\alpha_h}{1-\alpha_K} h_f$

Hence, the partial equilibrium (firm-level) elasticity of average productivity with respect to human capital is larger than its general equilibrium (aggregate level) counterpart. Under our assumptions, a productivity regression with firm-level data would overestimate the returns to education unless it is corrected for the effects of a greater demand for physical capital. Figure A.2 illustrates the situation: if we draw Q as a function of H and Q_f as a function of H_f for a representative firm on the same set of axis, the two functions will cross at the point where $H_f = H$ (which corresponds to the equilibrium), but the firm-level production function will be steeper than the aggregate one. An increase in H_f holding H constant will increase the firm's productivity by more than a similar increase in H will increase aggregate productivity because the firm is not constrained by the fixed aggregate supply of capital.

Figure A.2: Firm and aggregate-level production functions



Finally, we will consider the response of wages to human capital in this setting. If workers are paid their marginal products, the wage of a worker with human capital H_i will be given by

(11) $W(H_i) = \frac{\partial Y_f}{\partial L_i} = AK_f^{\alpha_k}\alpha_h E_f^{\alpha_h-1} H_i L_f^{1-\alpha_k-\alpha_h} + AK_f^{\alpha_k} E_f^{\alpha_h}(1-\alpha_k-\alpha_h) L_f^{-\alpha_k-\alpha_h}$

$= \alpha_h \frac{H_i}{H_f} Q_f + (1-\alpha_k-\alpha_h) Q_f = (1-\alpha_k) Q_f + \alpha_h \left(\frac{H_i}{H_f} - 1\right) Q_f$

Notice that the wage increases linearly with the worker's stock of human capital (since Q_f and H_f can be treated as exogenous constants from his perspective). Hence, at the individual level there are no decreasing returns to human capital. This implies that the coefficient of a wage equation with data at the individual level will, in the absence of the proper correction, overestimate the macro returns to education even more than equation (10) would.

To draw the wage schedule, notice that

(12) $W(0) = (1-\alpha_k-\alpha_h) Q_f$

$$(13)\ W(H_f) = (1-\alpha_k)Q_f$$

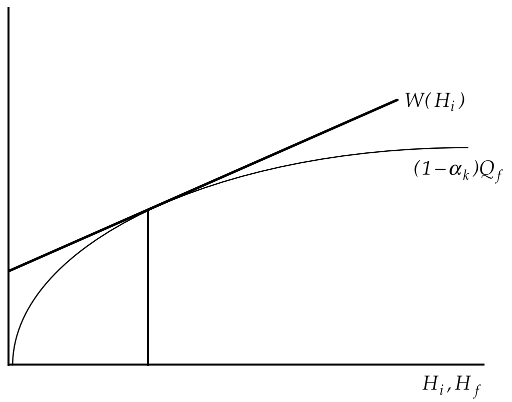
so the wage function $W()$ has a positive vertical intercept that corresponds to the wage paid to the worker with no human capital and interesects the function

$$(14)\ g(H) = (1-\alpha_k)Q_f = (1-\alpha_k)\Gamma(R, A)H^{\alpha_h/(1-\alpha_k)}$$

(where Q_f is given by the reduced form firm-level production function derived above) when H_i is equal to the average stock of human capital. In fact, $W()$ is tangent to this function at H_f, for

$$g'(H_f) = (1-\alpha_k)\Gamma(R, A)\frac{\alpha_h}{1-\alpha_k} H_f^{(\alpha_h/(1-\alpha_k))-1} = \alpha_h\frac{Q_f}{H_f} = W'(H_f)$$

Figure A.3: Firm-level production function and wage schedule



If human capital (H) is related to schooling (S) by $H = e^{\theta S}$, equation (11) comes very close to being a standard mincerian wage equation. If we rewrite it as

$$W(H_i) - W(0) = \alpha_h\frac{Q_f}{H_f} e^{\theta S_i}$$

and take logarithms, we have

$$ln\left(W(H_i) - W(0)\right) = c + \theta S_i$$

so one additional year of schooling will increase by θ% the premium over the wage paid to a worker with no human capital. To recover the exact Mincerian specification, we need to assume further that $\alpha_h = 1-\alpha_k$, i.e. that "raw labour" L does not enter the production function as a separate input. In that case $W(0) = 0$ (and the reduced-form firm-level production function is itself linear and coincides with the wage schedule, which now goes through the origin). Notice that in this case the standard wage equation will yield an estimate of θ which will have to be multiplied by $\alpha_h = 1-\alpha_k$ to obtain the value of ρ. If this assumption does not hold, (the Mincerian equation will be misspecified and) the previous adjustment will be only an approximation.

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