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Marginal Effective Tax Rates on Physical, Human and R&D Capital

Kathryn Gordon,

Harry Tchilinguirian

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ABSTRACT/RÉSUMÉ

This paper presents marginal effective tax rates (METRs) for a number of physical and intangible assets and for a number of funding sources. The assets include machinery, buildings, inventories, investments in short-lived R&D (that is, investments whose returns last only a few years) and in long-lived R&D (whose returns last many years). Two human capital assets are included -- firm-sponsored training and household-sponsored tertiary education. The calculations incorporate parameters from both the personal and corporate tax codes. They are performed for the "top-bracket" taxpayer and for the "average production worker" and cover between 15 and 22 countries, depending on data availability. The OECD has already used the King-Fullerton method to calculate METRs for physical capital (OECD, 1991) and this paper updates these calculations using established practices. As the method has not yet been applied to household-sponsored human capital, the paper describes the extension to this type of investment in some detail. The international averages for the METRs show that intangible capital generally receives more favourable tax treatment than physical capital. On average, the most favoured investment category is short-lived R&D. Household-sponsored human capital also receives favourable treatment. However, this stems from mainly direct subsidies given in the form of scholarships or below-cost charging for public education; the tax system itself tends to offset the incentive effects of direct subsidies. Firm-sponsored training also receives favourable treatment compared to that accorded to physical capital.

* * * * *

Cet article présente les taux d'imposition marginaux effectifs (TIME) pour un certain nombre d'actifs corporels et incorporels et selon leur mode de financement. Ces actifs comprennent les machines et biens d'équipement, les immeubles, les stocks, les investissements en recherche-développement à rentabilité courte, les investissements en recherche-développement à rentabilité longue, la formation financée par l'entreprise, la formation universitaire financée par les ménages. Les calculs font appel à des paramètres du code fiscal des personnes physiques et à celui des sociétés et sont réalisés pour le contribuable taxable à la tranche supérieure de l'impôt et pour l'ouvrier moyen. Ils concernent entre 15 et 22 pays selon la disponibilité des données. L'OCDE a déjà utilisé la méthode King-Fullerton pour calculer les TIME pour le capital physique (OCDE 1991) et cet article met à jour les calculs précédents en utilisant des pratiques bien établies. La méthode n'ayant pas encore été appliquée à l'investissement en capital humain financé par les ménages, ce papier décrit en détail la façon dont elle a été étendue à ce type d'investissement. Il ressort des calculs que les capitaux incorporels font généralement l'objet d'un traitement fiscal plus favorable que le capital humain. La catégorie d'investissement la plus favorisée est l'investissement en recherche développement à rentabilité courte. L'investissement en capital humain financé par les ménages fait aussi l'objet d'un traitement favorable. Cependant cela provient de subventions essentiellement directes sous forme de bourses d'études ou de frais de scolarité fixés en deçà du coût réel pour l'éducation publique et le système fiscal lui-même tend à annuler les effets incitatifs des subventions directes. La formation assurée par l'entreprise bénéficie aussi d'un traitement favorable comparé à celui accordé au capital physique.

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MARGINAL EFFECTIVE TAX RATES ON PHYSICAL, HUMAN AND R&D CAPITAL

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Introduction

1. Investment is shaped by many factors, including taxes. An extensive literature has developed that measures tax-related investment incentives. In particular, marginal effective tax rates (METRs) have been calculated that reflect the incentives created by personal and corporate tax policies, including the setting of tax rates, depreciation allowances, tax credits and special tax arrangements for different funding sources. These have typically been calculated for physical assets. They measure the tax wedge between the pre- and post-tax costs of capital using a method that was first formalised in King and Fullerton (1986). While the literature on METRs provides useful information on tax incentives for physical investment, it has for the most part neglected the portion of the capital stock that is amassed through intangible investment in human capital or innovation (for an exception in relation to R&D, see Griffith *et al*., 1995, Warda, 1996 and Bloom *et al.*, 1996 and 1997). This is a significant shortcoming because the accumulation of intangible capital is widely viewed as an important determinant of the growth of productivity and living standards and because the magnitude of such investment is quite high. Fullerton and Lyon (1987) present estimates of the intangible stock in the United States (including advertising but not human capital) which place its value at one-third to one-half the physical capital stock. McMahon (1991) estimates that the human capital stock in the United States is about one-half of the total capital stock when all stocks are measured on the basis of real investment cost.

2. The present article measures the marginal incentives created by the tax treatment of domestic investment in two types of intangible capital -- *1)* human capital accumulation undertaken by firms and households; and *2)* innovation capital acquired through research and development. It also provides comparable measures of tax incentives for investment in physical capital (inventories, equipment and buildings). Tax policies are characterised using the statutory parameters of the personal and corporate tax codes of 22 OECD countries. Two sets of personal tax parameter have been collected, one for the "average production worker[2]" and the other for a "top-bracket" taxpayer.

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1. Kathryn Gordon is a Senior Economist at the Organisation for Economic Co-operation and Development. Harry Tchilinguirian is a doctoral student at University of Paris IX-Dauphine. The authors wish to thank Steven Clark, Cornelius de Kam, Chiara Bronchi and Dominique Guellec for their contributions to and discussions of this paper and Sylvie Toly for expert programming assistance. The paper is the responsibility of the authors and does not necessarily reflect the views of the Organisation. Kathryn Gordon is the corresponding author. She can be reached at (331) 45-24-98-42 and at Kathryn.Gordon@oecd.org. Address: OECD Economics Department, 2 rue André Pascal, 75775 Paris Cédex 16, France.

2. The average production worker is defined to be an adult full-time production worker in manufacturing.

3. While these calculations clarify one aspect of government involvement in investment processes, they say nothing about whether the form and level of this involvement are appropriate. The arguments for and against the use of tax expenditures to promote intangible investment are complex and hinge on sector-specific issues of market structure, market failure and the role of governments. Discussions of these issues in relation to R&D can be found *inter alia* in Link (1996) and Lhuillery (1996) and in relation to human capital in Finegold (1995) and Stern and Ritzen (1991). The present paper provides an input into this debate. Estimating the returns to human capital investment is another important issue that is not directly addressed in this paper. Such estimates are much more difficult than simply estimating effective tax rates (e.g. they require information on who captures the gains from investment). Again, however, these tax rate estimates may serve as inputs to calculations of rates of return.

4. The paper begins with a general discussion of the King-Fullerton methodology in Section 1. In Section 2, the METR formula for household-sponsored human capital is derived and related data is described. In Section 3, the METR calculations are presented and discussed.

1. Calculating marginal effective tax rates on tangible and intangible investment

5. The methodology used here follows the approach first developed by King and Fullerton (1984). They invoke a standard investment rule -- that the marginal discounted after-tax cash flows of the marginal investment project must equal its marginal after-tax cost -- to derive the pre-tax return on investment in the project. A tax wedge can then calculated as the difference between this return and the post-tax real marginal rate of return required on this same investment project. In effect, the King-Fullerton (K-F) method uses the concept of cost of capital to form an index of tax influences on investment incentives. In particular, they provide a measure of how the tax system scales up (or down) the pre-tax rate of return that must be earned on investment project in order for it to yield a given after-tax return to households. The strengths of their method are considerable. It provides a way of indexing the incentive effects of a large number of tax and subsidy instruments in a manner that is solidly based in neo-classical economic theory (i.e. assuming perfectly competitive markets and rational economic agents). In particular, because of the method’s close attention to the timing of benefits and costs, it is consistent with investment theory. It shows how the level and timing of taxation affect decisions of firms and households to forego consumption today in order to have greater income-generating capacity in the future. It also integrates the tax implications of inflation.

6. The K-F method has a number of shortcomings, however. The most important of these is the fact that uncertainty -- an essential aspect of investment theory -- is not considered. Another important problem is that its view of financial structures and of the intermediation process is rudimentary. Thus, for example, firms have a fixed financial structure and cannot alter this structure in response to shifting tax incentives. Likewise, only the broad outlines of the functioning of the financial system appear in the K-F methodology. Several shortcomings are particularly noteworthy: 1. households do not issue debt on their own account, which eliminates the possibility of considering a range of important tax questions; 2. tax questions relating to the financial intermediation process cannot be considered since the method does not track corporate debt through the financial system to the final (personal) investor; 3. the types of financial instrument considered are limited. There is no venture capital, nor are there any other types of specialised financial intermediary (pension funds or other institutional investors). Finally, the method relies on statutory rates and not on the tax rates that firms and households actually face (once avoidance and evasion possibilities are accounted for).

7. This methodology has subsequently been extended in OECD (1991) and Devereux and Pearson (1995). The present paper follows the approach described in the OECD publication for domestic

investment in physical capital and extends this approach to provide comparable measures for human capital and research and development. A more detailed description of the OECD methodology and of its limiting assumptions can be found in the Annex. The tax parameters used in the calculations can be found on the last two pages of the Annex.

8. R&D tax policies involve instruments that are broadly similar to those used for physical investment. For this reason, the application of the K-F method to R&D is straightforward and will not be discussed here. The paper uses the methodology set forth in OECD (1991) and, for incremental tax credits[3], in Bloom *et al*. (1996). One specificity of R&D tax policy is that current expenditure is almost always expensed (the exception is New Zealand). Indeed, some countries allow companies to expense more than the actual R&D spending (Australia allows 150 per cent of R&D spending to be deducted and Austria allows 118 per cent) and others (e.g. Canada, Denmark, Spain and the United Kingdom) allow purchases of R&D equipment (and sometimes buildings[4]) to be expensed. Tax provisions relating to R&D have been collected for the 23 countries. The tax data used for the METRs are taken from a number of sources[5], while the economic depreciation rates for R&D investment projects are based on Goto and Suzuki (1989) and a review of the literature provided in Joly (1993). Joly notes that, in the United States, rates of economic depreciation (or rates of obsolescence) for R&D are very high -- in the vicinity of 25 per cent per year. Goto and Suzuki find, for R&D performed by Japanese manufacturers, that rates vary from a high of 25 per cent for precision machinery to a low of around 6 per cent for food. Based on these findings, this paper considers two types of R&D project: a short-lived project (the annual depreciation rate is assumed to be 25 per cent) and a long-lived project (the depreciation rate is 5 per cent)[6].

9. The application of the K-F method to human capital investment by firms (training) is also straightforward. Countries generally require immediate expensing of formal training expenses. Portugal -- which offers firms the option of amortising training expenditures over three years (but they may also be

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3. Bloom *et al.* propose a formula for valuing incremental R&D tax credits (that is, credits that are based on increments to R&D relative to some base level). They treat the value of incremental tax credits based on an average of the last k years of previous R&D as follows:

$$A_c = (1 - D_c \tau)\tau^c \left[1 - \tfrac{1}{K}\left(\sum\nolimits_{k=1}^{K}(1+r)^{-k}\right)\right]$$

where A_c is the value of the credit, D_c is 1 if the credit is taxable and zero otherwise, K is the number of years past research that counts in the base, *r* is the discount rate. This valuation formula assigns a steep discount due to the fact that investments undertaken in the current year raise the base the must be surpassed in subsequent years. The value of this discount (the final term in the brackets) is xx if K is 2 (so the base is the average over 2 years) and r is 5 per cent is about 93 cents per dollar of tax credit. The treatment for non-incremental credits is identical to the incremental formula except that the term in square brackets is set to one.

4. Denmark and the United Kingdom allow investments in buildings used for R&D to be expensed.

5. The tax parameters were taken from OECD (1996*a*), OECD (1997*a*), Clark *et al.* (1992), International Bureau of Fiscal Documentation (1996), Ministry of Finance (1996). A summary of the parameters used in these calculations for R&D and for physical capital is available upon request.

6. Notice that the depreciation rate on R&D only affects the METRs of countries that offer tax credits or “super-expensing”. For the others, the depreciation rate falls out in the algebra of the calculations. Note also that these annual (discrete time) economic depreciation rates are converted to continuous time equivalents using a formula that finds the continuous-time depreciation rate that gives the same discounted depreciation stream as the discrete time rate (see King-Fullerton, 1984, page 29).

expensed) -- is the only exception. When training costs are expensed, the value of tax allowances (the reduction in taxes due to the investment) is equal to the corporate tax rate. Thus, for the marginal investment in training, tax policy is neutral in the sense that the tax allowance equals the additional taxes paid on the returns from the investment. The effective tax wedges on training calculated later on, therefore, reflect only the effects of inflation and of the tax treatment of different funding sources[7]. Some countries offer tax breaks targeted on specific regions, firms (especially on small companies) or labour force segments (e.g. for hiring and training the long-term unemployed). Since this paper considers only universally available inducements, these targeted provisions are not considered[8].

2. The application of the King-Fullerton method to human capital

10. The tax environment surrounding human capital investment by households is somewhat more complex than for the other intangible assets. A number of considerations are relevant. First, most countries' personal tax codes treat household spending on human capital as consumption, so that it generates few or no write-offs. The reader will note that this treatment puts the household sector at a disadvantage relative to the corporate sector in sponsoring human capital investment[9]. Second, as documented in the human capital literature, the progressivity of personal income tax schedules is potentially important. Indeed, progressive tax schedules are often viewed as a tax on human capital accumulation (see, for example, Gravelle, 1984, Dupor *et al.*, 1996, Steuerle, 1996 and Trostel, 1993). If the only costs of household investment in human capital are earnings foregone while the studies are being undertaken, then a proportional tax system reduces the effective cost (the after-tax value of the foregone earnings) by the same proportion as the future after-tax benefits (i.e. both are reduced by one minus the personal tax rate). In contrast, a progressive tax system reduces the after-tax value of the future returns to education by more than it reduces the after-tax value the value of foregone labour market earnings. Hence, progressive personal tax systems tend to be particularly dissuasive of human capital investments whose returns accrue in the form of increases in taxable personal income. A third aspect of policy affecting household investment in human capital is the importance of direct subsidies -- including direct grants and public provision of services that are not charged at full cost -- in the policy mix.

11. Because of these special considerations, the application of the K-F method to human capital investment by households is worth considering at length. Normally, this method is applied to corporate investment decisions, but household-sponsored human capital investment circumvents the corporate sector's decision processes[10]. This is significant for two reasons. First, it implies that such investments

7. This can be seen by looking at equation [A 13] in the Annex. Since the training cost is expensed, it gives rise to an immediate deduction of τ. Hence $A=\tau$ and the terms (1-A) in the numerator and $(1-\tau)$ in the denominator cancel. This leaves only tax effects entering through cost of capital, ρ, and inflation, π.

8. Another measure that is not considered here is the French "taxe d'apprentissage", which contains elements of taxation and regulation. It requires that a certain percentage of the wage bill be spent directly on employee training, be donated to accredited tertiary institutions or be paid to the in the form of the "taxe d'apprentissage." This measure is not included in these calculations. We therefore implicitly assume that the regulatory floor it defines for a firm's training expenditure is not binding.

9. Among the 14 countries for which METRs for education were calculated, three countries provide tax relief for education expenditure. Italy offers a 22 per cent tax credit. The Netherlands allows occupation-related education expenditure to be deducted and Portugal allows deductions up to a limit. Germany and Austria allow deduction of expenses associated with sending a child away from home for occupational training. These last two countries' provisions are not included here.

10. Owner-occupied housing and some types of unincorporated private business are other investments that do not use the corporate sector as an "intermediary" investor.

are only affected by income taxes paid by households[11]. All other METRs calculated in this article (for investment in R&D, training, inventories, equipment and buildings investments by firms) reflect the combined effects of the personal and corporate tax systems. Second, it means that the marginal net present value rule that K-F originally applied to corporate decision-making applies instead to household decision-making.

12. In addition, there is some question as to whether the marginal concept is really appropriate for a "lumpy" investment project of the type that participation in multi-year degree programmes might represent. The education literature (although somewhat thin on this matter) provides some support in favour of the relevance of the marginal concept. In particular, Kane and Rouse (1993) and Grubb (1995) find that returns to degree programmes offered by "community colleges" (two-year colleges in the United States) are positive even if the student takes only a fraction of the course programme required to earn a degree. The present section develops the necessary equations and presents the parameters values that will be used in calculating the METR on education.

13. The derivation presented here is motivated in a slightly different way than the one presented in OECD (1991), but it provides identical results (except for the addition of a term relating to tax progressivity). OECD (1991) used the valuation of infinite stream of dividends in discrete time as the basis of its tax wedge. The present paper follows K-F in discounting an infinite stream of cash flows from the investment project[12], but, unlike K-F, it uses a discrete time formulation. Under this approach, the marginal discounted benefits from household-sponsored human capital investment can be expressed as follows:

$$[1] \qquad V = (1+\pi)(1-\tau)\,MRR\sum_{i=1}^{\infty}\frac{[(1+\pi)(1-\delta-\Omega)]^{i-1}}{(1+\rho)^{i}}$$

Note that the term to the right of the summation sign must be positive (if a rational investor is to invest).

If convergence conditions hold[13], equation 1 converges to:

$$[2] \qquad V = \frac{(1+\pi)(1-\tau)\,MRR}{\rho+\delta(1+\pi)+\Omega(1+\pi)-\pi} = \frac{(1+\pi)(1-\tau)(p+\delta)}{\rho+\delta(1+\tau)+\Omega(1+\pi)-\pi}$$

This is a simple expression for the discounted future after-tax benefits that the household's investment in human capital is expected to generate.

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11. The calculations assume, in particular, that all returns to human capital will be realised as increments to wage or salary income. For this reason, social security taxes are applied to these income streams, but not to income from capital. All personal tax rates are taken from the OECD tax equations (an Excel spreadsheet programmes that gives tax simulations). In addition, for household sponsored human capital, the tax rates reflect personal income taxes, social security contributions by employees and, where relevant, sub-national rates (using "typical rates" published in OECD, 1997*a*) are also added.

12. As under the K-F method, this infinite series of marginal cash flows can be thought of as an approximation to the "true" problem of valuing the finite series of cash flows generated over the project's finite economic life. The reason this approximation is used is that it avoids the inconvenient polynomials that arise in the finite version of the problem.

13. These require that $(1+\pi)(1-\delta-\Omega) < (1+\rho)^{2}$.

14. In this equation, *MRR* is the gross marginal real rate of return to this increment to the human capital stock[14] -- it is equal to the pre-tax marginal real return net of depreciation, *p*, plus the rate of economic depreciation, δ, of the human capital project. *MRR* is assumed to accrue in the form of increased real wages relative to what the worker would earn if he did not undertake further education. τ is the investor's current tax rate on labour income[15]. ρ is the household's nominal discount rate and thus is equal to *(1-m)i* where *i* is the interest rate and *m* is the tax rate applied to a demand deposit[16]. The nominal interest rate is assumed to consist of a component related to the real interest rate (assumed to be 5 per cent for all countries) and an inflation component (measured as the country-specific inflation rate prevailing in 1996). *MRR* grows at the rate of inflation, π. Tax progressivity is introduced via the term Ω, which "discounts" future pre-tax dollars back to their equivalent in current "gross of tax" income.

15. The calculations of Ω use two data points: the end of career tax that is paid on average by a person who has completed a college degree and the average production worker's current tax rate. Ω is the geometric growth rate that equates the current gross income (that yields one unit of net income) equal to the future gross income (that also yields one unit of net income), given the increase in the tax rate that is expected to occur due to the investment in education. Thus, Ω reflects the additional tax (over and above the current labour tax rate, τ, the average production worker pays) that will have to be paid as a result of the education investment[17]. If the tax schedule is flat, then Ω is zero, but if it is progressive and if education is expected to cause movement into higher tax brackets, then it is positive.

16. The estimated values of Ω are presented in Table 1. Column 1 shows "unadjusted" values for Ω, while column 2 presents "adjusted" values that remove shifts into higher tax brackets that are expected to

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14. Note that "real return" is in reference to the purchasing power of the currency at the time the investment is made (that is, time equal to zero). The initial multiplication by $(1+\pi)$ accounts for inflation during the period in which the investment is made.

15. τ includes all types of taxation applicable to such income (personal taxes, employee social security taxes and local income taxes).

16. Note that the discount rates applied to the investments channelled through the corporate sector (physical investment, R&D and training) are set so that they yield a gross return to the household sector that allows it to earn the same after-tax return as on the demand deposit while also paying whatever taxes apply to that form of income. Thus, for retained earnings (which is assumed to generate only taxable capital gains) the discount rate is the ρ_c that solves $(1 - z)\ \rho_c = (1 - m)i$.

17. The calculation of Ω is made using data underlying tables published in OECD (1996*b*) and OECD (1997*a*). Data on earnings by cohort and education level are used to determine end of career income levels under different levels of education attainment. Although data availability varies by country, two data points were generally taken -- end-of-career gross earnings (for both males and females) with a college degree and end-of-career gross earnings with a secondary school (high school) diploma. These are then used to locate the two end-of-career earnings in the tax schedule. An adjustment is then made to account for the increase in tax rates that would normally have occurred even without the investment in education: the increase in statutory tax rates experienced by someone whose education ends in secondary school is subtracted from the end-of-career statutory rate of a person with a college degree. The movement between the lower and the higher tax rate is assumed to occur smoothly throughout the person's career. The "tax discount rate" -- Ω -- is then calculated as the discount rate that sets the current tax rate equal to the adjusted future tax rate assuming that the length of career is 30 years (i.e. $\Omega = [(1+\tau$ (end of career with possible adjustment))/$(1+\tau$ (average production worker))]^(1/30)). For countries that had all other data necessary to calculate the wedge but no data on income across careers (Austria, Germany, Japan and Spain), the Ω estimates assume that the investor ends his career at the top marginal rate. In some cases this assumption does not matter (because the average production worker already pays the top rate), but for Japan and Spain (both of which have steep tax schedules) it is a restrictive assumption.

occur even if the average production worker does not undertake further education (this turns out to make a difference only for France and Portugal). The adjusted value is used in the calculations. For Sweden, the estimated Ω is 0.57 (both adjusted and unadjusted). This means that future income streams need to be discounted by an additional 0.57 percentage points in order to account for the expected upward shift in future tax rates. Since the real after-tax discount rate in Sweden is 3.36 per cent[18], the progressivity of the Swedish tax code is equivalent to adding about a sixth to the cost of capital for human capital investment for Sweden's average production worker. The fact that the adjusted and the unadjusted Ω are equal in Sweden means that a person who leaves school with a secondary diploma (i.e. at 17-18 years old) does not usually change tax brackets by the time he retires. Note that the value of Ω reflects two things: *1)* the steepness of the career earnings profile and *2)* the steepness of the tax schedule relative to the average production worker's initial income position. Thus, Ω can be zero for two reasons -- the tax schedule may not be progressive or, even if it is, education may not increase earnings enough to raise the average production worker's tax bracket in the course of his career (this is the case for Canada and the United States). Note also that for the top-bracket taxpayer Ω is, by definition, zero.

17. The discounted benefits (equation 2) are then set equal to *C*, the after-tax and after-subsidy effective cost of the incremental dollar of investment (*A* in equation 3 shows how subsidies and taxes reduce the effective cost of a unit of investment). Gross costs consist of two components: the share of foregone earnings in the marginal dollar of gross costs -- *w* -- and the share of direct costs in the marginal dollar -- defined as (1-*w*). The effective cost (after taxes and subsidies) for the investor can be expressed as follows:

$$[3] \qquad C = (1 - A) = (1 - \tau)w + (1 - \gamma)(1 - w)$$

The right-hand side of this equation divides the effective cost into two components: the first is the share of costs stemming from foregone earnings reduced by the taxes that would have been paid on those earnings -- $(1-\tau)w$. The second is the share of direct costs in total gross costs, (1-*w*), reduced by the public grant rate -- labelled γ.

18. The estimated parameter values for *w* and γ in equation 3 (i.e. the shares of foregone earnings and direct costs in gross cost and the grant rate) are reported in Table 2 for an "average production worker" and for a person who pays the top personal income tax rate[19]. The calculations assume that average parameter values apply on the margin. Total spending per student is the sum of private and public spending per student. Foregone earnings for the two types of taxpayer considered here (the "average production worker" and the "top-bracket" payer) are the average production worker's gross earnings and the first gross income that pays the top-bracket rate (i.e. as the income level that defines the lower bound on the top bracket). Take the case of the average production worker as an example. For him, *w* (shown in column E) is calculated as foregone earnings (column D) divided by the sum of gross earnings (column D) and total spending per student (column A). The grant rate γ (which is assumed to be the same for the

18. This 3.36 per cent is calculated as follows. The real market rate paid on the demand deposit is assumed to be 5 per cent. Sweden's 1996 inflation rate was 0.47 per cent, so that the nominal interest rate paid on a Swedish demand deposit is 5.49. The personal tax on demand deposits is 30 per cent in Sweden.

19. These calculations assume that the top-bracket earner's income is the first gross income level at which the highest statutory tax rate applies (i.e. it is the income level that defines the starting point for the top bracket). This level was determined by using the OECD tax equations to calculate the gross income that corresponds to the first taxable income level to which the top bracket applies. Thus, the calculation assumes that standard deductions apply. Gross income for the average production worker is a published in OECD (1997*b*).

average production worker and the "top bracket" taxpayer) is calculated as the share of public spending per capita in total spending (underlying data not shown, but they are available in OECD, 1996*b*). Table 2 confirms Boskin's (1977) conjecture that foregone earnings constitute the bulk of gross direct investment costs for household investment in human capital -- the countries with the lowest shares of foregone earnings in gross total costs are Sweden and the United States (where, for the average production worker, the shares are 62 per cent and 64 per cent, respectively).

19. Setting the marginal after-tax and after-subsidy cost of the investment project equal to the project's after-tax marginal discounted benefits and then solving for *p*, the pre-tax return net of depreciation, yields the following:

$$[4] \qquad p = \frac{(1-\tau)w + (1-\gamma)(1-w)}{(1-\tau)}[\rho + \delta(1+\pi) + \Omega(1+\pi) - \pi] - \delta$$

This equation is used to calculate the METRs for households' investments in tertiary education. As noted earlier , the discount rate, ρ, applied to this investment is the after-tax rate of return on demand deposits. This is also, by construction[20] (see OECD, 1991), the minimum post-tax return to households that all investments intermediated through the corporate sector (i.e. taking the form of new issues or retained earnings) must yield. Thus, the METRs on household investment in human capital are comparable to those calculated for the other investments made via the corporate sector in that all investments must yield the after-tax return on bank deposits.

3. Findings

20. The results of these calculations are reported in Tables 3 and 4. The first column in both tables presents the real after-tax return on a bank deposit prevailing in the countries studies. All other returns are stated with respect to this basic rate of return. That is, the METRs in the other columns show how much more (or less) than this after-tax real return on a bank deposit must be earned on an investment (before corporate and personal taxes are paid) if the project is to pay the same after-tax return to an investor[21] as the demand deposit. Thus, for example in Table 3, the tax wedge of -4.46 on machinery in the United States means that an investment by the corporate sector in machinery can earn -4.46 per cent less than the after-tax deposit rate (equal to 2.23 per cent in the United States) and still pay that after-tax rate of return to an investor. In other words, the corporate sector's investment in machinery can lose money (before corporate and personal taxes) and still pay the same return as a bank deposit to a personal investor.

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20. Both K-F and OECD (1991) construct the interface between the corporate and household sectors' investment processes as follows: the after-tax return to a household associated with an investment in a financial instrument (retained earnings are assumed to generate only capital gains, and new issues are assumed to generate only dividends) is equal to the after-tax rate of interest paid on a demand deposit. Both approaches adopt the point of view of an equity investor in the corporate sector and, consequently, the cost of debt is independent of the personal tax system (since individuals are assumed not to invest directly in corporate bonds).

21. This strong negative wedge on equipment is mostly due to the United States' very generous depreciation rules (see tax parameters in Annex).

21. The tables present METRs for two funding sources[22] (retained earnings and new equity) and for three types of physical investment (machinery, buildings and inventories[23]). Two types of R&D tax wedge are presented, one for "long-lived" R&D projects and the other for "short-lived" projects. METRs for two human capital projects are also presented in the tables. The first is for firm-sponsored training, which is assumed to have a short economic life (three years) and the second is for household-sponsored human capital, which is assumed (with support from literature) to have a long economic life (30 years). Table 3 presents METRs that reflect tax wedges introduced by the personal and corporate tax systems given that the personal taxpayer in question is the "average production worker," while Table 4 presents METRs for the "top-bracket" taxpayer. The main findings are summarised below:

22. *On average, intangible investment receives more favourable tax treatment than physical investment*. The tax treatment of all categories of intangible investment -- R&D and training by firms and tertiary education by households -- is decidedly more favourable, on average, than for any category of physical investment. With the exception of firm-sponsored training (where the average wedge is very small), the average wedges on all intangible assets are negative. As is found in a number of other studies (Chennells and Griffith, 1997, and OECD, 1991), machinery investment tends to be the most favoured among the physical investment categories, followed by buildings and then inventories (which receives the least favourable tax treatment among the seven assets studies).

23. *R&D receives the most favourable tax treatment of any investment category*. On average for the countries covered, short-lived R&D is the most favoured type of investment. The average METRs for short- and long-lived R&D (-1.51 per cent and -0.28 per cent, respectively, in Table 3) hide significant variation among countries, however. In fact, the favourable average METRs on R&D stem mainly from the large tax subsidies offered by only a few countries. These give rise to strongly negative tax wedges that pull down the overall average. For short-lived R&D, the high tax-expenditure countries include Spain (-9.4 per cent for the average production worker), Australia (-6.6 per cent), Canada (-4.9 per cent) and the United States (-4.7 per cent). In contrast, most other countries tend to have modestly positive METRs on R&D and a few others, modestly negative. Thus, while the tax environment for R&D is generally advantageous (compared to physical capital) in most countries, a limited number of countries offer very strong tax inducements in favour of R&D. The reader will note that long-lived R&D always receives either less favourable tax treatment than short-lived R&D or identical treatment. The less favourable treatment occurs in those countries that offer special tax credits for R&D or "super-expensing" (i.e. firms may deduct more than 100 per cent of current R&D expenses). This reflects the fact that policies that "front load" tax benefits provide stronger inducements for shorter-term projects than for longer-term projects. Comparing a four-year R&D project with a 20-year project, for example, it is clear that the four-year project will benefit from the tax inducements five times in a span of 20 years while the 20-year project will benefit from them only once.

24. *Household investment in tertiary studies also receives favourable treatment, but this stems from direct subsidies, not from tax policy.* The most common strategy with respect to tertiary education is to provide large direct subsidies (via expenditure programmes) in order to induce households to invest in education and then to tax away these inducements. Thus, what governments give with one hand

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22. The balance sheets underlying the calculations involving the corporate sector are the same as those assumed in OECD (1991). The balance-sheet configuration -- corresponding to a fairly capital-intensive manufacturing company -- is as follows: asset composition (50 per cent machinery, 28 per cent buildings, 22 per cent inventories); composition of liabilities and equities (55 per cent retained earnings, 10 per cent new equity and 35 per cent debt).

23. The wedges for physical capital use tax parameters that pertain to the manufacturing sector.

(subsidies) they tend to take away with the other (taxes). Table 5 sheds some light on this strategy. In column 1, it presents what the METR would be if all costs were direct costs and using the direct subsidy parameter, γ, as A (i.e. w is set to zero). Considering only direct costs and governments' subsidisation of these costs, the average METR on tertiary education is -4.13 per cent (see column 1 of Table 5). The full METR rises to -0.99 per cent, on average, once all taxes and subsidies are accounted for (column 2 of Table 5, which is the same as the final column of Table 3). Thus, on average, tax systems tend to offset the incentives created by direct subsidies to tertiary education but do not eliminate them entirely. In the eight countries where tax progressivity is a factor (Australia, Austria, Finland, France, Germany, Japan, Spain and Sweden), a non-negligible part of this "offset" comes from the progressivity of the tax system. This can be seen by looking at column 3 in Table 5, which sets the tax progressivity parameter equal to zero. The wedge calculated with Ω set to zero is an average of -1.18, whereas the total wedge for these eight countries averages -0.86. Thus, progressivity accounts for about 0.32 percentage points of the tax wedge in these countries. The reader should keep in mind that the quality of the data on income and education attainment that underpins the progressivity coefficient is the weakest[24] among the many data sources used for these calculations. But, subject to this limitation, the calculations reported in column 3 of Table 5 suggest that, for countries where tax schedules are progressive and where education causes significant movement across tax brackets, progressivity forms an important part of the tax environment in which household education decisions are made.

25. *Tertiary education undertaken by households almost always receives more favourable tax-subsidy treatment than enterprise-based training.* Steuerle (1996) points out that differences in the tax treatment of different forms of human capital investment create incentives for relabelling (e.g. converting informal to formal training, if the latter is tax-favoured) or for arbitrage (e.g. for employers providing or sponsoring education as a form of non-wage compensation to employees if corporate channels are more tax-favoured than household channels). The numbers presented here suggest that, on average, the incentive for arbitrage between firm- and household-sponsored training is not enormous for most countries, but that it does exist. In many countries, the household sector has a clear tax-subsidy advantage (relative to the corporate sector) in sponsoring human capital investment. This suggests that tax systems tend to favour arbitrage whereby human capital formation (even that required by the corporate sector) is channelled through the household sector. Incentives for this appear to be particularly strong in Austria, Canada, Finland, the Netherlands, Sweden and the United States[25]. Japan is definitely an exception in this respect. The direct subsidies it provides for tertiary education are quite small and its personal tax system is very progressive. Thus, for the average production worker in Japan, it makes more sense (from a tax perspective) to invest in human capital via the corporate sector.

26. *The tax environment for the average production worker who invests tends to be slightly more advantageous than the tax environment for the top-bracket investor, but progressive tax codes do not*

24. These data are weak in the sense that they pertain to a particular population observed at a single point in time. Using cross-sectional data to make inferences about income dynamics may introduce biases if the processes generating incomes for the different cohorts are not be stable across time. Another problem is that the income data are not available for some countries.

25. Since the favourable tax wedge for household-sponsored human capital stems from direct subsidies for tertiary studies then the logic of this arbitrage argument might not hold if the firms also qualify for these subsidies. Denmark is a case in point. A significant share of firm-sponsored training in Denmark is carried out in labour market training centres where firms pay only 30 per cent of the direct cost. The rest comes from various sources, including earmarked taxes paid by all salaried employees. Treating this as equivalent to a 70 per cent grant rate and assuming that the value of foregone output (while the employee is in training) is 60 per cent of gross marginal costs, the estimate of the tax-subsidy wedge on firm sponsored training is about -7.0 per cent.

translate neatly into progressive investment incentives. The relationship between the two sets of tax wedges shown in Tables 3 and 4 is a complex one -- it reflects *inter alia* the tax treatment of different sources of financing (are earnings treated like ordinary income or are they subject to special tax regimes? is there optional withholding? etc.) and the tax treatment of deposits. While the average production worker faces tax wedges that are, on average, more favourable (i.e. lower) than those facing the top-bracket taxpayer, it is not necessarily true that progressive personal tax schedules translate into progressive investment incentives[26]. For example, among the sources of financing, the average production worker faces a tax "penalty" for retained earnings (as can be seen by comparing Tables 3 and 4, his average wedge on retained earnings is 0.2 percentage points higher than the top-bracket taxpayer's wedge). This is because wedges on retained earnings reflect the preferential tax treatment of capital gains offered in many countries. The reader should keep in mind that, following K-F and OECD (1991) methodologies, the "new equity" investment represents an investment that will remunerated with dividends while retained earnings will be remunerated with capital gains[27].

27. The United States' tax treatment of retained earnings shows how special tax regimes can interact with generally progressive tax structures. The US tax system imposes a significantly lower tax rate on retained earnings (i.e. on capital gains, which were taxed at 28 per cent in 1996) than on other types of investment income (dividends and interest are both treated as ordinary income). The METR calculations reflect *inter alia* differences in tax treatment of investment instruments. Thus, lowering the capital gains tax relative to rates applied on ordinary income automatically favours the top-bracket taxpayer (who pays 46.6 per cent on ordinary income[28]) relative to the average production worker (who pays 35.5 per cent on ordinary income). This creates a strong tax clientele (consisting mainly of high-income taxpayers) for investments offering opportunities to earn capital gains.

28. *Tax incentives for household investment in tertiary education are regressive in a few countries.* In Japan, and Sweden[29], it is notable that the tax incentives for the average production worker investing in tertiary education are weaker than those facing the top-bracket earner. Sweden provides a particularly interesting case study in this respect. This paper's treatment of progressivity -- which assumes that tax increases occur smoothly across the worker's career -- does not fully capture the nature of the incentives created by the Swedish tax system. Sweden's tax schedule has one very high step up (worth 25 percentage points of marginal taxation). This occurs somewhat above the gross income of the average production worker (about 205 000 kronor). If we had incorporated an income level that was about 20 per cent higher than that of the average production worker (about 45 000 kronor higher), the value of Ω would have been zero. This means that Sweden's tax system creates a kind of "education trap" at income levels

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26. In order to get a sense of the size of this advantage in terms of the rates paid on taxable income, these tax wedges (which are measured in percentage points of marginal taxation) need to be divided by real taxable income. Take an investment in new equity as an example. The gross real return to a demand deposit is assumed in these calculations to be 5 per cent and the average production worker enjoys an average tax advantage of :43 percentage points of marginal taxation compared to the "top bracket" investor when investing through new equity (that is, 3.01 minus 2.58). In terms of gross income, this is equivalent to about 9 per cent of the real gross income earned on the investment (that is .43 per cent divided by (per cent).

27. In practice, the distinction between the forms of remuneration of new equity and retained earnings would not be this sharp. Financial managers can and do arbitrage between the two as a function of the tax treatment they believe will be most highly valued by investors.

28. This includes "typical" rates of sub-national taxation, as given in the *OECD Tax Database.*

29. Note that this also holds for Ireland, where it is due to the fact that the average production workers' gross earnings are higher than the top bracket taxpayer's gross earnings.

close to or below those of the average production worker (that is, it creates strong disincentives to invest in education) but is largely neutral once higher income levels are achieved.

29. As noted earlier, though, such results should be viewed with caution. They are influenced by the measure of the progressivity tax on education, which in turn depends on relatively weak data on income at different points in a worker's career. Nevertheless, the results suggest that, at least for these countries, lowering the progressivity of the tax code has the potential to enhance incentives to invest in education for people with moderate incomes.

Table 1. **Tax progressivity parameters (1996)**[1]

Per cent

	Unadjusted[2]	Adjusted[2]
Australia	0.21	0.21
Austria[3]	0.38	..
Canada	0	0
Finland	0.13	0.13
France	0.38	0.18
Germany[3]	0.20	0.20
Iceland[3]	0.11	0.11
Ireland	0	0
Italy	0	0
Japan[3]	0.62	..
Netherlands	0	0
Portugal	0.24	0
Spain[3]	0.72	..
Sweden	0.57	0.57
United States	0	0

1. The discount factor that brings future earnings back to their current gross amount.
2. In the second column the progressivity is adjusted for the progression of personal tax rates that a person with a secondary education experiences in the course of his career. That is it corrects for increases in personal tax rates that are unrelated to investment in education.
3. No data available on career earnings profile. This calculation assumes that the end of career salary is taxed at the top marginal rate.

Table 2. **Composition of investment costs for tertiary education**

	Direct costs (1994)		Foregone earnings (1996)		Composition of gross costs (share of foregone earnings %)	
	Spending per student (national currency)	Grant rate (per cent)	Top bracket tax payer[1] (national currency)	Average production worker[2] (national currency)	Top bracket W (per cent)	Average Production Worker W (per cent)
	A	B	C	D	E	F
Australia	13 028	79	50 000	35 287	79	73
Austria	121 393	99	832 195	295 000	87	71
Canada	14 073	86	62 193	33 316	82	70
Finland	37 380	100	309 724	137 046	89	79
France	39 813	82	462 220	121 000	92	75
Germany	17 345	92	130 129	57 579	88	77
Iceland	--	96	2 893 565	1 511 000	..	..
Ireland	5 005	81	12 340	14 150	71	74
Italy	7 438 785	91	334 292 607	35 753 220	98	83
Japan	1 607 369	33	34 279 878	4 175 381	96	72
Netherlands	18 144	98	115 146	56 444	86	76
Portugal	789 695	90	6 514 961	1 297 801	89	62
Spain	489 008	80	7 002 572	2 174 700	94	82
Sweden	126 926	96	250 365	204 714	66	62
United States	15 510	52	267 400	27 482	95	64

1. The lowest amount of income that is subject to the highest personal tax bracket.
2. The average gross earning of the average production worker in 1996.

Sources: Calculated from data in OECD tax equations; *Education at a Glance* (1996*b*); and *The Tax Benefit Position of Employees* (1997*b*).

Table 3. **Tax wedges for the average production worker**

Includes personal and corporate income taxes (1996 taxes parameters and country-specific inflation rates)

	Bank deposit[1]	Retained earning[2]	New equity[2]	Machinery[2]	Buildings[2]	Inventories[2]	R&D		Training[2]	Tertiary studies[2]
							Short-lived[2]	Long-lived[2]		
Australia	2.39	2.70	0.61	1.66	1.81	3.28	-6.60	-1.54	0.27	-0.86
Austria	3.50	1.22	3.23	0.42	0.96	2.53	-2.45	-0.78	-0.14	-1.68
Belgium	3.95	1.80	3.23	0.14	1.27	3.15	-0.47	-0.47	-0.51	
Canada	3.03	3.27	3.41	1.42	3.02	3.91	-4.85	-1.25	0.26	-1.40
Denmark	1.56	1.37	1.79	1.29	1.59	2.83	-2.65	-0.34	0.63	
Finland	3.44	1.97	0.71	1.06	1.55	2.23	0.53	0.53	0.48	-1.35
France	3.54	2.66	1.77	1.41	1.42	3.03	-1.52	-0.45	-0.10	-0.86
Germany	2.82	1.60	0.22	0.64	1.40	1.68	-0.21	-0.21	-0.35	-1.02
Greece	5.00	2.42	2.42	1.66	0.54	2.72	-0.51	-0.51	-0.57	
Iceland	5.00	4.80	8.48	2.64	3.02	4.46	0.79	0.79	0.52	
Ireland	1.86	2.30	2.45	1.77	2.18	3.34	0.78	0.78	0.78	-0.77
Italy	3.91	6.14	4.61	2.19	3.14	6.92	-0.45	-0.45	-0.78	-0.85
Japan	3.97	2.15	4.83	0.82	3.03	2.51	-0.08	0.15	0.08	1.28
Luxembourg	1.81	2.58	1.47	1.73	2.15	3.55	1.02	1.02	0.91	
Netherlands	1.48	0.74	5.57	1.44	2.09	1.91	-3.91	-0.45	0.72	-1.14
New Zealand	2.61	1.89	1.89	1.78	1.70	2.39	0.70	0.28	0	
Norway	3.25	0.85	0.85	0.70	0.99	1.52	-0.06	-0.06	-0.16	
Portugal	3.39	2.29	4.71	1.55	1.60	1.84	-0.12	-0.12	-0.12	-2.25
Spain	2.93	2.17	-0.63	0.39	1.66	1.73	-9.43	-2.89	-0.10	-0.19
Sweden	3.36	1.99	2.63	1.31	1.70	2.49	0.81	0.81	0.72	-1.98
United Kingdom	3.15	2.39	1.46	1.22	1.67	2.94	0.14	0.14	0.14	
United States	2.23	-0.79	1.14	-4.46	2.71	2.07	-4.72	-1.12	0.37	-0.33
Average[3]	3.02	2.21	2.58	1.03	1.87	2.85	-1.51	-0.28	0.09	-0.96

1. This is the post-tax real return on a bank deposit, as shown in equation A2 in the Annex.
2. The wedge is defined as the difference between p (see Annex equation A13) and the after-tax real return on a demand deposit (column 1). Columns 2-10 represent how much more than the return on a demand deposit (in percentage terms) an investment must yield before tax in order to pay to a personal investor the after-tax return as the bank deposit.
3. Simple average.

Table 4. **Tax wedges for the top bracket earner**

Includes personal and corporate income taxes (1996 taxes parameters and country-specific inflation rates)

	Bank deposit[1]	Retained earning[2]	New equity[2]	Physical Assets			R&D		Training[2]	Tertiary studies[2]
				Machinery[2]	Buildings[2]	Inventories[2]	Short-lived[2]	Long-lived[2]		
Australia	1.39	2.30	0.91	1.87	1.95	3.34	-6.07	-1.01	0.67	-0.58
Austria	3.50	1.22	3.23	0.42	0.96	2.53	-2.45	-0.78	-0.14	-0.84
Belgium	3.95	1.80	3.23	0.14	1.27	3.15	-0.47	-0.47	-0.51	
Canada	2.35	3.21	3.67	1.71	3.20	4.06	-4.43	-0.83	0.63	-0.68
Denmark	0.56	0.97	1.44	1.46	1.68	2.76	-2.27	0.05	0.92	
Finland	3.44	1.97	0.71	1.06	1.55	2.23	0.53	0.53	0.48	-0.73
France	3.54	2.66	5.67	1.77	1.82	3.46	-1.33	-0.21	0.17	-0.03
Germany	1.57	0.99	1.48	1.01	1.56	1.31	0.32	0.32	0.21	-0.41
Greece	5.00	2.42	2.42	1.66	0.54	2.72	-0.51	-0.51	-0.57	
Iceland	5.00	5.22	9.93	2.99	3.40	4.86	1.07	1.07	0.79	
Ireland	1.86	2.30	2.45	1.77	2.18	3.34	0.78	0.78	0.78	-0.86
Italy	3.91	6.14	4.61	2.19	3.14	6.92	-0.45	-0.45	-0.78	-0.08
Japan	3.97	2.15	4.83	0.82	3.03	2.51	-0.08	0.15	0.08	0.79
Luxembourg	1.81	2.58	1.47	1.73	2.15	3.55	1.02	1.02	0.91	
Netherlands	0.78	0.50	6.27	1.67	2.25	2.02	-3.53	-0.07	1.04	-0.54
New Zealand	2.61	1.89	1.89	1.78	1.70	2.39	0.70	0.28	0	
Norway	3.25	0.85	0.85	0.70	0.99	1.52	-0.06	-0.06	-0.16	
Portugal	3.39	2.29	4.71	1.55	1.60	1.84	-0.12	-0.12	-0.12	-0.64
Spain	0.27	0.55	-0.96	0.65	1.56	1.27	-7.63	-1.37	0.72	-0.11
Sweden	3.36	1.99	2.63	1.31	1.70	2.49	0.81	0.81	0.72	-2.00
Switzerland	2.96	1.24	4.13	0.93	1.64	2.14	..	..	..	
United Kingdom	2.04	2.27	1.92	1.65	2.01	3.22	0.69	0.69	0.69	
United States	1.34	-1.39	1.70	-4.27	2.62	1.94	-4.36	-0.76	0.64	0.01
Average[3]	2.69	2.01	3.01	1.15	1.93	2.86	-1.26	-0.04	0.33	-0.48

1. This is the post-tax real return on a bank deposit, as shown in equation A2 in the Annex.
2. The wedge is defined as the difference between p (see Annex equation A13) and the after-tax real return on a demand deposit (column 1). Columns 2-10 represent how much more than the return on a demand deposit (in percentage terms) an investment must yield before tax in order to pay to a personal investor the after-tax return as the bank deposit.
3. Simple average.

Table 5. **Human capital investment by households: the effects of direct subsidies and tax progressivity on the average production worker's tax wedge**

	Wedge due to direct subsidies only	Total wedge	Wedge with tax progressivity set to zero
Australia	-3.79	-0.86	-1.04
Austria	-6.68	-1.68	-1.95
Canada	-4.71	-1.40	..
Finland	-6.77	-1.35	-1.45
France	-4.01	-0.86	-1.01
Germany	-5.07	-1.02	-1.18
Ireland	-2.96	-0.77	..
Italy	-4.96	-0.85	..
Japan	3.01	1.28	0.61
Netherlands	-4.68	-1.14	..
Portugal	-5.94	-2.25	..
Spain	-4.24	-0.19	-0.82
Sweden	-6.10	-1.98	-2.35
United States	-0.93	-0.33	
Average	-4.13	-0.96	-1.14

METHODOLOGICAL ANNEX

This Annex describes the formulas used in the METR calculations. It follows the methodology used in OECD (1991), *Taxing Profits in a Global Economy -- Domestic and International Issues.* The difference between the two sets of formulas is that this one eliminates the terms related to cross-border taxation that appeared in the 1991 equations. This reflects the fact that the present paper considers only domestic tax incentives.

King and Fullerton (1984) originally developed the methodology used here.

The following summarises notational conventions.

r	Real interest rate, assumed to be 5% across all countries
i	Nominal Interest Rate
s	The post tax return to investors, or cost of capital
π	Inflation
τ	Corporate Tax Rate
δ^{eco}	Economic Depreciation
ρ'	Discount rate applied in the METR calculations
A	The present value of depreciation allowances for tax purposes
δ^{A}	Depreciation rate used in calculating net present value of depreciation allowances
m^{i}	Personal tax rate on interest income (on Bank Deposits)
m^{d}	Personal tax rate on dividend income
z'	tax rate on capital gains income, see below for applied rate z'
θ	Imputation rate
v	Share of FIFO Inventories. When Inventories are value by FIFO, v = 1 ; when valued at LIFO, v = 0

Nominal interest rate (i) and post-tax real return to investors (s):

[A1] $$i = (1 + r)(1 + \pi) - 1$$

[A2] $$s = \frac{1 + i(1 - m^{i})}{1 + \pi} - 1$$

Discount rates (ρ) per source of financing:

[A3] Retained Earnings: $$\rho' = \frac{(1 - m^{i})i - z'\pi}{1 - z'}$$

[A4] New Equity: $$\rho' = \frac{(1-\theta)(1-m^i)i - z'\pi}{1-m^d}$$

[A5] Debt: $$\rho' = i(1-\tau)$$

z' is the accrual equivalent capital gains tax rate applied to nominal gains. To calculate this rate, it is necessary to make some assumptions regarding the time at which the shareholder sells his shares, realises his gains and hence faces a tax liability. OECD (1991) assumes that the shareholder sells a constant proportion (α) of his stock in each period. We assume for all countries that gains are taxed in the period they are realised. In these calculations and in OECD (1991) α is assumed to be 10 per cent. The statutory corporate tax rate, z, is then given by:

[A6] $$z' = \alpha z \left[1 + \frac{1-\alpha}{1+j} + \frac{(1-\alpha)^2}{(1+j)^2} + \frac{(1-\alpha)^3}{(1+j)^3} + \ldots + \right] = \frac{\alpha z(1+j)}{(\alpha + j)}$$

$$j = i(1-m^i)$$

Net present value on a unit of capital of depreciation allowances (A) for tax purposes:

A_{SL} represents the net present value of tax allowances under straight-line depreciation whereas A_{DB} represent the value of allowances under a declining balance; (N) is the number of years for which a depreciation allowance can be claimed.

[A7] $$A_{DB} = \frac{\delta^A \tau (1-\rho')}{(\rho' + \delta)}$$

[A8] $$A_{SL} = \frac{\delta^A \tau (1-\rho')}{\rho'} \left[1 - \frac{1}{(1+\rho')^N} \right]$$

In some countries it is possible to switch from using the declining balance system to the straight-line system. If the declining balance system has a rate of δ^A_1, and is used for M years and the straight-line system for a further N years, the net present value $A_{DB/SL}$ is then given by.

[A9] $$A_{DB/SL} = A_{DB} \left[1 - \frac{(1-\delta^A_1)^M}{(1+\rho')^M} \right] + \left[\frac{A_{SL}}{(1+\rho')^M} \right]$$

Net present value on a unit of capital of depreciation allowances (A) for tax purposes in R&D:

With regards to the treatment of tax credits in R&D, the net present value of the overall allowance (A) is treated as the sum of a standard depreciation allowance (A_d) and the tax credit allowance (A_c).

[A10] $$A = A_d + A_c$$

A_d are obtained as just described, while A_c, the net present value of the tax credit, is obtained following Griffith *et al.* τ^c is the tax credit rate. This method gives the following for tax credits offered using current expenditure levels as the base:

[A11] $A_c = (1 - D_c . \tau)\tau^c$

For incremental tax credits using increases in expenditure relative to a past average (and **under the assumption of positive current growth and expected future growth in R&D expenditures),** the formula is:

[A12] $A_c = (1 - D_c . \tau)\tau^c \left[1 - \frac{1}{k} (\sum_{k=1}^{K} (1+r)^{-k}) \right.$

with (r) the discount rate, K the number of years over which the expenditure is averaged to define the base. $\boldsymbol{D_c}$ represents the portion of R&D which is deducted from taxable income. When the credit is taxable, D_c is set to 1, if not D_c is set to zero.

The Pre-tax Rate of Return (p) used for all assets (except inventories valued at FIFO) is given by:

[A13] $p = \frac{(1 - A)}{(1 - \tau)(1 + \pi)} \left[\rho' - \pi + \delta^{eco}(1 + \pi) \right] - \delta^{eco}$

When inventories are valued using the FIFO method, an extra term must be added to account for the inflation tax associated with inventory revaluation. The share of FIFO-valued inventories is denoted by *v* (whose value lies between zero and one) and the pre-tax rate of return, *p*, is given by:

[A14] $p = \frac{(1 - A)}{(1 - \tau)(1 + \pi)} \left[\rho' - \pi + \delta^{eco}(1 + \pi) \right] + \frac{v\tau\pi}{(1 - \tau)(1 + \pi)} - \delta^{eco}$

Parameters used in METR calculations for physical assets

	AUS	AUT	BEL	CAN	DNK	FIN	FRA	DEU	GRC	ISL	IRE	ITA
Real interest rate, r	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Inflation rate, p, (CPI)	2.75%	1.86%	2.06%	1.56%	2.13%	0.59%	2.01%	1.49%	1.49%	2.54%	1.56%	3.85%
Personal taxes												
interest income[1]	47.00%	22.00%	15.00%	40.58%	62.70%	28.00%	20.90%	53.00%	15%	0.00%	48.00%	30% or 12.5%
on capital gains[2]	47.00%	0.00%	0.00%	40.58%	40.00%	28.00%	19.40%	0.00%	0.00%	47.35%	40.00%	25.00%
on dividend income	47.00%	22.00%	15.00%	40.58%	40.00%	28.00%	56.80%	53.00%	0.00%	47.35%	48.00%	12.50%
Imputation rate[3] (as a percentage of gross dividend)	36.00%	0.00%	0.00%	9.45%	0.00%	28.00%	33.00%	47.96%	0.00%	0.00%	23.00%	56.00%
Corporate tax rate, t[h]	36.00%	34.00%	40.17%	43.13%	34.00%	28.00%	36.60%	45.00%	40.00%	33.00%	38.00%	52.20%
Machinery, D[th]												
Type of depreciation[4]:	db or sl	sl	sl	db	db	db	sl	db or sl	sl or db	sl	sl	db or sl
Rate for DB		..	..	30.00%	30.00%	30.00%	..	db:30	10 to 15%	..	..	..
Rate for SL	12.50%	12.50%	10 to 33%	..	..	..	12.50%	sl:10 or 20		9 to 12% & 15 to 20%	15.00%	15%
Length for SL	8	8	ufd	..	..	..	8	ufd		ufd	ufd	6.67
Extra allowance (Y/N)	n	y	n	n	n	n	n	n	n	n	n	n
If extra; rate	..	9.00%	..	..	..	..	..	..	..	..	..	..
Buildings, D[th]												
Type of depreciation[4]:	sl	sl	sl*	db	Kinked sl	db	sl	db or sl	sl	sl	sl	db or sl*
Rate for DB	..	..		4.00%	..	4%, 7%, 20%	..	..	..	..	..	..
Rate for SL	2.5 or 4 %	2.5 or 4%	3 or 5%	..	6% / 2%	..	2% or 5%	4.00%	5% or 8%	1.5 to 2% & 3 to 4%	4.00%	3% to 7%
Length for SL	25 / 40	ufd	ufd	..	10 y / 20 y	..	ufd	25	ufd	25	25 (ufd)	ufd
Extra allowance (Y/N)	n	y	n	n	n	n	n	n	n	n	n	n
If extra; rate	..	12.00%	..	..	..	..	..	..	..	..	..	..
Inventories valuation:	FIFO	FIFO	FIFO	FIFO	FIFO	FIFO	FIFO	LIFO	FIFO	FIFO	FIFO	FIFO

1. Personal taxes on interest payments correspond to interest payments from a Commercial bank deposit.
2. Switzerland: zero capital gains tax if gains reinvested, Belgium: Personal tax rates include surcharge, France: Personal tax rates include surcharge, Iceland: Personal tax rates include surcharge, Norway: imputation system available on capital gains.
3. Imputation rates taken from Table 2.1 (DAFFE/CFA/WP2(98)9.
4. Depreciation allowances are abbreviated as follows -- (db) -- Declining Balance Only, (sl) -- Straight Line Only, (db/sl) -- Switching is Allowed, db or sl: Choice of Method Allowed. (ufd) stands for until fully depreciated.

Notes: Economic Depreciation rates for Machines, Buildings, Inventories and Financial Assets are respectively: 12.25%, 3.61%, 0% and 0%; In absence of estimated life for tax purposes, the following were applied -- machines: 8 years, buildings: 25 years.

Parameters used in METR calculations for physical assets (continued)

	JPN	LUX	NLD	NZL	NOR	PRT	ESP	SWE	CHE	UK	USA
Real interest rate, r	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Inflation rate, p, (CPI)	0.14%	1.40%	2.08%	2.29%	1.26%	3.12%	3.56%	0.47%	0.81%	2.45%	2.93%
Personal taxes											
interest income	20.00%	50.00%	60.00%	33.00%	28.00%	20.00%	56.00%	30.00%	43.87%	40.00%	46.60%
on capital gains	10.00%	50.00%	0.00%	0.00%	28.00%	10% *	56.00%	30.00%	0.00%	40.00%	28.00%
on dividend income	35.00%	25.00%	60.00%	33.00%	28.00%	25.00%	56.00%	30.00%	43.87%	40.00%	46.60%
Imputation rate	0.00%	0.00%	0.00%	33.00%	28.00%	0.00%[5]	29.00%	0.00%	0.00%	20.00%	0.00%
Corporate tax rate, t^h	37.50%	39.09%	35.00%	33.00%	28.00%	39.60%	35.03%	28.00%	39.80%	33.00%	39.50%
Machinery, D^{th}											
Type of depreciation:	db	db or sl	sl or db	sl or db	db	db or sl	db or sl	db	db or sl	db	db /sl[f]
Rate for DB	33.00%	db:30	20% or 30%	10% to 33.3%	20.00%	12.5% to 25%	22.50%	30.00%	30.00%	25.00%	28.57%
Rate for SL		sl: 10 or 20	10% or 15%	7% to 24%	..	..	..	..	..	..	50.00%
Length for SL		..	ufd	ufd	..	..	..	..	..	..	2
Extra allowance (Y/N)	n	n	y	n	n	y	y	n	n	n	n
If extra; rate	..	..	2%	..	..	5.00% Tax Credit (I:2)	5.00% Tax Credit (B)		..	..	..
Buildings, D^{th}											
Type of depreciation:	sl	sl	sl	sl or db	db	sl	sl	sl	db or sl	sl	sl
Rate for DB		..	..	2.50%	2% or 5%	...	..	..	..	..	..
Rate for SL	1.54%	5.00%	2% or 3%	2.00%	..	2% or 5%	2% or 3%	1.5% to 5%	2 or 5%	4.00%	2.56%
Length for SL	65	20	ufd	ufd	..	ufd	ufd	ufd	ufd	25	39
Extra allowance (Y/N)	n	n	y	n	n	n	y	n	n	n	n
If extra; rate	..	..	2%	..	..	..	5.00% Tax Credit (B)	..	..	..	..
Inventories valuation:	LIFO	FIFO	LIFO	FIFO	FIFO	LIFO	LIFO	FIFO	LIFO	FIFO	LIFO

5. PRT: Option of taking of 33.75% imputation credit, if income tax > 25% choice to take 25% final tax on dividend.

Parameters used in METR calculations for R&D

	AUS	AUT	BEL	CAN	DNK	FIN	FRA	DEU	GRC	ISL	IRE
Machinery R&D	(A)	(Reg)	(A)	(A)	(A)	(Reg)	(A)	(Reg)	(A)	(Reg)	(A)
Type of depreciation:	sl	sl	sl	100%	100%	db	sl or db	db	100%	sl	100%
Rate for DB	..	..	..	..	..	30%	40.00%	30%	..	..	
Rate for SL	33.33%	20.00%	33.33%	..	..	..	20.00%	..	..	12%	
Length for SL	3	5	3	..	..	..	5	..	..	8.33	
Extra Allowance:		Yes: 9%	Yes: 13.5%	No	Yes: 25%	No	No	No	No	No	
Tax Credit allowance (Y/N)	None	None	None	Yes	None	None	None	None	None	None	None
Statutory Credit rate				20%							
Tax Credit Taxable ?				Yes							
Type Tax Credit:(B)ase or (I)ncremental				B							
Buildings-R&D	(A)	(Reg)	(Reg)	(Reg)	(A)	(Reg)	(Reg)	(Reg)	(Reg)	(Reg)	(A)
Type of depreciation:	sl	sl	sl	db	100%	db	sl	sl	sl	sl	100%
Rate for DB	..	..	..	4%	..	20%	..	..	..	..	
Rate for SL	2.5% / 4%	4%	5%	..	..	..	5%	4%	8%	4 % / 2%	
Length for SL	40/ 20	25	20	..	..	..	20	25	12.5	25/50	
Extra Allowance:	No	Yes: 12%	Yes: 13.5%	No	Yes: 25%	No	No	No	No	No	
Extra Tax Credit allowance (Y/N)	None	None	None	None	None	None	None	None	None	None	None
Statutory Credit rate											
Tax Credit Taxable?											
Type Tax Credit:(B)ase or (I)ncremental											
Current Expenditures-R&D:	150.00%	118.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Extra Tax Credit allowance (Y/N)	None	None	None	Yes	Yes: 25%	None	Yes Real Exp.	None	None	None	None
Statutory Credit rate				20%			50%				
Tax Credit Taxable?				Yes			No				
Type Tax Credit:(B)ase or (I)ncremental				B			I: 2 years				

a) Economic Depreciation rates for machines, Buildings, Current R&D: 12.25%, 3.61%, 25% or 5%.
b) (A) stands for Accelerated Depreciation; (Reg) stands for regular depreciation -- no special provisions for R&D. For tax credits: (I) is incremental scheme, (B) is base or level scheme.
c) Depreciation allowances are abbreviated as follows -- (db) -- Declining Balance Only, (sl) -- Straight Line Only, (db/sl) -- Switching is Allowed, db or sl: Choice of Method Allowed. (ufd) stands for until fully depreciated.
d) For France, incremental tax credit is applied to real expenditures.

Parameters used in METR calculations for R&D (continued)

	ITA	JPN	LUX	NLD	NZL	NOR	PRT	ESP	SWE	UK	USA
Machinery R&D	(Reg)	(Reg)	(Reg)	(A)	(Reg)	(Reg)	(A)	(A)	(Reg)	(A)	(Reg)[f]
Type of depreciation:	sl	sl or db	sl or db	sl or db	sl or db	db	sl	100%	db	100%	db/sl
Rate for DB	..	33.00%	30%	..	10% to 33.33%	20%	..		30%		28.57
Rate for SL	15%		..	20%	7% to 24%	..	33.33				50%
Length for SL	6.67%		..	5	ufd	...	3				2
Extra Allowance:	No		No	Yes 2%	No	No	No	No	No	No	No
Tax Credit allowance (Y/N)	None	Yes	None	None	None	None	Yes	Yes	None	None	None
Statutory Credit rate		5%					5%	20% (B) + 40%(I)			
Tax Credit Taxable?		No					No	No			
Type Tax Credit:(B)ase or (I)ncremental		I : 1 year					I : 2 years	I : 2 years			
Buildings-R&D	(Reg)	(Reg)	(Reg)	(A)	(Reg)	(Reg)	(A)	(A)	(Reg)	(A)	(Reg)
Type of depreciation:	sl	sl or db	sl	sl	sl or db	db	sl	sl	sl	100%	sl
Rate for DB	..		..	..	2.50%	5%	..	..	..		
Rate for SL	4%	1.54%	5%	4%	2%	..	5%	10%	5%		2.56%
Length for SL	25	65	20	25	ufd	..	20	10	20		39
Extra Allowance:	No		No	Yes 2%	No	No	No	No	No	No	No
Extra Tax Credit allowance (Y/N)	None	Yes	None	None	None	None	None	None	None	None	None
Statutory Credit rate		5%									
Tax Credit Taxable?		No									
Type Tax Credit:(B)ase or (I)ncremental		I : 1 year									
Current Expenditures-R&D:	100.00%	100.00%	100.00%	100.00%	no expensing	100.00%	100.00%	100.00%	100.00%	100%	100.00%
Extra Tax Credit allowance (Y/N)	None	Yes	None	Yes - Wages	None	None	None	Yes	None	None	Yes
Statutory Credit rate		20%		12.5% or 40%				20% (B) + 40%(I)			20%
Tax Credit Taxable?		No		No				No			Yes
Type Tax Credit:(B)ase or (I)ncremental		I : 1 year		B				I: 2 years			I: 3 years

a) Economic Depreciation rates for machines, Buildings, Current R&D: 12.25%, 3.61%, 25% or 5%.

b) (A) stands for Accelerated Depreciation; (Reg) stands for regular depreciation -- no special provisions for R&D. For tax credits: (I) is incremental scheme, (B) is base or level scheme.

c) Depreciation allowances are abbreviated as follows -- (db) -- Declining Balance Only, (sl) -- Straight Line Only, (db/sl) -- Switching is Allowed, db or sl: Choice of Method Allowed. (ufd) stands for until fully depreciated.

d) Italy allows a tax credit of 30% for small firms.

e) We assume Luxembourg allows 100% expensing for current expenditures.

f) US: Declining balance method is applied for 5 years before switch to sl is made for machinery.

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