TAXATION AND R&D – ISSUES NOTE

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A. Introduction

1. All countries recognize the importance of innovation in underpinning economic growth, and many governments are prepared to subsidize R&D in the form of tax incentives, cash grants and other forms of public support. This paper addresses the use of R&D tax incentives to subsidize current and capital R&D expenditure, and surrounding issues, including the level of tax on returns on R&D.

2. Section B begins by presenting a basic conceptual framework to help analyze tax effects on R&D. The creation of knowledge capital as an output of basic or applied research is considered separately from the creation of new products and production processes developed using knowledge capital. Section C considers two main arguments for tax incentives for R&D: the existence of (non-marketed) 'spillover benefits' from R&D and efficiency gains from subsidizing R&D; and efficiency gains from removing tax impediments to R&D investment. Section D reviews various types of tax incentives for R&D that lower the net cost of undertaking R&D. Basic tax incentive types and design features are reviewed for R&D current expenditures, and capital expenditures. Possible targeting criteria are listed.

3. Section E reviews parameter-based indicators of R&D tax policy, including the 'B-index', and METRs based on applications of the standard 'user cost of capital' framework to current and capital R&D expenditures. Also considered is an extension of the standard 'user cost of capital' framework that explicitly models knowledge capital as an output of research activity. The modelling of knowledge capital is shown to matter, as it enables separate measurement of a marginal effective tax rate (METR) for knowledge capital, shown to depend on METR values for factor inputs including physical capital. The framework thus enables the treatment of a much richer set of considerations than the standard approach allows.

4. Section F considers three levels of tax incentive evaluation (effectiveness, cost effectiveness, cost-benefit assessment). This section also questions whether empirical analyses of tax effects on R&D, and assessments of R&D tax incentive programs, are based on biased measures of the user cost of capital and METR for R&D. To address this question, policy analysts are encouraged to take detailed account of not only the tax treatment of R&D expenditures, but also the tax treatment of returns on R&D and in particular the implications of cross-border tax planning involving geographically mobile intangibles.

5. Section G closes by considering policy implications of the observation that assessments of tax relief for R&D typically focus on the tax treatment of R&D expenditure, and ignore tax-planning aimed at minimizing tax on income from the use of knowledge capital, often created with tax incentive support. A more detailed and accurate assessment would factor in the tax treatment of returns on R&D taking into account commonly used tax-planning strategies. Where returns on R&D are lightly taxed, the case for tax subsidies for undertaking R&D is reduced (compared to assessments that assume taxation of returns at the basic domestic corporate tax rate).

6. Moreover, factoring in limited taxation of returns on R&D is necessary to address behavioural effects. A policy of tax incentives for R&D expenditure, combined with a relatively high tax rate on

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returns on knowledge capital used in or licensed from the home country, would be expected to encourage domestic R&D expenditure, and then a transfer offshore of knowledge capital so that returns on R&D capital can be received tax free. This leads one to consider options involving reduced domestic taxation of returns on R&D (targeted or broadly-based), to discourage the migration offshore of intangibles, financed in part by a less generous set of incentives for R&D expenditure. Section G lists various tax parameters impacting the costs and benefits (and levels) of research and development.

B. Analyzing R&D – A Conceptual Framework

7. This section sketches out a basic conceptual framework to assist in the analysis of tax effects on R&D. The impetus comes from an observation that standard tax burden indicators for R&D – the B-index, and marginal effective tax rates (METRs) derived from the standard user cost of capital framework – do not capture well the micro-economic underpinnings of R&D. In particular, basic and applied research activity leading to the creation of knowledge capital is not modelled separately from subsequent development activity involving applications of knowledge capital to create new products and processes. Instead, R&D is treated as a single activity, with one set of inputs and one output.

8. Separate treatment of the creation of knowledge capital is necessary for modelling inputs and outputs of the components of R&D (research activity R, and development activity D), and to distinguish the tax treatment of costs and revenues at each stage. It is also necessary to distinguish economic depreciation of physical capital used in R and D, and economic depreciation of knowledge capital resulting from technological obsolescence (a key component of the user cost of knowledge capital). Separate treatment is also necessary to address tax-planning activities involving the transfer of an intangible (e.g. patent) to a tax haven affiliate (holding company), enabling tax-free receipt offshore of royalty income on applications of the knowledge capital in operating affiliates in various countries. A main part of the objective of this note is to address this limitation, consider how it can be overcome, and explore the policy implications.

9. It is useful to begin with the Frascati Manual definition of R&D:

> R&D comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge, including the knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications. The term R&D covers three activities: basic research, applied research and experimental development". (OECD Frascati Manual, Paris, 2002, sixth edition).

10. R&D may be generally characterized as an activity with an uncertain outcome, involving the use of various factor inputs (i.e. tangible physical capital, skilled labour, materials), where a central objective is to generate new knowledge capital that may be exploited in various ways.[1] In particular, new knowledge created by an R&D performer may be used as follows:[2]

1. Patented and licensed or sold to others (unrelated parties or foreign affiliates).

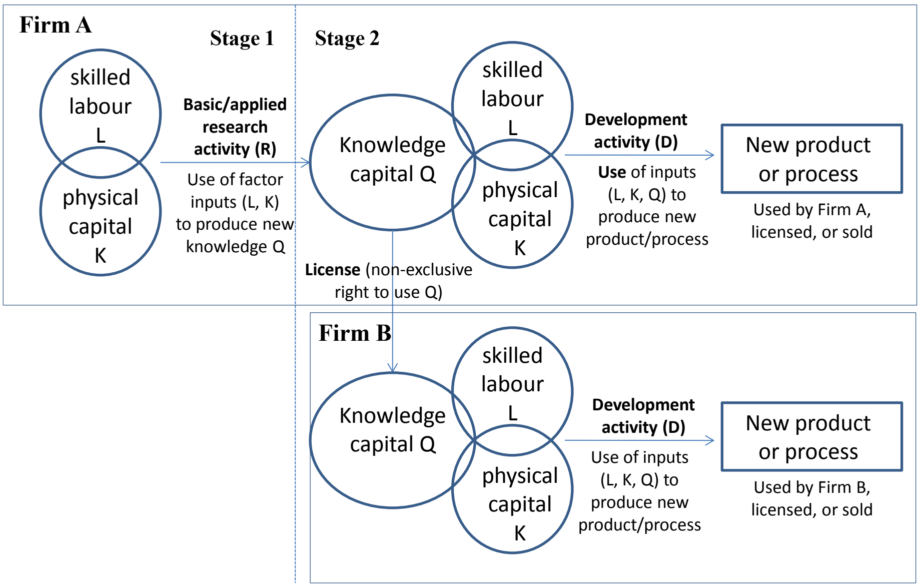
2. Used together with other factor inputs to create a new or improved product or production process applied by the R&D performer.

3. Used together with other factor inputs to create a new or improved product for sale to consumers, or other firms; or to create a new or improved production process licensed or sold to other firms.

11. Research and development activities are separately depicted in Chart 1. In particular, the illustration shows research activity in stage 1 leading to the creation of knowledge capital (Q) and, in stage 2, development activity leading to the creation of new products and processes which may be assumed to be

at the point of commercialization. As not all countries with R&D tax incentive programmes recognize development expenditures up the point of commercialization as expenditures qualifying for R&D tax incentives (with some countries targeting incentives to R&D expenditures up to the point of developing a non-commercial prototype), the tax treatment of stage 2 expenditures will vary across countries.

Chart 1 – Illustration of R&D



12. The R&D performer (Firm A, top box) is shown in stage 1 to hire skilled labour (L) and invest in physical capital (K) to generate knowledge capital (Q). While not shown in the chart, labour is hired at a pre-tax wage rate (w). The pre-tax user cost of physical capital ($\rho+\delta_K$) includes a cost of funds component (ρ) and an economic depreciation component (δ_K). Country-specific tax rules determine the tax treatment of these current and capital expenditures (see section E for a discussion of types of tax incentive measures that may apply), which in theory affect how much research is undertaken, and the cost minimizing factor mix.

13. Two firms are shown carrying out development activity. Firm A uses its own self-developed knowledge capital created in Stage 1, while Firm B uses the same knowledge capital licensed from Firm A (in the illustrative case, Firm B pays royalties for a non-exclusive right to use knowledge capital Q). In particular, Firm A is shown to use its knowledge capital (Q), labour (L) and physical capital (K) to produce a new product or process. Labour is hired at a pre-tax wage rate and physical capital is hired at a pre-tax user charge/cost, which may differ from the factor input costs in stage 1. Country-specific rules determine whether (or the extent to which) current wage and capital expenses in stage 2 qualify as R&D expenses eligible for special R&D tax relief. Firm A also licenses its knowledge capital to Firm B.[3] Firm B is shown to hire labour (L) and invest in physical capital (K) to produce a new product or process, with country-specific tax rules determining whether (or the extent to which) stage 2 current wage and capital expenses qualify for special R&D tax relief.

14. Several aspects of this basic framework/illustration are noteworthy. First, labour and physical capital types and proportions may differ between stages 1 and 2. Research leading to a new design for a hybrid engine (knowledge) may require more highly-skilled labour and may employ less plant and heavy equipment than stage 2 activity leading to the development and manufacture of a new hybrid engine proto-

type. This is relevant as labour and physical capital types have different pre-tax user costs (e.g. different wage rates, economic depreciation rates).

15. Second, the tax treatment of labour and physical capital costs in stage 1 may differ markedly from that in stage 2. In particular, tax incentives for current and capital costs may apply in full to research expenditures in stage 1, but may have more limited application in stage 2. Relatively high marginal personal income tax rates may apply to wages paid in stage 1.

16. Third, the basic framework in Chart 1 treats knowledge capital Q as a distinct output of stage 1 research. This is important for tax policy analysis, as it allows one to calculate effective tax rates on knowledge capital and to take account of the economic depreciation of knowledge capital, separately from the economic depreciation of physical capital as an input to R and D. Standard effective tax rate (METR) modelling approaches that do not separately treat knowledge capital are unable to assess the effective tax rate on knowledge capital – instead they assess the effective tax rate on factor inputs in R&D (namely, physical capital and labour (this point is elaborated in section E)).

17. Fourth, the framework addresses alternative uses of knowledge capital, which may attract different tax treatment. Where knowledge capital of an R&D performing firm is used by that firm in a development stage to create new products/processes, revenue on the sale/use would normally be subject to corporate income tax at the basic CIT rate. Where instead (or in addition) the knowledge capital is licensed to another firm (Firm B), the return to Firm A would be taxed as royalty income. Where the tax rate on royalty income in country A differs from the basic CIT rate, this distinction obviously matters. On this point, it may be noted that a number of OECD countries apply reduced tax rates to royalty income (i.e. royalty income derived from a license to a non-resident firm). Also to be addressed is the tax-planning case where the knowledge capital is shifted offshore to a tax haven, so that royalty income derived from the use of the capital in operating affiliates of a group can be received free of CIT in country A.

C. Rationale for Tax Incentives for R&D

18. R&D expenditure, by expanding the stock of knowledge capital and encouraging the generation of new products and processes, is a key driver of total factor productivity and economic growth. Thus tax policy makers are encouraged to ensure that the tax system is not impeding to R&D.

19. This section considers two main arguments for the use of tax subsidies to support R&D: 1) the existence of (non-marketed) 'spillover benefits' that result from private R&D; and 2) efficiency gains from removing tax impediments to investment in physical capital used in R&D. A third possible argument is also raised: the use of R&D tax incentives to counter effects on hurdle rate of return (costs of capital effects) resulting from information asymmetries that limit financing to innovative high-risk SMEs.

1. Spillover benefits (positive externalities) of R&D

20. Companies invest in R&D in order to create knowledge that can be applied to develop new products, lower production costs, or can be licensed to others, with the aim of maximizing profits for their shareholders. However, monetary benefits from R&D may 'spillover' without charge to other firms and individuals that are able to benefit from the knowledge created by the R&D of others. For example, R&D performers may be unable to obtain a patent protecting the knowledge gained, and even if a patent is granted, protection may be limited in time and coverage. Moreover, knowledge created by R&D that gets embodies in new products and producers may become understood and accessible to others, who then benefit from business applications. Spillover benefits may also accrue to individuals (e.g. scientists, engineers) that carry out the R&D and are able to exploit that knowledge when working for another firm.

21. The existence of these positive externalities creates a form of ‘market failure’, from society’s perspective. When making their R&D investment plans, private firms can be expected to only take into account the private returns from R&D and ignore the external return – that is, the difference between the social return tied to R&D spillovers, and the private return. As a consequence, the private market cannot be expected to generate the socially optimal level of R&D activity (see the illustration in Annex I). This outcome encourages policy makers to consider the use of R&D tax incentives in order to encourage private firms to increase their R&D spending to levels that maximize social welfare.

Addressing spillover benefits

22. While sound in theory, the spillover benefit argument is difficult to implement in practice. A number of complexities and uncertainties are met. A central question is how to determine the optimal tax treatment of R&D to address spillover effects. In examining this issue, Dahlby (2005) presents a framework which identifies three main considerations to be taken into account by policy makers when deciding or evaluating tax subsidies for R&D:

- the tax sensitivity of R&D
- the external (or social) rate of return
- the marginal cost of public funds.

23. While Dahlby is able to derive a formula for the optimal net tax rate on R&D activity that addresses spillover benefits, making the framework operational is difficult given considerable uncertainty (i.e. a wide range of estimates) over the magnitudes of each of the above-noted factors.

2. Tax impediments to investment

24. A common criticism of corporate income tax (CIT) is that it discourages investment in physical capital and other assets relative to the no-tax case, and relative to certain ‘neutral’ corporate tax system designs with a different tax base (e.g. a cash-flow tax). Tax distortions to investment in physical capital under a basic CIT may be alleviated by reducing the statutory CIT rate, allowing accelerated depreciation of physical capital costs, or providing a general investment tax credit for investment expenditure. However, broad-based tax relief is generally expensive in terms of foregone tax revenues, relative to targeted tax relief. Thus policy makers may prefer a targeted approach. An example is providing accelerated depreciation and/or investment tax credits in respect of purchases of physical capital used in R&D.[4]

25. Targeting CIT relief to R&D performing firms may be attractive to policy makers for a number of reasons. First, as noted, it could limit tax revenue losses. Second, targeting R&D performing firms may be an attractive pro-growth strategy, recognizing that R&D and innovation are critical to production efficiency gains and economic growth. On this basis, policy makers may be less concerned with tax relief that provides windfall gains to investors (i.e. tax relief on investment that would have been undertaken in the absence of tax relief). That is, while a main objective may be to remove impediments to R&D investment, and thereby encourage R&D to levels that would be observed under a neutral tax, less concern may be given to tax relief on infra-marginal R&D, given interest in supporting this group (as opposed to non-performers). An approach of targeting R&D firms also recognizes that R&D activity is mobile. Therefore, in a world where countries compete to attract R&D performing firms, tax relief targeted at R&D may be necessary to attract and maintain existing levels of R&D activity (while recognizing that the attractiveness of a country, as a base for R&D, depends on a number of important non-tax factors (e.g. availability of skilled labour, intangible property rights) and other features of a host country’s tax system.

3. Information asymmetries (cost of capital)

26. Another argument for R&D tax incentives considers capital market imperfections resulting from information asymmetries. Perhaps the most commonly cited example is where the profitability of a business, in particular an early-stage business with highly uncertain (risky) returns on R&D, is better understood by managers of firms than by outside creditors. Asymmetric information may result in the extension of credit to firms with 'quality' R&D investments but at excessive interest rates (in excess of what would be charged with symmetric information), or no funding (at market rates), or costly signalling, implying in each case under-investment.[5] Another example of information asymmetry arises where outside equity investors are unable to monitor activities of managers who may engage in consumption activities inconsistent with the maximization of firm value. In such cases, asymmetric information, leading to significant monitoring costs or demands for increased rates of return by outside investors, may lead to under-investment relative to an efficient outcome based on symmetric information. Arguments for tax incentives to correct for capital market imperfections of this type may refer to results from 'adverse selection' models.[6]

27. Proponents of targeting a richer set of R&D tax incentives to SMEs may point to capital market imperfections that are particularly pronounced for SMEs. Information asymmetries may be particularly problematic for small firms. For example, due to their size, medium- to large-scale firms may have fewer difficulties in encouraging potential equity providers to study business plans where returns are highly uncertain. Venture capitalists, for example, may be disinterested in considering small equity deals given lower average 'due diligence' costs (possibly due to a significant fixed cost component) in reviewing larger business deals. Furthermore, large firms generally have larger hard asset pools offering more collateral to support loans, and greater access to international capital markets.

D. Tax Incentives for R&D

28. This section reviews various types of tax incentives for R&D – that is, tax provisions that reduce the effective (net of tax) cost of purchasing or acquiring the services of inputs used to undertake R&D, primarily physical capital and labour.[7] Tables 1 and 2 in Annex II provide a list of R&D tax incentives in OECD countries in 2005.

29. Tax relief for R&D is a broader concept that includes:

- tax incentives for R&D (lowering the cost of undertaking R&D), and
- low/reduced tax rates on income derived from R&D.

30. Examples of low/reduced tax rates on income derived from R&D include:

- a targeted preferential tax rate on royalty income earned on the licensing of intangible property (e.g. a reduced tax rate on foreign royalty income).
- targeted tax relief provided by a reduction in the corporate income tax rate applied to profits derived from sales of new products/processes – in practice such an approach may be impractical, imposing significant tax administration and compliance costs, given difficulties in measuring income from innovation.
- non-targeted tax relief provided by a reduction in the basic corporate income tax rate on profits derived from new products/processes, where the reduced CIT rate applies other forms of income and possibly broadly to all types of business income.

31. This section is limited to a review of tax incentives for R&D. (Section G returns to the issue of tax relief for R&D through reduced taxation on income derived from R&D.) Sub-section 1 considers tax incentives that reduce the cost of R&D current expenditures. Sub-section 2 considers tax incentives that reduce the cost of R&D capital expenditures. Sub-section 3 reviews a number of targeting criteria that may be applied in the design of these incentives.

1. Tax incentives for labour (current expenditures)

a) *Enhanced allowance for R&D labour costs*. Normal income tax treatment of wage/salary expense would provide immediate expensing. Under an enhanced allowance for R&D wage expenses, an R&D performer would be provided with a tax deduction for more than 100 per cent of qualifying current wage/salary costs.

b) *Reduced employer social security contribution (SSC) on gross labour income*. Employer SSC relief may be provided in respect of labour income of employees engaged in R&D activity, for example by lowering the upper gross income threshold beyond which employer contributions are zero at the margin, or by waiving employer and employee social security contributions in certain cases (e.g. expatriates resident in the host country to perform R&D for a limited period, normally working for a foreign parent company).

2. Tax incentives for physical capital expenditures

a) *Accelerated depreciation of R&D capital costs*. A common tax incentive for investment in physical capital (machinery and equipment, buildings) used in R&D is accelerated depreciation. By allowing the acquisition cost of capital of a given type (e.g. machinery and equipment) to be depreciated at a faster rate when used to carry out R&D – meaning that depreciable capital costs can be deducted sooner (earlier) than under normal (non-accelerated) rules – the present value of depreciation allowance claims is increased. As depreciation allowances are deductions against the corporate income tax base (taxable profit), their value depends on the statutory corporate income rate applied to that base.

To illustrate, consider the case where tax depreciation rules normally allow machinery and equipment to be written off, on declining-balance basis, at rate (α). For a firm that is profitable and taxable in each period, so that depreciation claims are not restricted (i.e., can be deducted against taxable profit), the present value of the stream of capital cost allowances on one currency unit of investment is given by:

$$uZ_t^{norm} = u\sum_{s=t}^{\infty} \frac{\alpha(1-\alpha)^{s-t}}{(1+r+\pi)^{s-t+1}} = \frac{u\alpha}{r+\pi+\alpha} \tag{1}$$

where (u) denotes the statutory corporate income tax rate, (r) denotes the firm's real discount rate, and (π) denotes the rate of inflation. The example considers the case where the tax system does not provide for inflation-adjustment of capital costs.[8]

Where machinery and equipment used in R&D is depreciated at a declining-balance rate (α^R) that exceeds the rate (α) applied to non-R&D use, the present value of allowances on one unit of investment is:

$$uZ_t = u\sum_{s=t}^{\infty} \frac{\alpha^R(1-\alpha^R)^{s-t}}{(1+r+\pi)^{s-t+1}} = \frac{u\alpha^R}{r+\pi+\alpha^R} \tag{2}$$

This relief exceeds that under normal rules (uZ^{norm}), with capital costs written off at a faster rate ($\alpha^R > \alpha$). For a taxable profitable firm, the tax incentive provided by accelerated depreciation is measured by the additional amount of tax relief provided (the difference between the two present value calculations):

$$u(Z_t - Z_t^{norm}) \tag{3}$$

However, note that the effective purchase price of one currency unit of capital is given by (1-uZ) – that is, the effective purchase price of one currency unit, minus the present value of 'normal' depreciation claims on that purchase (uZ^{norm}), minus the tax incentive $u(Z-Z^{norm})$.

b) *Enhanced depreciation allowance for R&D capital costs*. Normal treatment of depreciable capital costs allows 100 per cent of qualifying investment expenditure to be depreciated. Under an enhanced allowance, more than 100 per cent can be depreciated. Consider an enhanced allowance for R&D capital depreciated on a declining-balance basis at rate α^R, where the enhancement variable exceeds one ($\theta>1$):

$$uZ_t = u\theta\sum_{s=t}^{\infty}\frac{\alpha^R(1-\alpha^R)^{s-t}}{(1+r+\pi)^{s-t+1}} = \frac{u\theta\alpha^R}{r+\pi+\alpha^R} \tag{4}$$

c) *Volume-based investment tax credit for R&D expenditures*. A volume-based (or flat) investment tax credit is calculated as a fraction λ of qualifying R&D expenditures (physical capital and in some cases, current expenses as well). For illustrative purposes, consider the case where qualifying expenditures are limited to capital, and let I_t denote expenditures on qualifying physical capital in period t. The volume-based investment tax credit earned in period t is calculated as:

$$ITC_t^{vol} = \lambda \cdot I_t \tag{5}$$

For a volume-based credit, the investment tax credit rate (ϕ) is given by the fraction λ:

$$\phi = (ITC_t^{vol} / I_t) = \lambda \tag{6}$$

As an investment tax credit is not deducted from the corporate income tax base (taxable profit), but rather is deducted against corporate income tax liability, its value does not depend on the statutory corporate income rate.

d) *Incremental investment tax credit for R&D capital costs*. An incremental investment tax credit provides a tax credit (deduction from tax otherwise payable) calculated as a fraction λ of current investment expenditure in excess of investment expenditure in prior years.[9] The simplest incremental investment tax credit design is where the reference year is the previous year, in which case:

$$ITC_t^{incr} = \lambda \cdot (I_t - I_{t-1}) \tag{7}$$

The corresponding incremental investment tax credit rate is given by:

$$\phi = \lambda - \frac{\lambda}{(1+\rho)} = \frac{\rho\lambda}{(1+\rho)} \tag{8}$$

3. Possible targeting dimensions

32. Tax incentives for current and capital R&D expenditures may be targeted along a number of dimensions. Targeting may involve a separate tax relief instrument applied solely to R&D (e.g. R&D investment tax credit), or may involve a generally applicable tax instrument (e.g. depreciation allowance) that provides *relatively* more generous tax treatment to R&D expenditure than to non-qualifying expenditure.

a) *Research vs. development*. Efficiency may call for targeting research (R) rather than development (D) where available evidence finds that positive spillover benefits are greatest with R, and the main purpose of the incentive is to correct for this positive externality. Where instead the main policy aim is to offset tax impediments to investment expenditure, then targeting R over D may introduce a tax distortion (assuming that R&D performers determine the most productive investment allocation) and efficiency losses. At the same time, targeting R may significantly reduce the foregone revenue loss of the program. This raises the question of whether it may be desirable, when taking into account efficiency and revenue considerations, to target R and D equally, and possibly at a lower effective rate to contain revenue loss.

b) *Capital vs. labour*. Efficiency may call for a larger subsidy for (physical) capital expenditure than labour costs – that is, providing a larger percentage reduction in the user cost of capital, compared with the user cost of labour – where the main policy aim is to address tax impediments to investment. Where instead the aim is to encourage R&D on account of spillover benefits, then in principle the tax incentive design should not distort a firm's factor input decision. This would call for equal percentage reductions in the user cost of capital and labour to leave capital/labour ratios unchanged from the no-subsidy case.

c) *Small vs. large*. A relatively limited number of large companies may account for the bulk of business R&D spending. Policy makers may be interested in targeting R&D tax relief to small companies – for example, by providing small companies with more generous depreciation allowance and/or investment tax credit treatment – to address financing constraints of small firms, and/or if spillover benefits are perceived to be greater with R&D undertaken by small firms. Small R&D performers may attract inbound merger and acquisitions (M&A), bringing spillover advantages stemming from R&D performed elsewhere. Another possible rationale for targeting small firms is to address information asymmetries which may negatively impact the cost of capital of primarily small firms.

d) *Existing vs. new (greenfield and M&A) investment.* Policy makers may be interested in targeting new investment (e.g. M&A by foreign companies), if evidence suggests that a higher percentage of such investment is additional (due to tax incentive relief), or provides greater spillover benefits.

e) *Sectoral targeting*. In many countries, R&D tends to be concentrated in certain industries. There may be policy interest in targeting these industries, if the likelihood of encouraging additional R&D is greater in sectors that undertake R&D for non-tax reasons (recognizing the higher tax administration costs of monitoring R&D tax claims for firms in all sectors). Alternatively, policy makers may wish to target sectors that are regarded as important to support for economic, security or other reasons, and that undertake substantial R&D, but mostly in other (e.g. larger) countries.

f) *Collaborative R&D (with universities, R&D centres of excellence)*. Where R&D activity tends to gravitate to collaborative R&D activity involving universities, and or other 'centres of excellence', this tendency may be reinforced (and possibly the quality of tax-assisted R&D higher) if such ventures receive public support including tax incentives for private R&D firms.

g) *Foreign branches of resident companies.* R&D by foreign branches of resident companies may generate spillover benefits in the domestic economy, with the output of R&D being the property of resident companies. However, spillover benefits may also be realized by non-resident firms competing in the same market as foreign branches. To the extent that foreign firms are better able to exploit the knowledge and gain a competitive advantage, this may reduce the relative competitiveness of domestic companies.

h) *Resident-owned versus non-resident owned domestic R&D performers*. In the past, parent companies of MNEs have tended to undertake the bulk of R&D for their group. However, data show that R&D activities of MNEs are increasingly internationalized. This may reinforce interest in not excluding non-resident owned companies from R&D incentive programmes. At the same time, this raises the question of whether non-resident owned R&D performers are likely to exploit the fruits of their R&D at home.

Aside from targeting criteria, other factors that characterize the type of R&D tax incentives include:

- the particular tax that is relieved (e.g. corporate income tax, versus employer social security contributions);
- existence or not of claw-back features that partly withdraw tax relief, by drawing it back into the tax base (or the base of another tax);[10]
- carryover provisions for unclaimed R&D tax incentives, dependent on the incentive type;[11]
- non-wastable incentives (refundable in cash where they cannot be claimed due to insufficient tax base), versus wastable (non-refundable) incentives;
- incentives with flow-through provisions (enabling the transfer of unused corporate tax incentives to shareholders), versus those without.

E. Tax Policy Indicators for R&D

33. This section reviews parameter-based indicators of tax policy in relation to R&D. The review begins under sub-section 1 with consideration of the 'B-index', widely used to enable cross-country comparisons of tax relief on R&D expenditure (see Warda (1994)). The limitations of the B-index in the complex analysis of tax effects on R&D are highlighted.

34. Sub-section 2 reviews applications of the standard 'user cost of capital' framework (Hall and Jorgensen (1967)), to current and capital R&D expenditures, and corresponding marginal effective tax rate (METR) measures (King and Fullerton (1984)) used to assess if corporate income tax is neutral, discouraging or encouraging to R&D expenditures. METRs on physical capital used in R&D activity are shown to differ from METRs on physical capital used in other activities, for example manufacturing, to the extent that i) capital proportions for different capital types (machinery, equipment, buildings) differ between R&D and manufacturing activity, and ii) tax allowances, deductions and tax credits on investment in tangible capital differ depending on their use. On this latter point, a key difference is special tax incentives for expenditures on physical capital when used to carry out R&D.

35. A point of clarification raised in sub-section 2 is that METRs derived from applications of the standard user cost model to the case of R&D are METRs on factor inputs (namely, physical capital and labour) used to undertake R&D. They are not METRs on knowledge capital. This follows, as knowledge capital is not explicitly modelled in the standard model. It is suggested that, to avoid confusion, METRs derived from the standard model should not be referred to as METRs on R&D capital, or METRs on knowledge capital – they are METRs on physical capital and labour employed to carry out R&D.[12]

36. Sub-section 3 considers an extension of the standard 'user cost of capital' framework that explicitly models knowledge capital as an output of research activity, created using tangible physical capital and labour as inputs, where in a subsequent development stage, knowledge, tangible physical capital, and labour are treated as factor inputs in the development of new products/production processes. The modelling of knowledge capital is shown to matter. Perhaps most importantly, it separately identifies returns on the exploitation of knowledge, and returns on production of new products/processes, where the tax rate on the former (for example, royalties on licensing of patented knowledge) may differ from the tax rate on the latter (sales of products).[13] It also introduces economic depreciation of knowledge capital as a key parameter in the METR for knowledge capital. In contrast, in the standard user cost approach, only depreciation of tangible physical capital factors in.

37. Modelling knowledge capital as a distinct output of research also enables the specification of factor input (labour and physical capital) types and proportions (weights) in undertaking research that may differ from input proportions in a subsequent development/production stage. Separate treatment also enables incorporation of different tax treatment of expenditures on physical capital and labour in each stage – for example, the restriction of tax credits to investment in physical capital used to undertake R&D.

38. Sub-section 4 considers the relative strengths of these indicators (B-index, standard METR, knowledge capital METR), and identifies certain shortcomings that may be addressed in future work.

1. B-index

39. Perhaps the most widely used R&D tax policy indicator is the B-index, defined as the present value of pre-tax income required to cover one currency unit of R&D expenditure taking into account the present value of tax relief on one currency unit of R&D expenditure. The B-index is used to compare across countries the 'generosity' of tax relief on R&D expenditures. One attraction is its relative simplicity.

40. Consider the following B-index formulae constructed for R&D current expenses, capital expenditures, and combined current and capital expenditures:

$$\text{B-index}^{cur} = (1-A^{cur})/(1-u) \qquad (9.a)$$

$$\text{B-index}^{cap} = (1-A^{cap})/(1-u) \qquad (9.b)$$

$$\text{B-index} = (1-SA^{cur}-(1-S)A^{cap})/(1-u) \qquad (9.c)$$

41. In the B-index for current expenses (labour) given by (9.a), the term A^{cur} measures the value of current tax deduction plus investment tax credit (if provided) on one currency unit of current (labour) expense.[14] Similarly, in the B-index for capital expenses (9.b), A^{cap} measures the present value of tax depreciation allowances plus investment tax credit (if provided) on the purchase of one currency unit of physical capital. In the overall B-index (9.c), S measures the share (fraction) of total R&D expenditures that are current expenditures. Applications of the B-index typically assume that the R&D performing firm is profitable and taxable, and thus not restricted in making depreciation and investment tax credit claims.[15] The term u in the denominator of the B-index is the statutory corporate income tax (CIT) rate.

42. The term $(1-A^{cur})$ in the numerator of B-index^{cur} captures the after-tax cost of one currency unit of current expense (e.g. wages), taking into account tax relief on current expense. In most countries, R&D current expenses are immediately deductible in full, so that $A^{cur}=u$, implying that B-index$^{cur}=1$.

43. The term ($1-A^{cap}$) in the numerator of B-index^{cap} captures the after-tax cost of purchasing one currency unit of physical capital used for R&D, taking into account the present value of tax relief on the expenditure. Where expenditures on physical capital for R&D can be immediately expensed and investment tax credits are not provided so that $A^{cap}=u$, then we have the result B-index$^{cap}=1$. Where the cost of physical capital used in R&D is capitalized and depreciated over time, B-index^{cap} exceeds one, absent investment tax credit relief. The more generous is tax depreciation or tax credit relief, and the lower the corporate tax rate on profits generated by R&D, the lower is B-index^{cap}.

44. The B-index does not assess tax systems solely in terms of tax relief for R&D expenditures. With the term (1-u) in the denominator, tax relief for R&D expenditures captured in the numerator is assessed in relation to the statutory CIT rate on profit/income derived from R&D. In other words, the B-index is sensitive to the degree of symmetry between the tax treatment of R&D expenditures and the tax treatment of income derived from R&D. Thus countries that offer the same depreciation system (in terms of depreciation rates and schedules) are treated equally under the B-index, even where country A has a higher CIT rate than country B so that the present value of depreciation allowances is higher in country A than in B (factoring in the CIT rate at which the allowances are deducted). Another implication is that the reduction in the B-index attributable to an investment tax credit, provided at a given rate, is larger the lower is the statutory CIT rate.

45. An attractive feature of the B-index is that it can be calculated for a variety of capital and current R&D expenditures (e.g., machinery and equipment, buildings, wages, training/education expenses, patents and patent rights, software).[16]

46. While a useful indicator of tax relief on the cost of acquiring capital and current inputs, and tax relief on returns on R&D, the B-index cannot be used to assess whether a tax system distorts (positively, negatively) or is neutral in its effect on R&D activity. This limitation arises because the B-index does not factor in the cost of financing R&D capital expenditures, and thus ignores the influence on R&D investment decisions of alternative tax treatment of debt and equity finance. Nor does the index capture differences between tax and economic depreciation of physical capital used in R&D activity. For example, a B-index value of 1 does not imply neutrality. Where R&D capital expenditures are immediately expensed, then a standard METR model would show that neutrality requires that the cost of finance, including interest, not be a deductible expense (cash flow taxation). By ignoring the flow cost of funds, the influence of alternative tax treatment of interest, dividends and capital gains on R&D levels is not captured.

2. Standard METR framework for R&D

47. In designing or modifying R&D tax incentives, a central consideration is the effect of the tax system on R&D activity – in particular, whether R&D expenditures are discouraged, encouraged or unaffected relative to the no-tax case – and how R&D expenditure would respond to an adjustment to the tax burden on R&D, for example with the introduction of special R&D tax incentives. A more in-depth analysis would aim to identify the effect of taxation on research activity, and to separately identify the impact of taxation on development activity (i.e. decompose tax effects on R&D).

48. The standard approach to assessing tax distortions to R&D, with and without special R&D tax incentives, applies the basic Hall-Jorgenson-King-Fullerton (HJKF) model widely used to assess tax distortions to investment in physical capital. Under this approach, user cost expressions and corresponding marginal effective tax rate (METR) formulae are derived for labour and physical capital (plant and machinery, and buildings) used in R&D activity. An overall METR for R&D is then calculated as a weighted average of METRs for labour and capital (see Griffith et al. (1995), Gordon and Tchilinguirian

(1998), Mackie (2002) and Wilson (2005)). Similarly, an overall user cost of capital for R&D is calculated as a weighted average of user costs for labour and capital.

49. The standard approach can be illustrated by assuming only two factors – labour and physical capital – as inputs to undertake R&D. While most applications are done at a more disaggregate level – for example, by separately considering plant and machinery, and buildings (rather than aggregate physical capital stock), and possibly other current expenses (materials) – the two factor model illustrates the main points. A more detailed presentation of the basic model is provided in Annex I.

50. The standard framework calculates a METR for R&D as a weighted average of METRs for physical capital ($METR_K$) and labour ($METR_L$) used to undertake R&D:

$$METR_{R\&D} = S_K METR_K(r_K^g) + S_L METR_L(r_L^g)\,. \tag{10}$$

where S_K and S_L are weights giving proportions of R&D spending allocated to physical capital and labour. Marginal effective tax rates for physical capital and labour are derived according to the standard HJKF model, and shown to be increasing functions of pre-tax hurdle rates of return on capital and labour, derived from profit-maximizing conditions:

$$r_K^g = \frac{(\rho + \delta_K)(1 - uZ - \phi)}{(1-u)} - \delta_K \tag{11}$$

$$r_L^g = \frac{(\rho + \delta_L)(1 - u - \phi)}{(1-u)} - \delta_L \tag{12}$$

where ρ denotes the cost of funds, δ_K is the rate of economic depreciation of physical capital, u is the basic statutory corporate income tax rate, Z measures the present value of tax depreciation allowances on one currency unit of physical capital used to undertake R&D expenditure, and φ measures the (volume-based) rate of investment tax credit earned on the same purchase. While labour costs are normally recognized as a current expense contributing to current income, the standard METR approach applied to R&D treats labour cost as investment generating future returns at a declining-balance rate (δ_L).[17]

51. In selecting parameter values and weights to measure $METR_{R\&D}$, weights are assigned to the factor inputs – labour and physical capital (plant and machinery, buildings) – to reflect factor proportions characteristic of R&D (as compared, for example, to non-R&D manufacturing activity). Also, economic depreciation rates for physical capital (plant and machinery, buildings) are adjusted upwards on the assumption that the specific types of physical capital used to carry out R&D depreciate more rapidly than capital used outside of R&D (more rapid technological obsolescence). The METR specifications also factor in tax allowances, deductions and investment tax credits specific to current and capital R&D expenditures.

52. Application of the standard METR model to R&D raises a number of questions, many of which stem from the fact that knowledge capital is not explicitly modelled as an output of research. As a result, certain studies are not clear on whether it is depreciation of physical capital or knowledge capital that is factored in. On this point, given that METRs derived from the standard user cost of capital approach are METRs on factors of production used to undertake R&D, METRs derived from the standard model should not be referred to as METRs on R&D capital – they are METRs on physical capital and labour employed to carry out R&D.[18] Another implication is that distinct returns on the exploitation of knowledge, and on returns on production of new products/processes, are not separately treated – while the tax rate on the

former (for example, royalties on licensing of patented knowledge) may differ from the tax rate on the latter (sales of products).[19]

3. METR for knowledge (intangible) capital

53. Arguably a more suitable framework to analyze tax policy effects on R&D is that developed by McKenzie (2005), who models intangible knowledge capital creation separately from physical capital accumulation and the production of new products/processes. With knowledge capital treated as a distinct input into development/production, the framework provides a measure of the METR for knowledge capital stock that depends on METRs for labour and physical capital used to create knowledge capital, as well as variables specific to the exploitation of knowledge capital – including the depreciation rate for knowledge (providing a more accurate treatment of technological obsolescence of knowledge than in the standard METR model) and the tax rate on returns from development/production activity.

54. Key formulae under this approach are presented in Box 1, with further details provided in Annex III. The hurdle rate of return on intangible capital is shown to depend on the cost of funds (ρ), the true or economic rate of depreciation of intangible capital (δ_Q), and a variable (T_R) measuring the percentage change in the marginal cost of producing an incremental unit of intangible R&D capital due to the taxation of labour and physical capital inputs to the production of R&D. This last variable – which may be thought of as an effective excise tax rate on R&D costs – depends on METRs for labour and capital, and requires selection of a representative production/cost function.

55. The modelling of knowledge capital, while introducing additional complexity into the analysis, allows one to consider returns on the exploitation of knowledge separately from returns on the production of new products/processes. The separate modelling of physical and intangible knowledge capital is attractive, as it mirrors the basic nature of (most) R&D activity (see the conceptual framework presented in section B of the paper). It is also important for tax policy analysis purposes, given that the tax rate on returns from exploiting knowledge capital (e.g. royalties on licensing of patented knowledge) may differ from the CIT tax rate on profit derived from sales or use of new products/processes. A preferential corporate tax rate may apply, for example, to foreign source royalty income (e.g. on the license of a patent to a foreign affiliate). It also introduces economic depreciation of knowledge capital as a key METR parameter, and remedies the source of confusion in the standard user cost of capital approach where only depreciation of tangible physical capital factors in.

56. Modelling knowledge capital as a distinct output of research also enables the specification of factor input (labour and physical capital) types and proportions (weights) in undertaking research that may differ from input proportions in a subsequent development/production stage. Separate treatment also enables incorporation of different tax treatment of expenditures on physical capital and labour in each stage – for example, if tax credits are restricted to apply to investment in physical capital used to undertake research.

57. The McKenzie model (2008) considers the case of in-house R&D, where knowledge capital resulting from research is used internally by the R&D performing firm to develop/produce a new product or production process. A number of extensions of the model would be useful. For example, it would be interesting to consider possible multiple uses of knowledge capital – for example, where ‘knowledge’ is used not only by the R&D performer, but also by other companies. A useful case to analyze is one where a parent company licenses non-exclusive rights to use patented information to domestic affiliates, foreign affiliates, and unrelated companies, with these sub-cases presenting different options for royalty payment schemes.

Box 1. METR for intangible knowledge capital - key equations

1. METR for knowledge capital (Q):

$$METR_Q = \frac{r_Q^g - \rho^*}{r_Q^g} . \qquad \text{(B.1)}$$

where r^g_Q is 'hurdle' rate of return on knowledge capital (see below), ρ is the exogenous pre-tax cost of funds.

2. Pre-tax, net-of-depreciation, 'hurdle' rate of return on knowledge:

$$r_Q^g = (\rho + \delta_Q)(1 + T_R) - \delta_Q \qquad \text{(B.2)}$$

where δ_Q captures the economic depreciation rate of knowledge capital, ρ the after-tax cost of funds, and T_R measures the effective excise tax on R&D costs (see below).

3. The effective excise tax rate on knowledge costs, measuring the percentage change in the marginal cost of producing an incremental unit of intangible knowledge capital due to the taxation of labour and physical capital inputs to the production of knowledge:

$$T_R = \frac{MC(I_Q; w(1 + METR_L), q(\rho + \delta_K)(1 + METR_K)) - MC(I_Q; w, q(\rho + \delta_K))}{MC(I_Q; w, q(\rho + \delta_K))} \qquad \text{(B.3)}$$

where w is the wage rate, q is the market price (acquisition cost) of a unit of physical capital, δ_K is the economic depreciation rate for tangible physical capital. Solving T_R requires the specification of a representative production function (e.g. Cobb-Douglas or CES production function - see Annex III)

4. Marginal effective tax rates on labour L and physical capital K:

$$METR_L = \frac{r_L^g - w}{w} = \frac{\frac{w(1 - u - \phi)}{(1 - u)} - w}{w} \qquad \text{(B.4)}$$

$$METR_K = \frac{r_K^g - q(\rho + \delta_K)}{q(\rho + \delta_K)} = \frac{\frac{q(\rho + \delta_K)(1 - uZ - \phi)}{(1 - u)} - q(\rho + \delta_K)}{q(\rho + \delta_K)} \qquad \text{(B.5)}$$

where u is the statutory corporate income tax rate, Φ is the investment tax credit rate, and Z is the present value of depreciation allowances on one currency unit of physical capital.

4. Relative strengths of alternative indicators

58. It is useful to consider the relative strengths of these tax policy indicators in terms of what they convey as regards: the degree of tax relief on R&D expenditure; tax effects on R&D activity and neutrality (scale and location decisions); tax drivers of R&D.

<u>*Tax relief on R&D expenditure*</u>

59. The B-index is useful in measuring the after-tax cost of R&D expenditure on labour and physical capital (assessed relative to the taxation of returns on R&D). In practice, applications of the B-index

assume the case of a profitable taxable firm that is not restricted in making depreciation and investment tax credit claims. However, this assumption is common across indicators, given the complexities and somewhat arbitrary assumptions in stipulating future profit and taxable income streams, and (tax-minimizing) applications of business loss and investment tax credit carryover provisions.

60. Given the focus of effective tax rate (METR) frameworks on identifying tax distortions to investment, and incorporating effects linked to the tax treatment of funds and differences between true economic and tax depreciation, such frameworks are less well suited as summary measures of tax relief on R&D expenditure.

Tax effects on R&D activity (scale and location decisions, neutrality)

61. The B-index cannot be used to assess tax effects on R&D activity, or neutrality questions (i.e. whether the tax system encourages, discourages or is neutral towards R&D, relative to the no-tax case) even in the pure domestic case (domestic in-house R&D and production). This is because the tax treatment of financing is ignored, as are (estimated) differences between tax and economic depreciation. As this issue concerns the treatment of depreciable capital, the concern is more (less) pronounced the larger (smaller) is the physical capital component in the R&D factor input mix.

62. By factoring in the cost of funds (in particular the tax treatment of interest on funds used to finance R&D), and differences between economic and tax depreciation of physical capital, the standard METR framework aims to capture possible tax distortions to R&D investment operating through user cost of capital variables (financing and depreciation). However, the treatment is less than satisfactory as knowledge capital is not explicitly modelled, and as a result, separate treatment is not given to the user cost of physical capital and the user cost of knowledge capital.

63. A central issue concerns the treatment of depreciation, a key user cost variable. Attempting to incorporate effects of rapid technological obsolescence of R&D capital by adjusting upwards economic depreciation rates for physical capital, is problematic, as it obscures tax distortions to investment in physical capital arising from differences between economic and tax depreciation of physical capital. Technological obsolescence affects the user cost of knowledge capital, not physical capital (unless physical capital used in R&D is single-purpose capital), where separate consideration should be given to economic and tax depreciation of knowledge capital.

64. Another issue concerns the separation by MNEs of research activity and development/production activity to minimize tax, and the inability of the standard METR model to address effects of this practice on R&D scale decisions, neutrality and efficiency. This inability arises because knowledge capital (the output of successful R&D) is not separately modelled. In particular, where tax relief from the separation of research activity and development/production activity is not taken into account, the standard model would tend to overstate tax impediments to R&D scale activity (by overstating the amount of tax on returns to R&D).

65. The explicit modelling of knowledge capital, as in the McKenzie model, in principle offers a better indicator of tax policy effects on R&D activity by separately identifying and treating inputs to and outputs of research activity and (post-R&D) development activity. As noted, separate modelling of physical and knowledge capital is attractive, as it mirrors the basic nature of (most) R&D activity (see section B), and enables separate identification of the tax rate on returns from exploiting knowledge capital (e.g. royalties on licensing of patented knowledge) that may differ from the CIT tax rate on profit derived from sales or the internal use of output from a development/production stage. For example a preferential corporate tax rate may apply, for example, to foreign source royalty income (e.g. on the license of a patent to a foreign affiliate). It also introduces economic depreciation of knowledge capital as a key METR

parameter, and remedies the source of confusion in the standard user cost of capital approach where only depreciation of tangible physical capital factors in.

66. Modelling knowledge capital as a distinct output of research also enables the specification of factor input (labour and physical capital) types and proportions (weights) in undertaking research that may differ from input proportions in a subsequent development/production stage. Separate treatment also enables incorporation of different tax treatment of expenditures on physical capital and labour in each stage – for example, the restriction of tax credits to investment in physical capital used to undertake R&D.

67. The McKenzie model could be usefully expanded in a number of directions. One would be to extend the model to consider discrete rather than marginal R&D investments. Modelling discrete investment choices, involving the calculation of average effective tax rates (AETRs) as distinct from marginal effective tax rates (METRs), would be helpful when considering the impact of tax on R&D location decisions.

68. A second extension would be to incorporate the mobile nature of intangible knowledge capital, and the ability of firms to minimize tax by undertaking research activity in one country – for example one with generous R&D tax incentives on investment expenditure – and locating intangibles (e.g. patents) resulting from the research in another country that imposes no/low tax on royalty income (use of an)). (See section X of CTPA/CFA/WP2(2009)27, *Taxation and Innovation Policy*, for a discussion of cross-border tax planning structures including the use of offshore intellectual property holding companies).

F. Evaluation of R&D Tax Incentives

69. With R&D recognized as key to expanding production possibilities and efficiencies, policy makers interested in pursuing pro-growth strategies often look to R&D tax incentives as an attractive policy instrument. Increasing use of R&D tax incentives heightens interest in evaluating their effects. This section considers three levels of tax incentive evaluation (posed as evaluation questions), and various approaches that may be taken to assess a given R&D tax incentive (or basket of R&D tax incentives):

1. Is the R&D tax incentive effective in increasing R&D?

2. Is the R&D tax incentive cost-effective in increasing R&D?

3. Do the social benefits of the R&D tax incentive exceed the social costs?

70. Following the review of assessment frameworks, the standard assumption of taxation of returns on R&D at the basic CIT rate is questioned.

1. Effectiveness of R&D tax incentives

71. To assess whether R&D tax incentives are effective in increasing private R&D spending, two approaches may be used that do not require detailed information on effective tax rates on R&D. One approach is to carry out case study analysis, involving the development and analysis of responses to questions posed to senior management of firms involved in making R&D activity decisions. A second approach is empirical estimation of an *ad hoc* R&D demand equation (not based on a model of investment behaviour).

Case study analysis

72. Under the case study approach, questions are posed to senior management of firms to determine whether R&D expenditures responded positively to the introduction of an R&D tax incentive (see

Mansfield (1986) for a discussion of case study analysis of effects of introducing an R&D investment tax credit).

73. A potential advantage of the case study approach is that managers can control for other explanatory factors when assessing whether R&D tax incentives motivated R&D spending. On the downside, managers may give a biased assessment for subjective or perceptual reasons.[20] Given the relatively high costs of carrying out detailed case studies involving interviews with managers, the sample size of a case study investigation of tax incentive effects tends to be relatively small, raising uncertainty over how representative the case study results are.

Estimation of ad hoc R&D demand equation

74. Another approach to assess the effectiveness of R&D tax incentives is to estimate an *ad hoc* R&D demand function that relates R&D spending to a list of explanatory variables including a 'dummy variable' capturing the availability or not of an R&D tax incentive (see Box 2). The sign of the estimated coefficient (γ) for this variable indicates whether R&D expenditure responds positively to the availability of tax incentive relief, while the estimated value of the coefficient provides an estimate of the amount of R&D expenditure induced by the introduction of the R&D tax incentive (e.g. R&D tax credit). Reliance on firm-level data is preferable to the use of aggregate data.

2. Cost-effectiveness of R&D tax incentives

75. A key evaluation question is whether the estimated <u>additional</u> amount of R&D investment undertaken by firms directly as a result of an R&D tax incentive, more than offsets the corresponding amount of foregone tax revenue (tax expenditure).[21] Consider the following cost-effectiveness measure:

cost effectiveness=additional R&D/foregone tax revenue

76. Where the cost effectiveness indicator is assessed to be zero, implying no additional R&D expenditure, this means that each currency unit of tax relief provided (foregone tax revenue) is offset by a one currency unit reduction in privately funded R&D. Where the indicator is assessed to be unity, then each currency unit of tax relief provided results in one additional unit of R&D expenditure and no crowding out of privately funded R&D. Values between zero and one imply partial crowding out, while values exceeding one imply that R&D spending increases by more than the tax subsidy.

Estimates of additional R&D

77. Estimates of the additional amount of R&D investment directly resulting from an R&D tax incentive typically draw on empirical results from estimation of a structural R&D demand equation (see Box 2) that relates R&D expenditure to a number of explanatory variables including the tax-adjusted user cost of capital (discussed in section E). In particular, the additional R&D resulting from a tax incentive is calculated using empirical estimates of the elasticity of R&D with respect to its price ('user cost') – that is, the percentage change in R&D caused by a 1 per cent change in the price of R&D – combined with measures of the percentage change in the price (user cost) of R&D resulting from the R&D tax incentive.[22]

78. Most econometric work attempts to explain the relationship between R&D investment (expenditures on R&D) – in particular, investment in physical capital of various types (equipment, plant, buildings) used in R&D – as a function of the weighted average price (user cost) of these capital types.[23]

Box 2. Estimating R&D demand equations

Ad hoc R&D demand equation

Another approach to assess whether R&D expenditure is higher with the availability of tax incentives is to estimate an R&D demand function that relates R&D spending to a list of explanatory variables including a dummy variable (d) assigned a value of 1 or 0 reflecting the availability or not of an R&D tax incentive:[1]

$$R\,\&\,D_{it} = \alpha + \beta \cdot x_{it} + \gamma \cdot d_{it} + \varepsilon_{it}\,. \text{ (B.1)}$$

The sign and size of the estimated coefficient (γ) for the dummy variable provides an estimate of the amount of R&D induced by the introduction of the R&D tax incentive (e.g. R&D tax credit). Use of firm-level data is preferable. Where the sample of firms includes only firms eligible for R&D tax incentives,[1] then the estimated value of the tax incentive coefficient (γ) provides an estimate of the average R&D response for qualifying firms – including those that are taxable (profitable) and can claim current tax relief, and those that are non-taxable and unable to make a current claim. Greater precision over the value of the tax incentive coefficient for firms that are able to claim a credit is possible if the data distinguish taxable and non-taxable firms, enabling a dummy variable value assignment of 1 for only the first group.

Reliance on aggregate (industry or economy-wide) data is simpler, but less precise as the identification of the tax incentive effect will we determined only by variation in R&D demand over time. Also, by treating all firms the same (those that qualify for the incentive, those that do not; qualifying firms that are taxable and those that are not), the estimated co-efficient is an average dependent on the mix of firms that do and do not qualify, which may change between years.[1]

Estimating an *ad hoc* R&D demand equation provides a means to test whether a given R&D tax incentive is effective (successful) in encouraging R&D. However, use of a dummy variable as a switch (identifying when R&D tax relief is available, and when it is not) restricts the set of policy adjustments that can be assessed.

Structural R&D demand equation

A generally preferred approach to estimating the sensitivity of R&D to R&D tax incentives is to use structural R&D demand equation that includes, as a key explanatory variable, a tax-adjusted user cost of capital variable constructed for R&D investment.[1] The user cost variable, appearing in the R&D demand equation below as (c_{it}), measures a pre-tax 'hurdle' rate of return on investment that incorporates key variables impacting marginal investment costs, including R&D tax incentives.[1]

$$R\,\&\,D_{it} = \alpha + \beta \cdot x_{it} + \gamma \cdot c_{it} + \varepsilon_{it}\,. \text{(B.2)}$$

Estimation of (2) is complicated by the fact that the user cost variable can depend on the level of R&D, so the user cost is not an exogenous variable, calling for its replacement with an instrumental variable (i.e. a variable correlated with the user cost variable, but uncorrelated with current R&D).[1] In general, this implies some loss of precision in estimation.

A useful summary of empirical studies of R&D factor demand based on the user cost of capital approach is provided by Hall and van Reenen (2000). Their review leads to the conclusion that the tax elasticity of R&D spending in the U.S. in the 1980s is in the order of unity, possibly higher, with somewhat lower short-run elasticity reflecting time required for firms to adjust to changes in tax incentive policy.[1]

Predicting the R&D expenditure response to an adjustment in an R&D tax incentive, using the structural demand equation, is a two step process. The first step involves the use of disaggregate and preferably firm-level data to empirically estimate the sensitivity of R&D expenditure to an R&D user cost variable, as per equation (2), giving an estimated value for the coefficient (γ) of the user cost variable. The second step involves the mechanical derivation of the change in the user cost variable resulting from the adjustment to the R&D tax incentive, based on the user cost formula.[1]

Estimates of foregone tax revenue

79. Estimates of the amount of tax revenue foregone as a result of a given R&D tax incentive may be estimated using a corporate income tax micro-simulation model, based on taxpayer-level information gathered from stratified samples of corporate income tax returns.[24] A main advantage of such models is that they factor in the interactions of tax variables, carryover provisions, and distinguish taxable firms from those in a tax-loss position. This approach is preferable to one that simply adds up the value of R&D tax allowances and tax credits claimed, without capturing interactions and carryover provisions.[25]

3. Cost-benefit assessment of R&D tax incentives

80. As reviewed above, an assessment of the cost-effectiveness of a given R&D tax incentive is limited to a comparison of the benefit of additional R&D directly related to the incentive, against the cost of foregone tax revenues. A cost-benefit assessment would attempt to capture other benefit and cost factors, assessed from a public (societal) perspective. As the name implies, a cost-benefit assessment compares (societal) costs and benefits, taking into account not only current but also predicted future benefit/cost amounts:

$$CB = \frac{\sum_{s=1}^{\infty} \frac{B_s}{(1+r_s)^{s-1}}}{\sum_{s=1}^{\infty} \frac{C_s}{(1+r_s)^{s-1}}} . \tag{13}$$

81. The numerator of the cost-benefit ratio measures the sum of the present discounted value of expected current and future period benefits, and the denominator measures the sum of the present discounted value of expected current and future costs.

82. In principle, benefits to factor into a full cost-benefit assessment of an R&D tax incentive would include:

- increased producer surplus accompanying an expanded R&D capital stock;[26]
- net spillover effects (knowledge/profit spillovers).[27]

83. As regards the costs to be factored into a full cost-benefit assessment, main components are:

- foregone tax revenues, assessed taking into account the opportunity cost of public funds;
- compliance costs of R&D performing firms applying for R&D tax incentives;
- tax administration costs of governmental bodies administering the R&D programme.

84. In measuring producer surplus, the analysis takes into account not only the estimated additional amount of R&D resulting directly from the tax incentive (the focus of cost-effectiveness assessment), but the return on the R&D, recognizing that returns at the margin to (subsidized) R&D may be relatively low.[28]

4. Implications of possibly biased assessments of the tax burden R&D

85. As reviewed above, common practice involves reliance in empirical work on standard measures of the user cost of capital (used in standard METR measures for R&D) in empirical work. In particular, estimated coefficients on the standard user cost of capital variable (the tax explanatory variable in a structural R&D demand equation) are used to derive the tax elasticity of R&D, which in turn is used to estimate the additional amount of R&D resulting from a tax incentive or package of incentives. Estimates of additional R&D are used to assess cost effectiveness, and cost-benefit ratios.

86. As discussed in section E (sub-section 4), standard user cost and METR measures for R&D may be mis-specified. One concern is the assumption of taxation of returns on R&D at a country's basic CIT rate. A key question to be addressed is whether empirical analyses of tax effects on R&D, and evaluations

of R&D tax incentive programs, are based on biased measures of the user cost of capital that do not factor in the implications of cross-border tax planning involving geographically mobile intangibles.

87. Assessments of the amount of tax relief afforded to R&D typically focus on the tax treatment of R&D expenditure, and do not factor in relief from limited taxation of returns on R&D. As reviewed in section D, with few exceptions, the focus in theoretical and empirical work is on tax incentives that lower the effective (net of tax) cost of purchasing or acquiring the services of inputs used to undertake R&D, primarily physical capital and labour. Consistent with this, as reviewed in section E, the main tax policy indicators for R&D – the B-index and standard METR measures – assume that revenue derived from R&D is subject to tax at basic statutory corporate income tax rates. However, a more complete assessment would take into account the full range of applications of knowledge capital (including licensing) and instances where revenues derived from such applications are taxed at reduced rates.

88. Where knowledge capital is used in domestic production, and revenues from commercialization (sales) are included in the domestic tax base, the applicable tax rate would normally be the basic (or small business) statutory corporate income tax rate. Where knowledge capital is licensed, preferential taxation may apply. For example, a low scheduler tax rate may apply to foreign-source royalty income, as under Dutch rules. In countries that tax foreign direct dividends (e.g. the U.S.), excess foreign tax credits on high-taxed dividend income may be applied to shelter foreign royalty income from domestic tax.

89. Where knowledge capital is transferred to an offshore holding company, little or no income taxation of foreign royalty income may apply. Various tax-planning strategies may be routinely used by companies (MNEs) to avoid tax on royalty income on patents and other intellectual property (IP), often generated with the support of R&D tax incentives. For example, a parent company, benefiting from tax credits on R&D that results in a patent, may enter into a cost sharing agreement with a tax haven IP holding company that enables tax-free receipt of royalty income earned on licenses of the patent with operating affiliates in different countries.

90. Under domestic law, a parent company of an MNE group may be required to allocate income derived from the use of self-developed IP to members of the MNE group on the basis of an allocation of costs and risks in developing the IP. Consider, as an example, the case where a parent and an IP holding company agree to equally share (50/50) the costs and risks in developing IP. Also assume that 50 per cent of the income derived from the IP is income generated from the use by the parent of the IP in domestic production, while the other 50 per cent is derived from licenses to foreign operating affiliates and possibly third parties. In this case, all of the royalty income may be assigned to the IP holding company where it is received tax free. Where the parent company is not subject to controlled foreign company (CFC) rules, or CFC rules are in place in the home country that in principle would tax the parent on a current basis on foreign royalty income passively received by its foreign affiliates – but application of the rules can be avoided by tax-planning to circumvent the rules (e.g. as under U.S. check the box rules), then foreign royalty income is earned free of income tax (non-resident withholding tax may apply at source, but possibly with scope to reduce this tax charge).

91. Charts 1-4 in Annex IV illustrate how the B-index, when measured under the assumption that returns on R&D are taxed at the basic CIT rate (u), does not provide an representative R&D tax burden indicator where knowledge – for example, a patent – is licensed to a foreign affiliate and a preferential tax rate applies. In the case of a non-intermediated license to a foreign affiliate, the relevant tax rate on royalty income is less than the basic CIT rate where foreign royalty income is taxed preferentially under domestic rules (Chart 2). Where a patent is held offshore (e.g. under a cost sharing agreement), the relevant tax rate on returns may be limited to non-resident withholding tax at source on royalty payments (Chart 3). This rate may apply even if CFC rules apply (Chart 4) where a hybrid entity is used.

92. As detailed in CTPA/CFA/WP2(2009)27, *Taxation and Innovation Policy*, tax-planning in the case of intangibles can take a variety of forms, facilitated by the highly geographically mobile nature of this asset type. To the extent that it is central element in the management of knowledge capital (IP), its effects in determining the effective tax rate on returns from R&D should be taken into account in an overall assessment of the tax treatment of R&D. A full assessment would also require consideration of the possible application of anti-avoidance rules – including anti-deferral (controlled foreign company-type) rules and transfer pricing rules – and how effective these rules are in countering tax avoidance. This level of detail implies a complex set of considerations. Yet attempts to sort out the implications of tax-planning and counter-measures are important, in order to establish the accuracy of the standard assumption in empirical work and policy assessment, including efficiency and revenue implications of R&D tax policy. In assessing overall tax relief provided, it is important to consider the tax treatment of R&D expenditures *and* income derived from R&D, and the balance of tax relief targeted at cost versus income. Both the B-index and the standard METR framework are not well suited for this identification, as they do not separately treat knowledge capital. The McKenzie (2008) framework provides this separation, and may be applied to give a broader perspective.[29]

G. Profit vs. Expenditure Based Tax Relief

93. As noted above, assessments of tax relief for R&D typically focus on tax incentives that lower the net cost of R&D expenditure, and ignore tax-planning aimed at minimizing tax on income from the use of knowledge capital, created in an increasing number of OECD countries with significant tax incentive support. A more detailed and accurate assessment would factor in the tax treatment of returns on R&D taking into account commonly used tax-planning strategies.

94. Factoring in limited taxation of returns on mobile intangibles is necessary to address behavioural effects. A policy of offering tax incentives for R&D expenditure, while taxing at a relatively high rate the returns on knowledge capital used in or licensed from the home country would be expected to encourage:

- domestic R&D expenditure, subsidized by R&D tax incentives; and
- transfers of knowledge capital offshore, so that returns on development activity and commercial applications can be received tax free.

95. Tax policy may be questioned where it provides generous tax support for R&D expenditures, imposes relatively high rates of tax on royalty income received directly, and at the same time waives current taxation of royalty income received by offshore IP holding companies. While policy assessment should factor in spillover benefits of domestic R&D, the tax base implications of such an outcome lead one to consider alternative policy options.

96. A reduced domestic tax rate on foreign royalty income – involving a targeted rate reduction or a general CIT rate reduction taxing all business income at a reduced rate – may discourage the migration of intangibles offshore while at the same time encourage domestic R&D. Revenue losses could be financed in part by a less generous set of tax incentives for R&D expenditure. However, targeting foreign royalty income may raise concerns, while reducing the basic CIT rate tends to be expensive in terms of foregone tax revenue. It may be that tax revenue gained by reducing or even eliminating tax incentives on R&D expenditure would cover revenue losses of only a small cut in the basic CIT rate (e.g. 1 percentage point). Where royalty income can be received tax-free offshore, migration would continue to be attractive to business. This suggests that to effectively discourage the migration offshore of intangibles, steps may be required that apply and enable robust enforcement of controlled foreign company rules that tax passive foreign royalty income on a current basis.

97. Box 3 lists various tax policy variables that influence the profitability of undertaking research and development onshore.

Box 3

Tax drivers of R and D

The conceptual framework presented in section B characterizes R&D (innovation) as a two-stage process. The first stage (basic and applied research activity) involves the use of physical capital (K) and labour (L) to produce knowledge capital (Q) that, in a second stage (development activity), is used internally, licensed or sold.[1] Where used internally, the knowledge capital is assumed to be combined with physical capital, labour, and purchased or licensed intangible capital, to develop a new product/production process for sale and/or internal use. Where licensed or sold, the knowledge capital is also assumed to be applied in a development activity. Key tax drivers of research, development and commercialization activities centre on these inputs and outputs.

Cost-based drivers of research activity:

- Depreciation allowances, investment tax credits affecting the net cost to business of acquiring physical capital services (K) used in research activity to create Q.
- CIT/PIT/SSC provisions affecting net cost to business of hiring labour services (L) used in research activity to create Q (e.g. reduced employer social security contributions on wages; reduced personal income tax and employee social security contributions on wage income shifted back onto firms).

Profit-based drivers of research activity

- CIT rate on profits derived from the use of Q in development/commercialization activity.
- CIT rate on royalty income derived from licensing Q.
- CIT/capital gains tax rate on sale of Q.

Cost-based drivers of development/commercialization activities:

- Depreciation allowances, investment tax credits affecting the net cost to business of acquiring physical capital services (K) used in development activity (to create new products/processes).
- CIT/PIT/SSC provisions affecting net cost to business of hiring labour services (L) used in development activity.
- CIT relief for licensing / purchasing intangible capital used in development activity.

Profit-based drivers of development/commercialization activities:

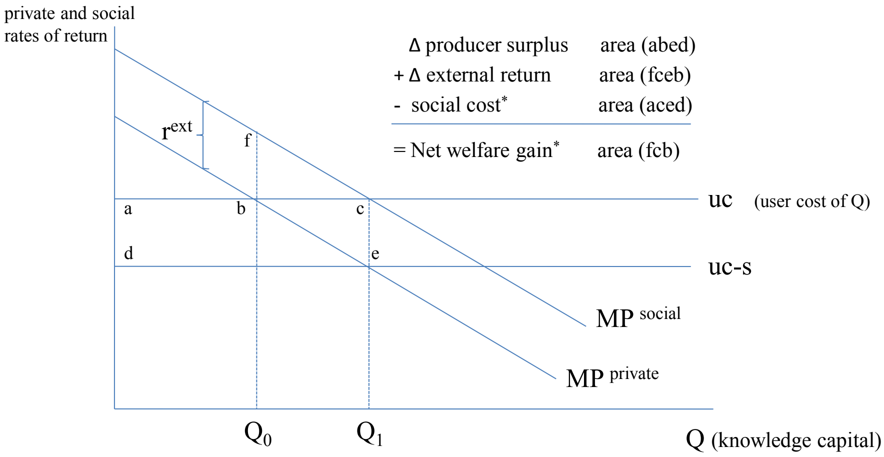
- CIT rate on profit derived from sale/internal use of new products/new production process.

ANNEX I – SPILLOVERS AND R&D TAX INCENTIVES

This annex presents a simple model underlying the 'spillover' argument for tax incentives for R&D, discussed in section C. The illustration draws on work by Dahlby (2005) and Parsons and Phillips (2007).

Chart I.1 considers a firm that employs labour and physical capital to create knowledge capital Q, used to create new products/production processes. The private return on knowledge capital is assumed to decline as the stock of Q increases, as reflected in the downward-sloping private marginal product schedule $MP^{private}$.[30] The horizontal schedule (uc) shows the user cost of knowledge capital, defined as the minimum (hurdle) rate of return on Q required to cover costs (financing, depreciation, taxes) incurred in the creation of Q (see Annex III). The firm maximizes its profit by investing in knowledge capital up to Q_0, at the point (b) where the private marginal product of knowledge capital just equals the user cost of knowledge capital.

Chart I.1
Optimal knowledge capital (Q_1)



* Illustration assumes non-distortionary (lump-sum) taxation.

The R&D activity is assumed to generate spillover benefits to society (increased production efficiency of other firms able to freely benefit from the new knowledge). Let r^{ext} denote the external rate of return on knowledge capital. The marginal social rate of return on knowledge capital is given by:

$$MP^{social} = MP^{private} + r^{ext} \qquad (1)$$

From society's perspective, the optimal level of knowledge capital is shown by Q_1, where the marginal social rate of return equals the user cost of knowledge capital at point (c). In order to encourage the firm to increase its R&D to achieve Q_1, a subsidy could be provided to the firm that reduces the adjusted user cost of capital (inclusive of the subsidy) to the amount given by the schedule (uc-s), where the subsidy amount (s) equals the external rate of return on knowledge capital. Setting the rate of subsidy (e.g. tax incentive) to the external rate of return on knowledge capital assumes that government can finance its activities with lump-sum taxes. Where tax incentives are financed by distortionary taxes (with government expenditure fixed), the marginal benefit from the subsidy must be compared with marginal cost of public funds (which in general, is greater than one (see Dahlby (2005)).

ANNEX II – R&D TAX INCENTIVES IN OECD COUNTRIES, 2005

Table 1. B-index and general R&D tax treatment in OECD countries: Major parameters, 2005

Country	**B-index** Large/SME	**Tax subsidy** (1-B-index)	**CIT rate** Large/SME %	**Current deduction** %	**Depreciation** ME	**Depreciation** B
Australia	0.883	0.12	30	100	5 years	40 years
Austria	0.922	0.08	25	100	5 years	25 years
Belgium	1.009/1.009	-0.01	33.99	100	3 years	20 years
Canada (federal)	0.827/0.678	0.17/0.32	32.12/23.12	100	100%	4%
Czech Republic	0.698	0.30	26	100	5 years	30 years
Denmark						
– without allowance	1.013	-0.01	28	100	30%	20 years
– 150% allowance	0.839	0.16				
Finland	1.008	-0.01	26	100	25%	20%
France	0.866	0.13	34.33	100	40%	20 years
Germany	1.030	-0.03	38.70	100	20%	33 years
Greece	1.015	-0.02	35	100	3 years	12.5 years
Hungary			16	100	3 years	50 years
– 200% R&D allowance	0.838	0.16				
– 400% allowance at universities	0.495	0.50				
Iceland	1.012	-0.01	18	100	10 years	50 years
Ireland	0.951	0.05	12.5	100	100%	100%
Italy	1.023/0.575	-0.02/0.42	33	100	10 years	33 years
Japan			42/32	100	50%	50 years
– R&D intensity <10%	0.865/0.808	0.14/0.19				
– R&D intensity >10%						
– with universities and other R&D institutes	0.831/0.808	0.17/0.19				
	0.782/0.808	0.22/0.19				
Korea	0.820/0.842	0.18/0.16	27.5/14.5	100	5 years	5 years
Mexico[1]	0.627	0.37	30	100	35%	20 years
Netherlands	0.934/0.762	0.07/0.24	31.5/27	100	5 years	25 years
New Zealand	1.023	-0.02	33	100	22%	4%
Norway	0.794/0.769	0.21/0.23	28	100	20%	4%
Poland	1.011	-0.01	19	100	5 years	40 years
Portugal	0.717	0.28	27.5	100	4 years	20 years
Spain	0.559	0.44	35	100	100%	33 years
Sweden	1.015	-0.02	28	100	30%	25 years
Switzerland (Zurich)	1.010	-0.01	24.5	100	40%	8%
United Kingdom	0.904/0.894	0.10/0.11	30/19	100	100%	100%
United States (federal)	0.934	0.07	35	100	5-year MACRS property	39-year property

1. Mexico allows a 94% immediate deduction for machinery and a 74% immediate deduction for buildings. Source: DSTI/DOC(2006)4

Table 2. R&D tax credits and R&D allowances in OECD countries: Major characteristics, 2005

Country[1]	Rate on level	Rate on incre-ment	Base for increment[2]	Expense base[3]	Deducted from TI or CIT[4]	Taxable	Separate treatment of SMEs
Australia	125%	175%	3 yrs	C, ME	TI	Yes	
Austria							
– special allowance	125%	135%	3 yrs	C	TI	Yes	
– capital allowance	115%			ME, B	TI	Yes	
– alternative refundable tax credit	8%			C	CIT	No	
Belgium							
– investment deduction	113.5%			ME, B	TI	Yes	
Canada (federal)	20%			C, ME	CIT	Yes	35%; refund
Czech Republic	200%			C	TI	Yes	
Denmark							
– collaborative R&D with universities	150%			C	TI	Yes	
France	5%	45%	2 yrs	C, MED, BD	CIT	No	Refund-able
Hungary							
– with/at universities	400%			C			
– other R&D	200%			C			
Ireland							
– R&D expenditure		20%	Single period 3 years back	C, ME	CIT	No	
– R&D buildings	20%			B	CIT	No	
Italy							
– small companies	30%			C, ME, B	CIT	No	SME only
Japan							
– large firm <10% research intensity	10%			C, MED	CIT	No	15%
– large firm >10% research intensity	12%			C, MED	CIT	No	15%
– collaboration with universities and other R&D institutes	15%			C, MED	CIT	No	15%
– basic technology	5%			ME	CIT	No	
Korea							
– development of tech.	15%			C	CIT	No	
– alternative		50%	4 yrs	C	CIT	No	
– facilities	10%			ME, B	CIT	No	
Mexico	30%			C	CIT	No	
Netherlands	14%			Research wages	TI	Yes	42%
Norway (refundable)	18%			C	CIT	No	20%
Portugal	20%	50%	2 yrs	C	CIT	No	

Table 2 (cont'd). R&D tax credits and R&D allowances in OECD countries: Major characteristics, 2005

Country[1]	Rate on level	Rate on increment	Base for increment[2]	Expense base[3]	Deducted from TI or CIT[4]	Taxable	Separate treatment of SMEs
Spain							
- Tax credit	30%	50%	2 yrs	C	CIT	No	
- Capital R&D	10%			ME	CIT	No	
United Kingdom							
– Small company	150%			C	TI	Yes	Refund-able
– Large company	125%			C	TI	Yes	
United States (federal)		20%	Maximum 50% of current expenses	C	CIT	Yes	

1. Other OECD countries do not have tax credits or taxable income allowances.
2. Average over specified number of years.
3. C = current; ME = machinery; B = buildings; MED = ME depreciation; BD = B depreciation.
4. CIT = corporate income tax; TI = taxable income.

Source: DSTI/DOC(2006)4

ANNEX III – MODELLING METRS FOR R&D

This annex presents in summary fashion the 'standard' approach to assessing a marginal effective tax rate (METR) for R&D as a weighted average of METRs on labour and on physical capital used in R&D. It also presents an alternative framework that provides a METR on knowledge capital (explicitly modelled). Relative strengths and weaknesses of the two approaches are addressed in the main body of the note (see sub-section 4 of section E).

1. Standard METR framework for R&D

The conventional approach adopted to date to assess tax distortions to R&D is to apply the standard Hall-Jorgenson-King-Fullerton (HJKF) method to separately assess the user cost and corresponding marginal effective tax rates (METRs) on labour and on physical capital (plant and machinery, and buildings) used in R&D activity. Overall values are then calculated as weighted averages of separate user cost and METR measures (see Griffith et al. (1995), Gordon and Tchilinguirian (1998), Mackie (2002) and Wilson (2005)).

The following provides a basic illustration. Under the standard approach, a METR for R&D is calculated as a weighted average of a METR for physical capital ($METR_K$) and for labour ($METR_L$) used in R&D, with weights S_K and S_L:[31]

$$METR_{R\&D} = S_K METR_K + S_L METR_L . \qquad (1)$$

The component METR measures are derived under the assumption that capital and labour are hired just up to the point where after-tax benefit of an additional unit just equals the after-tax cost.

METR for physical capital used in R&D

The METR for physical capital measures the difference (tax wedge) at the margin between the pre-tax, net-of-depreciation, rate of return on one currency unit of physical capital (r^g_K), and the (fixed) required after-corporate tax rate of return (ρ^*), as a percentage of the pre-tax, net-of-depreciation rate of return:

$$METR_K = \frac{r^g_K - \rho^*}{r^g_K} . \qquad (2)$$

In general, the required pre-tax, net-of-depreciation 'hurdle rate of return' is calculated as follows:

$$r^g_K = \frac{\partial(PF(L,K)/\partial K)}{P} - \delta_K = F_K - \delta_K = \frac{(\rho + \delta_K)(1 - uZ - \phi)}{(1-u)} - \delta_K \qquad (3)$$

which assumes that physical capital used to undertake R&D is carried out up to the point where the marginal benefit of investment, given by the marginal product of capital F_K, just equals the marginal cost (so-called user cost of capital c_K):

$$F_K = c_K = \frac{(\rho + \delta_K)(1 - uZ - \phi)}{(1-u)} \tag{4}$$

where P is the price of output produced using labour (L) and physical capital (K) according to a production function F(L,K) , δ_K is the declining-balance rate of economic depreciation of physical capital used to undertake R&D, u is the statutory corporate income tax rate, Z measures the present discounted value of tax depreciation allowances on one currency unit of physical capital used to undertake R&D expenditure, and φ measures the (volume-based) rate of investment tax credit earned on the same purchase. The after-tax cost of funds to the firm is ρ.[32]

METR on labour used in R&D

While labour costs are generally regarded as a current expense contributing to current income, the standard METR approach when applied to R&D treats labour expense as an investment expenditure. That is, labour is assumed to generate current and future returns, at a declining balance rate (δ_L). With this simplifying assumption, the METR on labour is assessed in an analogous fashion to that for physical capital:

$$METR_L = \frac{r_L^g - \rho^*}{r_L^g}. \tag{5}$$

$$r_L^g = \frac{\partial(PF(L,K)/\partial L)}{P} - \delta_L = F_L - \delta_L = \frac{(\rho + \delta_L)(1 - u - \phi)}{(1-u)} - \delta_L \tag{6}$$

$$F_L = c_L = \frac{(\rho + \delta_L)(1 - u - \phi)}{(1-u)} \tag{7}$$

Note that while labour costs are modeled as investment expenditure, the immediate expensing of labour costs provided in tax systems is captured. The formulae assume that labour costs qualify for an investment tax credit (as with investment in physical capital).

User cost for R&D

Empirical work based on the standard approach, that examines the relationship between R&D expenditure and taxation relies on a user cost measure of R&D, taken as a weighted average of the user costs of labour and capital (equations (4) and (7) above):

$$C = S_K c_K + S_L c_L \tag{4}$$

2. METR on knowledge (intangible) capital

This section reviews a framework developed by McKenzie (2008) that measures METRs on knowledge capital, distinct from METRs on labour and physical capital used to create knowledge capital.[33] Separate measures arise, as the approach separately treats knowledge capital creation and the development of new products/processes where knowledge capital used as a distinct input. Compared with the standard METR approach reviewed above, this approach would appear to better capture the underpinnings of R&D activity and clarify the various tax considerations involved.

In this framework, the tax treatment of labour and physical capital used as intermediate inputs to create knowledge capital is captured by METRs on these inputs. The METRs for labour and physical capital factor into a measure of the marginal tax rate on R&D costs, measuring the percentage change in the cost of producing an additional unit of knowledge capital, due to the taxation of labour and capital inputs. (The marginal tax rate on research costs can be thought of as an effective excise tax rate applied to the production of knowledge capital within the firm). The marginal tax rate on research costs factors into the profit-maximizing decision of the optimal amount of knowledge capital to create (comparison of marginal revenues and costs). The following sketches out this framework, with a focus on the separate METR measures for labour, physical capital and knowledge capital.

Under this framework, the marginal effective tax rate on knowledge capital is measured as follows:

$$METR_Q = \frac{r_Q^g - \rho^*}{r_Q^g} \,. \tag{8}$$

The tax wedge in the numerator captures taxes paid on a marginal unit of knowledge capital produced within the firm, given by the difference between the gross-of-tax, net-of-depreciation, rate of return on a marginal unit of knowledge capital (r^g_Q), and the required after-corporate tax rate of return (ρ^*).

The gross-of-tax, net-of-depreciation rate of return is measured as follows:

$$r_Q^g = \frac{\partial PF(X,Q)/\partial Q}{MC(I_Q; w, q(\rho+\delta_K))} - \delta_Q \tag{9}$$

with depreciation of knowledge capital captured by the term δ_Q. The numerator term $\partial PF(X,Q)/\partial Q$, derived from profit maximizing conditions of the firm (see below), measures the marginal addition to the firm's revenue function resulting from an additional unit of knowledge capital. Dividing this term by the before-tax marginal cost of a unit of knowledge capital $MC(I_Q;w,q(\rho+\delta_K))$ gives the marginal addition to the firm's revenue from an additional one currency unit (e.g. Euro) of knowledge capital.

As noted, the numerator term $\partial PF(X,Q)/\partial Q$ in (9) is derived assuming that a profit maximizing R&D performer will invest in labour and physical capital, to create knowledge capital, just up to the point where the marginal addition to revenue from an additional unit of knowledge capital ($\partial PF(X,Q)/\partial Q$) equals the marginal cost of producing an additional unit of knowledge capital:

$$\frac{\partial PF(X,Q)}{\partial Q} = MC(I_Q; w, q(\rho+\delta_K))(\rho+\delta_Q)(1+T_R) \tag{10}$$

where $MC(I_Q;w,q(\rho+\delta_K))$ is the before-tax marginal cost of knowledge capital. The right-hand-side of equation (10) is the (tax-adjusted) user cost of knowledge capital. It differs from a standard user cost of capital measure in two ways. First, the before-tax marginal cost of knowledge capital $MC(I_Q;w,q(\rho+\delta_K))$ appears, rather than a market price of a unit of knowledge capital. With knowledge capital produced in-house, the relevant price is the marginal cost of producing it.[34]

Second, the term ($1+T_R$) captures an aggregation of METRs on the inputs used to produce knowledge capital according to the R&D production function. The variable T_R – which may be thought of as an effective excise tax rate on research costs – measures the percentage change in the marginal cost of producing an incremental unit of knowledge capital due to the taxation of labour and capital (inputs into the creation of knowledge):[35]

$$T_R = \frac{MC(I_Q; w(1+METR_L), q(\rho+\delta_K)(1+METR_K)) - MC(I_Q; w, q(\rho+\delta_K))}{MC(I_Q; w, q(\rho+\delta_K))} \tag{11}$$

$$METR_L = \frac{r_L^g - w}{w} = \frac{\dfrac{w(1-u-\phi)}{(1-u)} - w}{w} \tag{12}$$

$$METR_K = \frac{r_K^g - q(\rho+\delta_K)}{q(\rho+\delta_K)} = \frac{\dfrac{q(\rho+\delta_K)(1-uZ-\phi)}{(1-u)} - q(\rho+\delta_K)}{q(\rho+\delta_K)} \tag{13}$$

Using the profit-maximizing condition (10), the gross-of-tax, net-of-depreciation rate of return on knowledge capital can be solved as follows:

$$r_Q^g = (\rho+\delta_Q)(1+T_R) - \delta_Q \tag{14}$$

Substituting this result into (8) gives the solution to the METR on knowledge capital.

The solution to the effective marginal tax rate on R&D costs (T_R) requires that the R&D cost function be parameterized. In the case of a Cobb-Douglas production function (elasticity of substitution of unity), it can be shown that:[36]

$$T_R = \prod_i \left(1+METR_i\right)^{S_i} - 1 = (1+METR_L)^{S_L}(1+METR)^{S_K} - 1 \tag{14}$$

where S_L and S_K are the factor shares of labour and capital.

ANNEX IV – B-INDEX CALCULATIONS UNDER ALTERNATIVE INTANGIBLE CAPITAL HOLDING STRUCTURES

Chart 1
<u>Simple domestic structure</u>

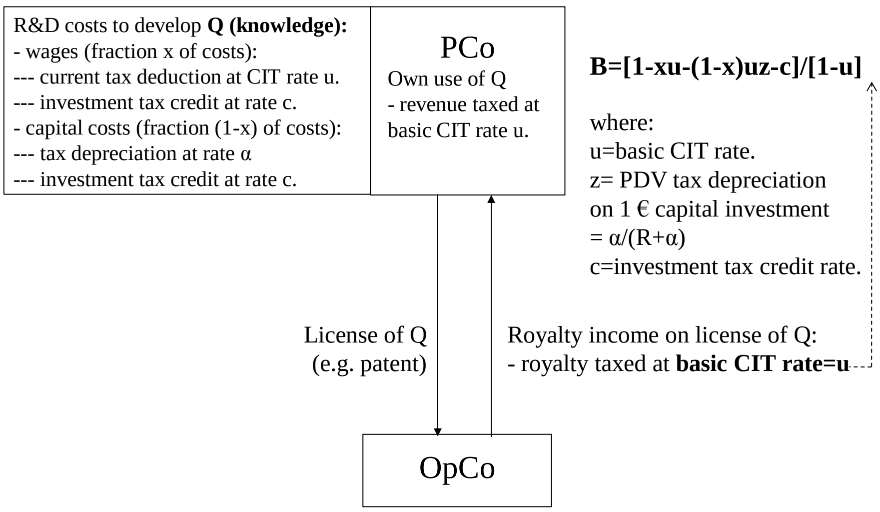


Chart 2
Simple cross-border structure

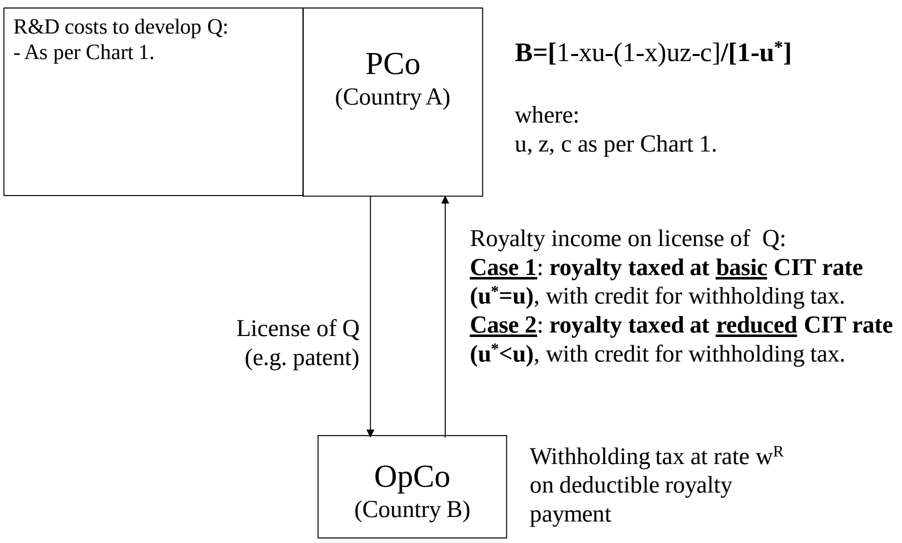


Chart 3
Triangular structure, no 'anti-deferral' rules

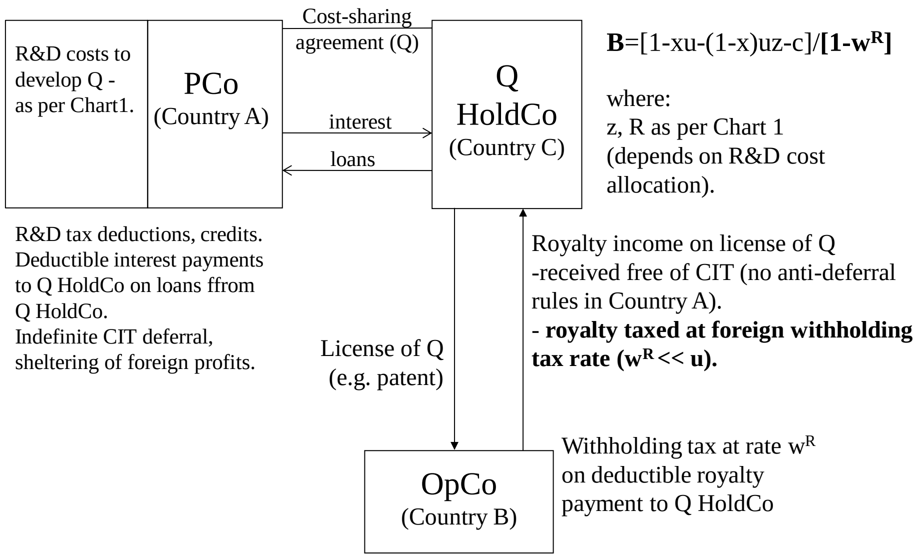
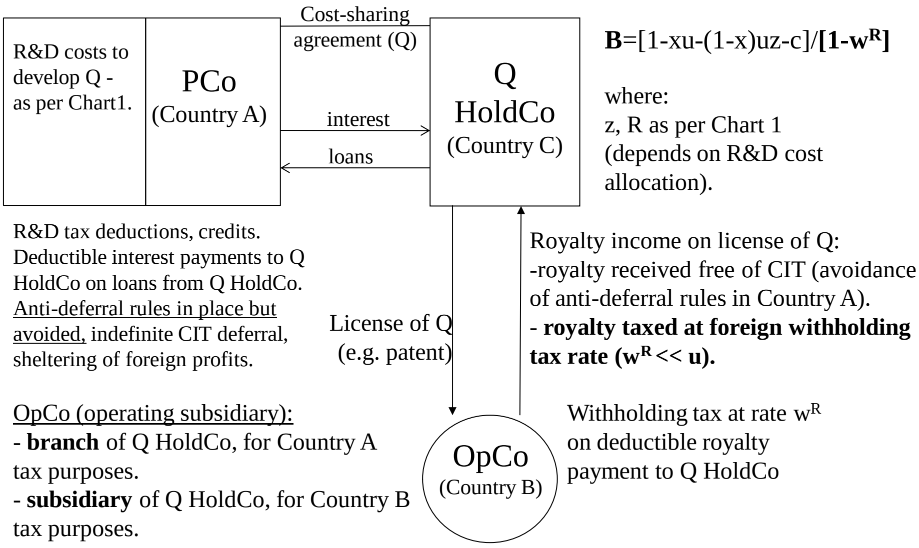


Chart 4
Hybrid structure, avoidance of 'anti-deferral' rules



REFERENCES

Adéa, D., J. Lester, and J. Warda (2009), "Modifying the B-Index to Improve International Comparisons of Tax Assistance to Investment in R&D, mimeo. A paper presented to the May 2009 meeting of Working Party No.2 of the OECD Committee on Fiscal Affairs.

Bernstein, J. (1986), "The effect of direct and indirect tax incentives on Canadian industrial R&D expenditures", *Canadian Public Policy* XII, 438-448.

Bernstein, J. (1996), "R&D spillovers between U. S. and Canadian industries", *Canadian Journal of Economics, Special Issue, Part 2*. 463-367.

Bloom, N., R. Griffith and J. van Reenen (2002), "Do R&D Credits Work? Evidence from a Panel of Countries 1979-1997", *Journal of Public Economics* 85(1), 1-31.

Dahlby, B. (2005), "A Framework for Evaluating Provincial R&D Tax Subsidies", *Canadian Public Policy* 31(1), 45-58.

Devereux, M., and R. Griffith (1998), "Taxes and the Location of Production: Evidence from a panel of U.S. Multinationals", *Journal of Public Economics*.

Gordon, K. and H. Tchilinguirian (1998), *Marginal effective tax rates on physical, human and R&D capital*. OECD Economics Department Working Paper 199.

Griffith, R., D. Sandler and J. van Reenen (1995), "Tax incentives for R&D", *Fiscal Studies*, 16, 21-44.

Grubert, H. (200XXX)

Haegeland, T, and J. Moen (2007), "Input additionality in the Norwegian R&D tax credit scheme, reports 2007.47, Statistics Norway 2007.

Hall, B. (1993), "R&D tax policy during the eighties: Success or failure?", *Tax Policy and the Economy*, 7, 1-36.

Hall, B., and J. van Reenen (2000), "How effective are fiscal incentives for R&D? A review of the evidence", *Research Policy*, 29, 449-469.

Hall, R., and D. Jorgenson (1967), "Tax policy and investment behaviour", *American Economic Review* 57, 391-414.

Hines, J.R. (1993), "On the sensitivity of R&D to delicate tax change: the behaviour of U.S. multinationals in the 1980s". In: Giovanni, A., Hubbard, R., Slemrod, J. (Eds), *Studies in International Taxation, III*. University of Chicago Press, Chicago, 149-94.

King, M. and D. Fullerton (1984), *The taxation of income from capital: a comparative study of the United States, United Kingdom, Sweden and West Germany*, Chicago: University of Chicago Press.

Mackie, J. (2002), “Unfinished business of the 1986 tax reform: an effective tax rate analysis of current issues in the taxation of capital income”, *National Tax Journal*, vol.55, 293-337.

McKenzie, K., J. Mintz and K. Scharf (1997), “Measuring effective tax rates in the presence of multiple inputs”, *International Tax and Public Finance* 4(3), 332-259.

McKenzie, K. (2008), “Measuring tax incentives for R&D”, *International Tax and Public Finance*, 15, 563-581.

Mansfield, E. (1986), “The R&D tax credit and other technology policy issues”, AEA Papers and Proceedings, 76, 17-25.

OECD (2002), Frascati manual 2002: Proposed standard practice for surveys on research and experimental development. OECD.

Parsons, M. and N. Phillips (2007), An evaluation of the federal tax credit for scientific research and experimental development. Department of Finance, Canada, Working paper 2007-08.

U.S. General Accounting Office (1989), “The research tax credit has stimulated some additional research spending”, Vol. GAO/GGD-89-114, U.S. General Accounting Office, Washington, D.C..

Warda, J. (1994), “Canadian R&D tax treatment: an international comparison”. Vol. report No. 125-94. The Conference Board of Canada, Ottawa, Ontario.

Wilson, D. (2005), “Beggar thy neighbour? The in-state vs. out-of-state impact of state R&D tax credits”, Federal Reserve Bank of San Francisco Working Paper 2005-08.

ENDNOTES:

1 In discussions of R&D tax policy, it is helpful to rely on a broad conceptual framework that identifies what is meant by research and development activities, what factors/inputs are involved, and what the main outputs/outcomes are.

2 The list of applications is non-exhaustive. Other cases to examine include undertaking R&D jointly with another company, for example under a cost sharing agreement where the assignment of royalty income derived from licensing patents or other intangibles resulting from R&D is allocated amongst the two parties according to cost contributions and risk allocations. For a discussion, see section F (sub-section 4) and CTPA/CFA/WP2(2009)27.

3 Licensing agreements may provide for an exclusive right or non-exclusive right to use Q. Chart 1 considers the non-exclusive right to use case.

4 Policy makers may also provide tax relief in respect of labour, for example by lowering employer social security contributions on gross wages paid to qualifying R&D staff. In general, CIT treatment of labour (unlike capital) is neutral, with wages/deductible at the same CIT rate applicable to the marginal product of labour. However, tax relief in respect of labour expense may be required to avoid a tax distortion favouring capital if tax incentives for investment in physical capital result in a negative net tax rate on investment.

5 A ‘quality’ investment is an investment where the expected rate of return based on inside knowledge to the firm exceeds the market rate (safe rate plus risk premium.

6 Adverse selection arises where information needed to assess potential profit on investment (the probability distribution of net returns) is known by the manager/owner of a firm but not by outside creditors. One possible outcome is that creditors cannot distinguish amongst firms, and require that all firms pay the same rate of return. In such models, quality firms with projects earning above-average expected rates of return pay an interest rate premium relative to rates they would be required to pay if lenders had symmetric information known to the firm (with the premium effectively subsidizing firms with projects earning below-average expected rates of return). Alternatively, quality firms willing to pay a market rate of interest may be denied financing. In both cases, less investment would be predicted than with symmetric information (see for example de Meza and Webb (1987)). So-called ‘signalling models’ would predict that high-quality firms would engage at considerable expense in activities to signal to potential investors the quality of their prospective returns, where that activity cannot be copied by (is too expensive for) lower-quality firms. For example, a strong cash-flow from existing investments may be signalled by a high dividend payout ratio (see Miller and Rock (1985)), or a high debt-equity ratio (see Ross (1977)).

7 The definition of tax incentive for R&D may also include tax provisions that lower the cost of funds for undertaking R&D (e.g. flow-through provisions that allow unused corporate-level tax incentives to be passed on to shareholders, with the policy expectation that shareholders will lower their expected rate of return on shares (required to be induced to purchase shares) and thereby lower the cost of funds for firms. As with tax incentives tied to expenditures on labour and physical capital services, this form of incentive operates by lowering costs.

8 With depreciation allowances calculated on a nominal basis, the present value of future claims is eroded with inflation. The illustration assumes a constant rate of inflation.

9 An alternative design provides a credit for current investment in excess of an average of investment over preceding years (e.g. 3 years): $IITC_t=\lambda(I_t-(I_{t-1}+I_{t-2}+I_{t-3})/3)$.

10 For example, in some systems providing an investment tax credit on investment in depreciable capital, the credit amount reduces the base of the capital cost allowance for the investment.

11 Carryover provisions for accelerated depreciation may be determined by loss carryover rules where depreciation claims are mandatory. Where depreciation claims are discretionary, separate carryover provisions for unused capital cost allowances would normally apply. Investment tax credits would normally have carryover provisions specific to that incentive.

[12] To characterize standard METRs on physical capital and labour used in R&D as 'METRs for R&D capital' is tantamount to saying that physical capital and labour are R&D capital. This terminology is confusing as it is common to think of R&D capital as knowledge capital (an output of R&D). Standard effective tax rate (METR) modelling approaches (which do not separately treat knowledge capital) are unable to assess the effective tax rate on knowledge capital – instead they assess the effective tax rate on physical capital and labour used in R&D.

[13] A preferential corporate tax rate may apply, for example, to foreign source royalty income (e.g. on the license of a patent to a foreign affiliate).

[14] Where deductions for current expenses are deferred, A^{cur} measures the present discounted value of tax relief.

[15] Relaxing this assumption would involve assumptions over the stream of future profits and taxable income, and (tax-minimizing) applications of business loss carry-back and carry-forward provisions, investment tax credit carry-back and carry-forward provisions and tax credit refund provisions where applicable.

[16] See DSTI/DOC(2006)4 for B-index values (2005) for these R&D expenditure types for OECD countries.

[17] While labour costs are modeled as investment expenditure, immediate expensing of labour costs is taken into account. Labour costs are assumed to qualify for an investment tax credit (as with investment in physical capital). .

[18] Characterizing METRs derived from applications of the standard user cost model as 'METRs for R&D capital' is equivalent to saying that physical capital is R&D capital.

[19] A preferential corporate tax rate may apply, for example, to foreign source royalty income (e.g. on the license of a patent to a foreign affiliate).

[20] Managers may indicate that an R&D tax subsidy was a deciding factor in undertaking R&D, even where it was not, in order to continue to benefit from tax relief, if there is a perception that the results of the survey will be taken into account by policy makers in deciding future R&D tax policy. Another bias risk is that managers may focus on their own vision or performance rather than the features of the business environment as the factor encouraging R&D.

[21] A cost-effectiveness assessment is sometimes referred to as a test of 'additionality', or an assessment of the 'bang for the buck'.

[22] Measuring the change in the user cost of capital resulting from a change in a tax incentive is a mechanical exercise, based on the user cost of capital equation.

[23] As noted in section X, in general, R&D (knowledge) capital is created using some combination of physical capital, labour and materials, where the combination of physical capital types (machinery, plant, buildings) and other factors can be very different than the combination used to produce other goods. For example, the creation of knowledge capital may involve relatively greater use of light equipment (e.g. test tubes) and skilled labour than, for example, the manufacture of automobiles (e.g. involving heavy equipment, plant, etc). Also note that some studies attempt to explain total (business) R&D expenditure – not just investment in physical capital but also current expenses on labour – as a function of the weighted average of user costs of capital, by type, and the after-tax wage rate.

[24] With unincorporated businesses reporting taxable income in personal income tax returns, estimates of the amount of income tax revenue foregone by R&D tax incentives claimed in the unincorporated business sector require use of a personal income tax micro-simulation model.

[25] T he crudest approach to measuring tax revenues foregone takes R&D expenditure amounts and multiplies these by tax incentive parameters (e.g. an investment tax credit rate; an investment allowance rate and statutory corporate tax rate), without taking into account restrictions determining qualifying R&D expenditures, and without factoring in the tax status of firms (taxable, non-taxable).

[26] With a downward sloping marginal benefit schedule for R&D capital, the increase in producer surplus is more than offset by reduced tax revenues (implying a 'triangle' efficiency loss assessed at the opportunity cost of public funds).

27 Net spillover effects are measured as positive spillover effects (knowledge/income spillovers), reduced by negative spillover effects (technological obsolescence/loss of market share for non-R&D performers).

28 In addition to cost-benefit analysis, policy analysts may attempt to assess productivity/competitiveness gains resulting from effects of additional R&D on innovation (e.g. as measured by innovative sales as a percentage of total sales/turnover).

29 Inputs and outputs to research activity and development activity in the McKenzie (2008) paper consider only the case where in-house research is used internally within the firm. Licensing out of knowledge capital and the licensing in of intangibles, to be used in development activities are not considered. However, the model could be extended to consider these cases.

30 The illustration in Annex I is adapted to consider the two stage R&D process discussed in section B. The downward sloping $MP^{private}$ schedule assumes that the marginal productivity of knowledge capital declines as Q increases, holding constant labour and physical capital used together with Q in development activity.

31 Most studies separately consider two or more physical capital components. For example, Bloom, Griffith and Van Reenen (2002) separately treat buildings, and plant and machinery, where labour (current expenditure) is assigned a weight of 0.90, a weight of 0.064 for plant and machinery, and a weight of 0.036 for buildings.

32 The standard model assumes debt and equity finance (and ignores tax planning). Let i^* denote the interest rate on bonds, and ρ^{eq} denote the required rate of return on equity, which may be taken as set (fixed) in international capital markets (open economy model). The cost of capital (rate of return that the firm must pay its creditors/shareholders) is measured by $\rho^*=\beta i^*+(1-\beta)\rho^{eq}$ with β and $(1-\beta)$ measuring fractions of debt and equity finance. With interest expense being tax deductible, the cost of funds to the firm is $\rho=\beta i^*(1-u)+(1-\beta)\rho^{eq}$.

33 In the McKenzie (2008) paper, knowledge capital is referred to as intangible R&D capital.

34 Knowledge capital is a ‘non-marketed’ input into the development of a new product or production process. That is to say that, unlike physical capital, it is not purchased at a market price, but is produced using physical capital, labour, other inputs (materials). Where research is contracted out to an R&D services company, knowledge capital that results is not purchased – instead, the R&D performer/contractor is paid for services.

35 McKenzie (2008) considers a model that factors into $METR_L$ employer social security contributions, and the share of personal income tax on labour income and employee social security contributions shifted onto business. These are not included in the specification shown in this note.

36 See McKenzie (2008) for solutions for T_R in the general case of a constant elasticity of substitution production function. As the elasticity of substitution between labour and physical capital increases, the effective marginal tax rate on research costs (T_R) decreases (with increased scope to respond to changes in relative factor prices given by $(1+METR_L)$ and $(1+METR_K)$, the firm is better able to change the input mix to produce a given amount of knowledge capital at minimum cost).