THE TAXATION OF DISCRETE INVESTMENT CHOICES

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Abstract

Traditional analysis of the taxation of income from capital has focused on the impact of tax on marginal investment decisions; the principal impact of tax on investment is through the cost of capital, and is generally measured by an effective *marginal* tax rate. In this paper, we consider cases in which investors face a choice between two or more mutually exclusive projects, both of which are expected to earn at least the minimum required rate of return. Examples include the location decisions of multinationals, firms' choice of technology, and the choice of investment projects in the presence of binding financial constraints. In these cases the choice depends on the effective *average* tax rate. We propose a measure of this rate and demonstrate its relationship to the conventional effective marginal tax rate. Estimates of both are presented and compared for domestic and international investment in Germany, Japan, the UK and USA between 1979 and 1997.

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1. INTRODUCTION

Since the seminal works of Jorgenson (1963) and Hall and Jorgensen (1967) the standard approach to investigating the impact of taxation on firms' incentive to invest has been to examine its impact on the cost of capital - the minimum pre-tax rate of return on an investment required by the investor. The vast majority of both theoretical and empirical work focuses on the impact of taxation on marginal investment on the assumption that all potential investment projects that earn at least the cost of capital will be undertaken.

However, in many circumstances investment choices do not correspond to the framework adopted in this literature. Where an investor faces a choice between two or more mutually exclusive projects that are expected to earn more than the minimum required rate of return the choice of which project to undertake depends on the level of the post-tax economic rent that would be earned from each project. The impact of tax in this case is measured by the proportion of the pre-tax economic rent taken by the government - the effective average tax rate. Conditional on choosing one of the projects, the level of investment may be affected by taxation through the cost of capital in the usual way. This distinction is analogous to the labour supply decision where it is well known that the impact of tax on an individual's incentive to participate in the labour market is through the average tax rate, while the number of hours worked is affected by the marginal tax rate.

In Devereux and Griffith (1998) it was shown that the effective average rate of corporate income tax that a firm might expect to face on an investment project is an empirically significant factor for US multinational firms choosing where within Europe to set up a production facility. In the model in that paper, the firm expects to earn an economic rent on its activity by exploiting some firm specific advantage, such as a patent, but due to economies of scale in production it will not build more than one plant.[1] The effective marginal tax rate is relevant in determining the optimal scale of the investment conditional on the location having been chosen. The choice of location depends on the level of post-tax economic rent; the impact of tax is through its effect on this level, determined by the effective average tax rate.

In this paper it is argued that this model has a broader application than simply firms' location choices. For example, consider a firm that faces a choice between a number of alternative means of production, with a suitable investment in R&D a production facility may be made more automated, compared with a relatively labour-intensive production process in the absence of the R&D. Conditional on choosing which strategy to undertake, the effective marginal tax rate may affect the level of investment undertaken. However, the firm will only follow the strategy that yields the highest post-tax level of economic rent, which depends on the effective average tax rate. Another example is a firm operating in a differentiated goods market, choosing the type or quality of good to produce. If production of the goods is taxed differently - for example because they use different qualities or quantities of inputs which are taxed differently - then the difference in the effective average tax rates may affect the firms' choice.

There are two common elements in these examples - the investor faces a choice between mutually exclusive investment projects and at least two of these projects must be expected to generate positive economic rent before tax. The mutually exclusive nature of the investment projects may arise for different reasons, but is likely to require the existence of economies of scale. In the first two examples above, it is assumed that the

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[1] A number of theoretical models, based loosely on the OLI framework of Dunning (1977,1981), have this property. See for example, Caves (1996), Horstman and Markusen (1992) and Markusen (1995).

firm faces a given demand schedule, and is choosing between alternative ways of meeting demand. By assumption, it would be less profitable for the firm to undertake more than one of its strategic options. For example, the multinational may face fixed costs of setting up in each location. Setting up in two locations would mean paying fixed costs twice, which – for a given demand - is likely to imply a lower overall post-tax economic rent. Similarly, in the second example, the R&D creates economies of scale - having undertaken the R&D, it would be less profitable to use both the old and new technologies, rather than only the new technology. In the third example it is assumed that production of more than one variety is constrained by a given demand schedule.

The second common element of these examples is that at least two strategies must exist which are expected to generate a positive economic rent before tax. If only one strategy is expected to generate a positive economic rent then whether it should be undertaken can be analysed without reference to other possible strategies (assuming non-negative tax liabilities). This means that the firm must operate in conditions of imperfect competition. The precise form of imperfect competition is not important; all that is required for the tax on economic rent to play a role is that at least two mutually exclusive projects have the potential to earn economic rent.

Previous empirical work using average tax rates has tended to treat them as an imperfect approximation to the effective marginal tax rate and has measured them using accounting or tax return data.[2] These measures generally take the current tax liability as a proportion of current income. Several problems arise in using the realised amounts to analyse investment strategies. For example, accounting measures of average tax rates typically consider the firm at a single point in time, reflecting investments made by the firm over

[2] See, for example, Swenson (1994), Grubert and Mutti (1996) and Collins and Shackelford (1995).

many previous periods as well as the current period, the return on those investments and the way in which they were financed. They may also reflect the dynamic tax position of the firm; for example, in a year in which the firm earns high income it may not incur any tax liability because earlier losses may be brought forward. Accounting data on tax liabilities may also reflect tax payments in other jurisdictions in which the firm operates. Using these accounting or tax return based measures to make international comparisons is also problematic due to differences in accounting definitions and the timing of tax payments.

This paper sets out a framework to analyse the impact of tax on firms' choice between discrete investment decisions. We propose a new measure of the effective rate of taxation of investment projects, an effective average tax rate (EATR). This builds on the standard approach to measuring the effective marginal tax rate (EMTR).[3] This approach developed, for example, by Auerbach (1979) and King and Fullerton (1984), and at the international level by Alworth (1988), Keen (1991) and OECD (1991), considers the net present value of the income stream from an investment and the net present value of the cost of the investment.[4] Setting these equal defines the marginal investment and the required pre-tax rate of return can be derived. This type of approach permits the analysis of the impact of current (and expected future) tax regimes on the net present value of a new investment project. It also provides a useful tool for policy makers to analyse the impact of the tax system in isolation from other economic factors. However, although

[3] Notably King and Fullerton (1984), Alworth (1988), OECD (1991) and Keen (1991).

[4] An alternative approach, taken for example by Fershtman et. al. (1997), is to estimate the impact of tax changes econometrically.

quite complex elements of the tax system can be analysed, several assumptions about the structure and financing of the investment must be made. A number of important real world features, such as the tax planning activities of multinational firms, cannot be dealt with completely.

To compute the EATR, the net present value of the income stream is derived for an investment which earns a given pre-tax rate of return. The economic rent generated is simply the difference between this value and the net present value of the cost of the investment. In principle, the EATR can be measured as the proportionate difference between the pre-tax and post-tax economic rent, for a given pre-tax rate of return. However, in practice, we propose a slightly different measure for two reasons. First, such a measure is undefined for an investment which is marginal pre-tax, and hence has a zero pre-tax economic rent. Secondly, the proposed measure of the EATR has the attractive property that, for a marginal investment, it is equal to the EMTR. It can therefore be interpreted as summarising the distribution of tax rates for an investment project over a range of profitability, with the EMTR representing the special case of a marginal investment.

In the empirical section of this paper estimates of the EATR are presented for four countries –Germany, Japan, UK and USA - over the period 1979-1997. An analysis of how tax reforms in these countries have changed the shape of the tax schedule is given. How these tax schedules might affect investment incentives and choices in a number of situations is illustrated.

The structure of the remainder of the paper is as follows. The following section discusses in more detail some circumstances in which the EATR is the appropriate measure for investigating the impact of taxation on firms' investment decisions. Section 3 sets out a framework in which the EATR is then derived and analysed in a domestic context. This is extended in Section 4 to the case of international investment. In section 5 empirical values of the EATR for four countries are presented. Section 6 briefly concludes.

2. CONCEPTUAL FRAMEWORK

A number of situations are described in which the EATR may affect investment choices. A simple framework makes it easier to highlight the common elements of these choices. This framework can be extended in a number of directions to model any particular choice in more detail.

Consider the profit-maximising behaviour of a single firm that faces two investment opportunities, denoted strategies $i = 1,2$. The precise form of the competition is not crucial; however, the possibility of earning a positive pre-tax economic rent must exist. The cost structure of each of the two strategies consists of an investment in a fixed asset, F_i, and variable cost per unit of output. Denote the pre-tax net present value of the stream of income net of variable costs as Y_i^*, where the asterisk indicates a pre-tax value. The pre-tax economic rent, R_i^*, associated with strategy *i* is assumed to be positive:

$$R_i^* = Y_i^* - F_i > 0. \tag{2.1}$$

There are three options available to the investor: strategy *1*, strategy *2*, or both. Undertaking both strategies would incur investment of $F_1 + F_2$. Unless variable costs are increasing with output, then any given output could be produced at lower cost by following only one of the strategies. Only the case in which economies of scale rule out undertaking both strategies is considered. Given this assumption, in the absence of tax, the investor would choose the strategy with the highest level of R_i^* (as long as this is non-negative). Defining a binary indicator X_i^* of whether strategy i is chosen in the absence of tax, it will take the values,

$$X_i^* = \begin{cases} 1 \text{ if } R_i^* = \max\{R_1^*, R_2^*\} \\ 0 \text{ otherwise} \end{cases} \tag{2.2}$$

Now consider how tax will affect this choice. The statutory corporate income tax rate is denoted τ_i and the net present value of tax allowances per unit of investment is denoted A_i. Assume that income is taxed and variable costs are fully tax deductible. If the level of output is independent of the size of the investment (that is, F_i is a fixed cost) the full deductibility of variable costs implies that the optimal level of output in the presence of tax and conditional on choosing strategy i, Y_i, is the same as its level in the absence of tax, Y_i^*. This implies that the net present value of the income stream becomes $(1-t_i)Y_i^*$, and the net cost of the investment is $(1-A_i)F_i$. The post-tax economic rent of strategy i is therefore:

$$R_i = (1-t_i)Y_i^* - (1-A_i)F_i. \tag{2.3}$$

Post-tax the investor will choose the project with the highest level of R_i (again, as long as this is non-negative). That is, defining a binary indicator, X_i, of whether strategy i is chosen in the presence of tax, it will take the values:

$$X_i = \begin{cases} 1 \text{ if } R_i = \max\{R_1, R_2\} \\ 0 \text{ otherwise} \end{cases} \tag{2.4}$$

It is straightforward to generalise this to the case in which output depends on the level of investment. In this case, the optimal level of investment for any strategy, conditional on having chosen that strategy, will be determined by the equality of marginal revenue and marginal cost, implying a role for the effective marginal tax rate (EMTR). In this case $R_i = (1-t_i)Y_i - (1-A_i)F_i$, and the EATR is determined with reference to Y_i rather than to Y_i^*. In this case, the EATR cannot summarise all of the difference between investment choices in the absence of tax and the presence of tax. However, this is true of almost all such measures. For example, it is standard to compute the EMTR with reference to the actual required post-tax rate of return rather than the required rate of return in the absence of tax.

Neglecting the distinction between Y_i and Y_i^*, the key issue is whether the tax system can affect the ranking of projects, that is whether $X_i^* \neq X_i$. Clearly this is possible if the projects face different tax regimes, as is often the case. However, it can also be true even if all projects face an identical tax regime, represented by $\tau = \tau_1 = \tau_2$ and $A = A_1 = A_2$. For the case where $Y_i = Y_i^*$ the necessary and sufficient condition for tax to change the ranking of the projects, $R_1^* > R_2^*$ but $R_1 < R_2$, is that

$$(1-t)(F_1 - F_2) < (1-t)(Y_1^* - Y_2^*) < (1-A)(F_1 - F_2). \tag{2.5}$$

In this case, where the tax system is the same for the two projects, the ranking of projects can only change if the fixed costs are unequal, $F_1 \neq F_2$, and if they cannot be fully depreciated in the first period, that is $A < \tau$.

For empirical and policy purposes it is useful to be able to summarise the impact of tax on the ranking of projects in a single measure. The effective average tax rate (EATR) provides such a measure. The most obvious approach would be to define an effective average tax rate, $\hat{\Im}_i$, such that $(1-\hat{\Im}_i)R_i^* = R_i$ implying that $\hat{\Im}_i = {(R_i^* - R_i)}/{R_i^*}$. With this definition, the choice of the highest R_i is identical to the choice of the highest $(1-\hat{\Im}_i)R_i^*$. However, this measure suffers from the disadvantage that it is undefined for investment projects which are marginal pre-tax, that is for $R_i^* = 0$.

Instead, we define effective average tax rate as the difference between the pre and post-tax economic rent scaled by the net present value of the pre-tax income stream: $\Im_i = (R_i^* - R_i)/Y_i^*$. In choosing between strategies, simply applying this rate to R_i^*

would not be appropriate. However, it is straightforward to compare two strategies, as long as Y_i^* and F_i are both known. Choosing the strategy with the highest R_i is equivalent to choosing the strategy with the highest $R_i^* - \Im_i Y_i^*$. Equivalently, $R_1 > R_2$ iff $(1-\Im_1)Y_1^* - (1-\Im_2)Y_2^* > (F_1 - F_2)$.[5]

A number of economic situations in which the EATR is the appropriate measure of the impact of corporate income taxation on firms' incentives to invest are now considered.

2.1 Alternative locations of production

Consider a firm which has decided to serve a foreign market, and which could do so by producing at home and exporting (strategy 1), or by producing in the foreign location (strategy 2). It has an advantage over local firms in that it owns a superior technology, so that there is a barrier to other firms entering the market. It will choose to produce in the location in which it will earn the higher post-tax economic rent.

There may be additional costs to setting up abroad, relative to expanding existing home capacity so that fixed costs of strategy 1 are lower than 2, $F_1 < F_2$. On the other hand, exporting the product to the foreign location is costly, so that variable costs are higher under strategy 1, $Y_1 < Y_2$. The ranking of these two strategies therefore depends on the relative size of fixed versus variable costs. Tax regimes differ across countries so that, $\tau_1 \neq \tau_2$ and/or $A_1 \neq A_2$. It is clearly possible for tax to change the ranking of projects so that , for example, $R_1^* < R_2^*$ but $R_1 > R_2$ so that in the absence of tax the firm would prefer to produce abroad, but in the presence of tax the firm would prefer to produce at home.

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5 If the optimal level of output is affected by tax, then this condition should use Y_i rather than Y_i^*.

Models of the location decision of multinationals, such as Horstman and Markusen (1992), have employed this framework. This example can easily be extended to many possible foreign locations. Conditional on deciding to produce abroad, a firm may face a number of alternative sites. Examples would include a US car manufacturer deciding where to produce in Europe in order to serve the European market, or a Korean electronics producer choosing a North American location from which to enter the North American market. Differences in the tax regimes facing the firm may alter the ranking of alternatives. A model of this type was developed in Devereux and Griffith (1998), in which the optimal level of output under each strategy depends on the effective marginal tax rate, but the choice between strategies depends on the ranking of post-tax economic rent, and hence on the effective average tax rate.

2.2 Alternative production technologies

The different fixed costs, F_1 and F_2, may reflect investment in alternative production technologies. For example, strategy 1 may represent high expenditure on R&D which is expected to yield a more automated and cheaper production process. By contrast, strategy 2 could mean lower investment in R&D. This would imply that fixed costs are higher under strategy 1, $F_1 > F_2$, but variable costs lower, $Y_1 > Y_2$. Either strategy would be more profitable than following both. The tax system can change the ranking of the two strategies; which strategy is chosen will depend on the post-tax level of economic rent which is affected by the effective average tax rate.

A central concern in the literature on effective marginal tax rates has been the distortions which might be introduced by differential taxation of alternative forms of production, which might induce investors to choose a sub-optimal mix of assets. This has generally been measured by comparing the costs of capital for investment in alternative assets.[6] But this approach relies on the assumption that the mix of assets can be continuously varied, with the outcome that the quantity of each asset is chosen so that its marginal product is equal to its cost of capital. By contrast, in the framework presented here it is assumed that there are a limited number of production strategies from which to choose, each strategy corresponding to a particular asset mix.

2.3 Choice of product type or quality

Consider a firm that is operating in a differentiated product market, choosing between supplying a product of either low or high quality. Suppose that the two products are highly substitutable in demand so that the additional revenue derived from producing both products would be less than the additional cost. The tax system could affect the ranking of the post-tax economic rent and thus distort the firm's choice between the goods. An extreme example would be the choice of what property to build on a piece on land (where there is no possibility of constructing more than one type of building) – whether, for example, to build private houses, an apartment block or a hotel.

Empirical work looking at the impact of tax on product choice has tended to focus on the impact of excise and commodity taxes.[7] In this paper we focus on the impact of corporate income taxes on firms' investment choices. Because revenue from different

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[6] For example,Goolsbee (1998) develops a model where the tax treatment of investment affects firms' choice of quality of investment good. This is because tax applies only to the purchase and installation of the capital good, while future maintenance and training costs are not counted as part of the investment but are expensed when incurred. Goolsbee's results indicate that when the cost of capital falls a larger proportion of high quality investment goods are purchased.

[7] For example, Cremer and Thisse (1994) show that an increase in commodity taxation in a vertically differentiated product market, where firms compete on price, changes the quality mix of products provided. Fershtman et. al. (1997) look at the impact of tax in the Israeli automobile market, which they assume to be oligopolistic. They simulate the affect of tax on firms' behaviour and are thus able to show how the imposition of the tax has affected the profile of goods sold and their relative prices.

sources is generally taxed at the rate same, the impact of corporate tax on product choice will be through the differential treatment of inputs, for example due to difference depreciation allowances.

2.4 Choice of investment given financial constraints

There is a sizeable literature investigating the extent to which firms' investment plans are constrained by the availability of financial capital, either from internal or external sources.[8] One important effect of the average tax rate is the impact it has on the amount of internal funds available for investment. The size of internal funds will clearly depend on the average tax rate. But this is a different concept to the one dealt with in this paper – our measure is forward-looking and based on the present value of returns and costs of a new investment.

The existence of financial constraints introduces a role for the measure developed in this paper. Financial constraints may make it difficult for the firm to undertake all of its potentially profitable investment projects. Suppose that there is an absolute limit on the funds which can be raised for new investment. The firm will choose only those projects which are expected to yield the highest post-tax economic rent based on a ranking which may be affected by taxation.

[8] See, for example, the survey by Hubbard (1998).

3 THE EFFECTIVE AVERAGE TAX RATE ON DOMESTIC INVESTMENT

This section describes the proposed measure of the effective average tax rate (EATR) as it applies in a domestic setting. A standard model is set up which can incorporate discrete investment. In the next section this is extended to an international setting. The properties of the EATR in the international case are equivalent to those for the domestic case.

Consider a value-maximising firm. In the tradition of King (1974), the value of the firm can be derived from the capital market equilibrium condition. Risk is ignored. The value of the firm in period *t* is the net present value of the post-tax income stream, given by V_t:

$$(1-m^i)iV_t = \frac{(1-m^d)}{1-c}D_t - N_t + V_{t+1} - z(V_{t+1} - V_t - N_t) \tag{3.1}$$

where i is the nominal interest rate, D_t is the dividend paid in period *t*, N_t is new equity issued in period *t*, m^i is the personal tax rate on interest income, m^d is the personal tax rate on dividend income, c is the rate of tax credit available on dividends paid, and z is the accruals-equivalent capital gains tax rate. The right hand side of (1) is the return from purchasing the equity of the firm; in the absence of arbitrage opportunities and risk, this is equal to the return from lending V_t; hence V_t represents the value of the firm's equity. Rearranging (1) yields an expression for V_t:

$$V_t = \{\gamma D_t - N_t + V_{t+1}\}/(1+\rho) \tag{3.2}$$

where $\gamma = (1-m^d)/(1-c)(1-z)$ is a term measuring the tax discrimination between new equity and distributions and $\rho = (1-m^i)i/(1-z)$ is the shareholders' nominal discount rate.

Net dividends paid by the firm can be found from the equality of sources and uses of funds in each period:

$$D_t - N_t = Q(K_{t-1}) - I_t + B_t - (1+i)B_{t-1} - T_t \tag{3.3}$$

where $Q(K_{t-1})$ is output in period *t*, which depends on the beginning of period capital stock, K_{t-1}, I_t is investment, B_t is one-period debt issued in period t and T_t is the tax liability. Choosing the appropriate units of capital and output, the prices of output and capital goods are normalised to unity in period t. The tax liability is defined as:

$$T_t = t\left\{Q(K_{t-1}) - iB_{t-1} - f(I + K_{t-1}^T)\right\} \tag{3.4}$$

where τ is the statutory tax rate, ϕ is the rate at which capital expenditure can be offset against tax, and K_{t-1}^T is the tax-written-down value of the capital stock at the end of period *t* defined as

$$K_t^T = (1-f)K_{t-1}^T + I_t . \tag{3.5}$$

It is useful to define the net present value of allowances per unit of investment as *A*, where[9]

$$A = \tau\phi\left\{1 + \left(\frac{1-\phi}{1+\rho}\right) + \left(\frac{1-\phi}{1+\rho}\right)^2 + \ldots\right\} = \frac{\tau\phi(1+\rho)}{\rho+\phi} . \tag{3.6}$$

The net cost of one unit of physical investment in period *t* is therefore $(1-A)$. Finally, the equation of motion of the capital stock is standard:

$$K_t = (1-\delta)K_{t-1} + I_t . \tag{3.7}$$

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[9] This expression corresponds to the case of exponential, or declining balance, depreciation. The expression is for straight line depreciation is given by equation (A.11) in Appendix A.

3.1 Measuring effective tax rates

Measures of effective marginal and average tax rates on domestic investment can now be derived. The standard approach in deriving the cost of capital, and hence the effective marginal tax rate, *EMTR*, is to consider a perturbation of the capital stock in one period, say period *t*. Setting economic rent equal to zero at the margin, $dV_t/dK_t = 0$, defines the cost of capital and permits the optimal capital stock in period *t* to be found. We follow the sprit of this approach in developing a measure of the effective average tax rate, *EATR*. Consider an investment which increases the physical capital stock of the firm by one unit in period *t* only, so that the change is $dK_t = 1$ and $dK_s = 0 \ \forall s \neq t$. This requires an increase in investment in period *t* of one unit: $dI_t = 1$ and a reduction in investment in period *t+1* such that $dI_{t+1} = -(1-d)(1+p)$, where p is the nominal increase in prices between periods *t* and *t+1*. The addition to K_t increases output in period *t+1*. This generates a change in output of $dQ_{t+1} = p + \delta$, where *p* represents the financial return and δ reflects the one-period cost of depreciation, and a change in net revenue of $dQ_{t+1}(1+p) = (p+d)(1+p)$. Here we have simplified the analysis by assuming that π is a general inflation rate common to capital and output. We therefore abstract from specific inflation of the price of capital, although this would be straightforward to introduce.

Modelling of the financial policy of the firm is typically arbitrary in models which construct measures of the effective marginal tax rate. For example, the well-known expressions used by King and Fullerton (1984) imply financial cash flows which are difficult to justify by modelling a simple one period investment. The approach here is implicitly that of setting financial constraints – in particular, non-negativity constraints on dividend payments, new equity issues and debt issues. Edwards and Keen (1984) demonstrate that in such a model the cost of capital depends on whether these constraints are binding in each of period *t* and period *t+1*. Given these three constraints in each period implies that there may be nine different combinations of financing the investment and receiving the return from the investment. In order to generate measures that are close to those commonly used, it is necessary to assume that the constraint on non-negative dividends is not binding in period *t+1*. Since dividends are the residual in this model, this implies that, at the margin, any return from the investment made in period *t* is distributed as a dividend in period *t+1*.[10] In the case of new equity, most tax systems treat a repurchase of equity at its original price to be a repayment of capital which is not taxed. It is assumed that the firm takes advantage of this opportunity for the case of new equity finance. Any payment to shareholders above this amount is taxed as a dividend, and is therefore treated here as a dividend payment. This reduces the number of possibilities to three, corresponding to the cases when the investment is financed by retained earnings, new equity and debt in period *t*.

Rather than model the constraints explicitly, changes to these forms of finance in periods *t* and *t+1* are considered. The cases for domestic investment are shown Table 3.1, where dN_t and dB_t are the changes in new equity and debt respectively in period *t* (F_t is defined below). In the case of retained earnings, the investment is financed by a reduction in dividend payments in period *t*; hence debt and new equity issues are unaffected. In the case of new equity finance the firm issues new equity in period *t* of $1-\phi\tau$; this finances a physical investment of *1* since an immediate tax allowance worth $\phi\tau$ can be claimed. As note above, in period *t+1* the firm repurchases that equity at the

10 This assumption is also followed elsewhere; see, for example, Keen (1991) and Devereux, Keen and Schiantarelli (1994).

original price. In the case of debt financed investment the firm borrows $1-\phi\tau$ in period t and repays that amount plus interest (at rate i) in period $t+1$.

Table 3.1: Financial constraints on investment by source of finance

Retained Earnings	$dN_{t+s} = dB_{t+s} = 0 \quad \forall s$	$\Rightarrow F_t = 0$
New Equity	$dB_{t+s} = 0 \quad \forall s$ $dN_t = 1-\phi\tau$; $dN_{t+1} = -dN_t$ $dN_{t+s} = 0 \quad \forall s > 1$	$\Rightarrow F_t = \frac{-r(1-g)}{(1+r)}(1-ft)$
Debt	$dN_{t+s} = 0 \quad \forall s$ $dB_t = 1-\phi\tau$; $dB_{t+s} = 0 \quad \forall s > 0$	$\Rightarrow F_t = \frac{g(1-ft)}{(1+r)}\{r - i(1-t)\}$

In general, define R_t to be the net present value of this investment - equal to the net present value of the economic rent generated. In general, this is defined as:

$$\begin{aligned} R_t &= (1+r)dV_t = dD_t + dN_t + dV_{t+1} \\ &= \sum_{s=0}^{\infty}\left\{\frac{gdD_{t+s} - dN_{t+s}}{(1+r)^s}\right\} \end{aligned} \qquad (3.8)$$

To implement this definition consider the change in dividends, dD_{t+s} implied by (3.3) and substitute into that expression the values of the change in investment in periods t and $t+1$, the change in net revenue in period $t+1$, and changes in the source of finance from Table 2.3. The resulting expression can be usefully split into two parts: (i) the rent attributable to investment financed by retained earnings, R_t^{RE}, and (ii) the additional cost of raising external finance, F_t, defined in (3.10) and Table 3.1. In sum, $R_t = R_t^{RE} + F_t$. The two elements of the post-tax economic rent are:

$$R_t^{RE} = -g(1-A) + \frac{g}{1+r}\{(1+p)(p+d)(1-t) + (1+p)(1-d)(1-A)\} \qquad (3.9)$$

and

$$F_t = \gamma dB_t \left\{1 - \frac{1+i(1-\tau)}{1+\rho}\right\} - (1-\gamma) dN_t \left\{1 - \frac{1}{1+\rho}\right\}. \qquad (3.10)$$

This framework easily permits the derivation of standard measures of the cost of capital: set $R_t = 0$ and solve for the marginal financial rate of return, denoted $\tilde{p}$:

$$R_t = 0 \Rightarrow \tilde{p} = \frac{(1-A)}{(1-t)(1+p)}\{r + d(1+p) - p\} - \frac{F_t(1+r)}{g(1-t)(1+p)} - d. \qquad (3.11)$$

The tax inclusive effective marginal tax rate (*EMTR*) is given by $EMTR = (\tilde{p} - s)/\tilde{p}$, where s is the post-tax real rate of return to the shareholder:

$$s = \frac{(1-m^i)i - \pi}{1+\pi}. \qquad (3.12)$$

This *EMTR* can be illustrated in the case in which $m^i = z = 0$ and hence $\rho = i$, the nominal interest rate. Define r to be the real interest rate: $(1+r)(1+\pi) = (1+i)$. Then the cost of capital for investment financed by retained earnings ($F_t = 0$) becomes:

$$\tilde{p}^{RE} = \frac{(1-A)}{(1-\tau)}\{r + \delta\} - \delta \qquad (3.13)$$

and the equivalent *EMTR* is:

$$EMTR^{RE} = \frac{(r+\delta)(\tau - A)}{(r+\delta)(1-A) - \delta(1-\tau)}. \qquad (3.14)$$

The general expression for the cost of capital in (3.11) is similar to measures of the cost of capital derived elsewhere. There are two principal difference from the King and Fullerton (1984) formulation. First, here the net present value of depreciation allowances, *A*, is derived using the shareholders' discount rate, $\tilde{p}$. Second, the impact of alternative forms of financing is limited to periods t and $t+1$ in the case of new equity and period t in the case of debt. This implies that the allowance in period t - that is $\phi\tau$ - is important, rather than simply the net present value of allowances, A. We choose this approach on the grounds that the financial flows implied by the King and Fullerton formulation for new equity are very difficult to justify.

The effective average tax rate, $EATR$, is defined for $p \geq \tilde{p}$, as described in the previous section, by dividing the difference between pre- and post-tax economic rent by the net present value of the income stream. Evaluating the pre-tax economic rent at the interest rate in the presence of tax yields an expression for the pre-tax economic rent, R_t^* of:

$$\begin{aligned} R_t^* &= -1 + \frac{1}{1+i}\left\{(1+p)(p+d) + (1+p)(1-d)\right\} \\ &= \frac{p-r}{1+r} \end{aligned} \tag{3.15}$$

Note that in the absence of tax, the additional terms due to financing by new equity or debt (the pre-tax equivalent of F_t) both have a net present value of zero and so do not affect the pre-tax economic rent.

As noted above, a natural measure of the $EATR$ would be the proportional difference between R_t^* and R_t ie. $(R_t^* - R_t)/R_t^*$. However, this is undefined when $R_t^* = 0$. Instead, we scale the difference $(R_t^* - R_t)$ by the net present value of the pre-tax income stream, net of depreciation: $p/(1+r)$. Hence the measure of the $EATR$ proposed here is:

$$EATR_t = \frac{R_t^* - R_t}{p/(1+r)}. \tag{3.16}$$

A general expression for the $EATR$ which uses the value of R_t from (3.9) and (3.10) and the value of R_t^* from (3.15) is given in the Appendix in expression (A.15). Here we illustrate its properties in the absence of personal taxes on interest income and capital gains: $m^i = z = 0$, implying that $\rho = i$. Substituting these values into the expression for R_t and simplifying yields:

$$R_t = \frac{\gamma}{1+r}\{(p+\delta)(1-\tau)-(r+\delta)(1-A)\}+F_t\,. \tag{3.9a}$$

Combining (3.16), (3.9a) and (3.15) and rearranging yields:

$$EATR_t = 1-g(1-t)-\frac{\{r[1-g(1-A)]-gd(t-A)+F_t(1+r)\}}{p}\,. \tag{3.17}$$

This measure of the EATR has several interesting and attractive properties which are now discussed using six propositions. The first three propositions concern the distribution of the EATR over a range of profitability. They indicate the upper and lower bounds on the values taken by the EATR, and hence the conditions under which the EATR rises or falls as the rate of profit rises.

Proposition 1 In the absence of personal taxes on interest income and capital gains ($m^i = z \quad 0$), the effective average tax rate for a marginal investment is equal to the effective marginal tax rate, $R_t = 0 \Rightarrow EATR =$

Proof. For a marginal investment, economic rent is zero and the rate of return is equal to

$R_t = 0$ and hence $p = \tilde{p}$. Deriving $p = \tilde{p}$ from (3.9a) yields:

$$R = 0 \Rightarrow \tilde{p} = \frac{rg(1-A)+dg(t-A)-F_t(1+r)}{g(1-t)} \tag{3.11a}$$

Substituting for $p = \tilde{p}$ from (3.17) and rearranging yields:

$$EATR = 1-g(1-t)+\frac{g(1-t)\tilde{p}-r}{\tilde{p}} = \frac{\tilde{p}-r}{\tilde{p}} = EMTR\,. \quad \square \tag{3.17a}$$

Proposition 2 In the absence of personal taxes on interest income and capital gains ($m^i = z = 0$), the effective average tax rate for a very profitable investment approaches an "adjusted" statutory tax rate: $p \to \infty \Rightarrow EATR \to 1-\gamma(1-\tau)$.

Proof Immediate from (3.17). □

Proposition 3 In the absence of personal taxes on interest income and capital gains ($m^i = z = 0$), the effective average tax rate increases with profitability if and only if the "adjusted" statutory tax rate exceeds the effective marginal tax rate, ie. $\partial EATR / \partial p > 0 \Leftrightarrow EMTR < 1-\gamma(1-\tau)$.

Proof. Differentiating (3.17) with respect to *p* implies:

$$\partial EATR / \partial p > 0 \Leftrightarrow r[1-\gamma(1-A)] - \gamma\delta(\tau - A) + F(1+r) > 0 .$$

Using the expression for $\tilde{p}$ in (3.11a) this can be written as:

$$\partial EATR / \partial p > 0 \Leftrightarrow r > g(1-t)\tilde{p} .$$

Substituting using the expression $EMTR = 1 - r/\tilde{p}$ and rearranging yields:

$$\partial EATR / \partial p > 0 \Leftrightarrow EMTR < 1-\gamma(1-\tau) . \ \square$$

These three properties of the $EATR$ are attractive. The $EATR$ can be seen as reflecting the whole schedule of effective tax rates over the range of profitability from a marginal investment, where $EATR$=$EMTR$, to a very high rate of profitability, where the $EATR$ tends towards the statutory tax rate, adjusted for the tax treatment of dividends, $1-\gamma(1-\tau)$. The $EMTR$ and the adjusted statutory tax rate thus represent the upper and lower bounds of values of the $EATR$.

Three further features of the $EATR$ are worth noting, in comparison with well-known properties of the *EMTR*. First, Auerbach (1979) showed that the *EMTR* for investment financed by retained earnings is independent of the taxation of dividends paid to the shareholder. This does not hold for the $EATR$ at positive values of economic rent.

Proposition 4 In contrast to the *EMTR*, the $EATR$ is *not* independent of the tax rate on dividends (γ) for an investment financed by retained earnings.

Proof. Immediate from (3.17). Adding personal taxes clearly does not affect this dependence. □

The remaining two propositions describe the value of the $EATR$ for two special forms of taxation.

Proposition 5 In the absence of personal taxes on interest income and capital gains ($m^i = z = 0$), a "neutral" business tax, with *EMTR=0* and a classical tax system ($\gamma = 1$), has an $EATR$ with a lower bound of zero for a marginal investment and approaches the statutory tax rate for a very profitable investment.

Proof. Immediate from Propositions 1 and 2, given $EMTR = 0$ and $\gamma = 1$.□

Proposition 6. In the absence of personal taxes ($m^i = z = m^d = 0$), for a domestic tax system which gives relief for true economic depreciation but no relief for the cost of finance, the $EATR$ is equal to the *EMTR* and also equal to the statutory tax rate, τ, irrespective of profitability.

Proof. A tax system that give relief for true economic depreciation implies that

$A = \frac{\delta\tau}{1+r}\left\{1 + \frac{1-\delta}{1+r} + \left(\frac{1-\delta}{1+r}\right)^2 + ...\right\} = \frac{\delta\tau}{r+\delta}$. Substituting this value, and $F = 0$, into (3.17) yields $\tilde{p} = r/(1-\tau)$ which implies that $EMTR = \tau$. In the absence of personal taxes on dividends and any relief for equity finance, then $\gamma = 1$. This implies that both the lower and upper bounds on the $EATR$ are equal to τ, and hence $EATR = EMTR = \tau$.□

4 THE EFFECTIVE AVERAGE TAX RATE ON INTERNATIONAL INVESTMENT

The approach used in the previous section can be used also to measure the effective marginal and average tax rates for an international investment. In this section we sketch the derivation of these effective tax rates; the detailed measures are given in the Appendix. The basic approach is to consider a parent firm located in the "residence" country j which undertakes investment in the "source" country n through a wholly-owned subsidiary. The parent firm is assumed to be owned by shareholders located in j.

We take account of taxes levied by the government of n on income earned by the subsidiary in n, corporate taxes levied by the government in j on the same income and personal taxes levied by the government in j on the shareholders. The precise nature of the combined tax system is similar to that in Keen (1991) and OECD (1991) and is summarised in the Appendix. However, it is useful to here to note two tax parameters: s_{jn} is the overall corporate tax rate levied on dividend payments from the subsidiary to the parent and w_{jn} is the overall corporate tax rate levied on interest payments from the subsidiary to the parent. In general, tax parameters in n are equivalent to those defined in the previous section; to note that they apply to country n they carry a subscript n.

Suppose that the previous section refers to the domestic activities of the parent firm. Allowing for this firm to have a foreign subsidiary does not affect the general expression for the value of the firm in (3.2); this remains the firm's maximand. However, the sources and uses of funds statement (3.3) must be extended to allow for financial flows to and from the subsidiary, together with any consequential tax effects. This includes new equity in the subsidiary provided by the parent and lending to the subsidiary by the parent. It also includes dividends and interest received by the parent, net of taxes paid to the source country government. Finally it includes further taxes due in the residence country on the income earned in the source country. These flows are shown in detail in the Appendix.

As in the domestic case, we consider a perturbation in the capital stock of the firm – in this case the subsidiary – in period *t*. This is achieved by changing investment in the subsidiary in periods *t* and *t+1* in the same way as in the previous section. We consider three ways in which the subsidiary finances the increase in investment, again corresponding to domestic case: retained earnings, new equity issued to the parent and borrowing from the parent. In the latter two cases, we in turn allow the parent to choose between the three sources of finance. We do not consider the case of borrowing in the source country *n*; this would be a straightforward extension.

The net present value of the economic rent generated by the perturbation of the subsidiary's capital stock takes the same form as for the domestic case. Dropping time subscripts, we label this $R_n = R_n^{RE} + F + F_n$ where for convenience we have dropped the time subscript. The first element, R_n^{RE} , corresponds to the economic rent generated by a perturbation in the capital stock financed by retained earnings. The second element, F summarises the net present value of the cash flows associated with new equity and debt financing of the parent firm, and is identical to the expression in (3.10). The third element, F_n , summarises the net present value of cash flows associated with new equity and debt finance of the subsidiary. The first and third terms have the following values (see the Appendix for details.):

$$R_n^{RE} = -\gamma\left(1-\sigma_{jn}\right)\left(1-A\right) + \frac{\gamma(1-\sigma_{jn})}{1+\rho}\left\{E(1+\pi_n)(p_n+\delta)(1-\tau_n)+E(1+\pi_n)(1-\delta)(1-A_n)\right\} \quad (4.1)$$

and

$$F_n = \frac{\gamma dB_t}{1+\rho}\left\{E\left[\sigma_{jn}(1+i(1-\tau_n))-\omega_{jn}i\right]-\gamma\sigma_{jn}\right\}-\gamma\sigma_{jn}dN_t\left\{1-\frac{E}{1+\rho}\right\}. \quad (4.2)$$

where variables have the same meaning as in the previous section, except where the subscript *n* represents the source country. The exchange rate is normalised at unity in period *t* and takes the value *E* in period *t+1*. The expression $E(1+\pi_n)-1$ therefore reflects the nominal price change expressed in the currency of the residence country. These expressions correspond closely to (3.9) and (3.10). The new variables σ_{jn} and ω_{jn} reflect the impact on overall tax liabilities of changing the flows from the subsidiary to the parent of dividends and interest respectively. Thus, for example, all cash flows associated with an investment in the subsidiary financed by retained earnings directly affect the flow of dividends (which are reduced by financing the investment in period *t*, but increased by the return on the investment in period *t+1*): in both cases the value to the ultimate shareholder is therefore multiplied by the factor $1-\sigma_{jn}$. Similarly, for given investment, flows of new equity and debt to and from the subsidiary also have a direct impact on the flow of dividends and hence introduce σ_{jn}. Payment of interest from the subsidiary to the parent – assumed to be at the market interest rate *i* – introduces the net tax rate on such flows: ω_{jn}.

As in the domestic case, this framework permits derivation of measures of the cost of capital for international investment. Define the cost of capital to be the real return in the home currency for which $R_n = 0$. Denote this $\tilde{\rho}_n = E(1+\pi_n)p_n/(1+\pi)$. It is straightforward to show that this is:

$$R_n = 0 \Rightarrow \tilde{p}_n = \frac{(1-A_n)}{(1+p)(1-t_n)}\{r + dE(1+p_n) - [E(1+p_n)-1]\} - \frac{(F+F_n)(1+r)}{g(1+s_{jn})(1+p)(1-t_n)} - \frac{dE(1+p_n)}{(1+p)} \tag{4.3}$$

The *EMTR* for an international investment is $EMTR_n = (\tilde{p}_n - s)/\tilde{p}_n$, where s is the post-tax rate of return to the shareholder.

We follow the same approach as for the domestic case in defining a measure of the *EATR*. In the absence of tax, $F = F_n = 0$, and so the pre-tax economic rent (again evaluated at the same interest rate, *i*) is

$$R_n^* = \frac{\{E(1+p_n)(1+p_n)-(1+i)\}}{1+i}. \tag{4.4}$$

We define the *EATR* for international investment as:

$$EATR_n = \frac{R_n^* - R_n}{E(1+p_n)p_n / 1+i} \tag{4.5}$$

where the denominator is again the net present value of the income stream from the perturbation to the capital stock of the subsidiary, R_n^* is defined in (4.4) and R_n is defined as the sum of (4.1), (3.10) and (4.2). A detailed expression for this *EATR* is given in the Appendix.

However, to give more intuition here, note that for the special case of purchasing power parity, $E(1+p_n) = (1+p)$, and no personal taxes in the residence country on interest income or capital gains ($m^i = z = 0$), these expressions simplify to:

$$R_n^{RE} = \frac{p_n - r}{1+r} \ , \tag{4.6}$$

$$R_n = \frac{g(1-s_{jn})}{1+r}\{(p_n + d)(1-t_n) - (r+d)(1-A_n)\} + F + F_n \tag{4.7}$$

and

$$EATR_n = \frac{R_n^* - R_n}{p_n/1+r} = 1 - g(1-s_{jn})(1-t_n) - \frac{\{r[1-g(1-s_{jn})(1-A_n)] - dg(1-s_{jn})(t_n - A_n) + (F+F_n)(1+r)\}}{p_n} \tag{4.8}$$

This expression is similar to that for the domestic case, given in (3.17). There are three main differences. First, most of the tax variables refer to the source country, *n*, rather than the residence country. Second, an additional term $1 - s_{jn}$ appears in several places, reflecting the additional tax on dividends paid by the subsidiary to the parent. Third, there is an additional financing term, reflecting the tax implications of financing the subsidiary as well as the parent.

This measure of the EATR for international investment has equivalent properties to that for the domestic investment described above. We briefly repeat the first four in this context.

Proposition 1a In the absence of personal taxes on interest income and capital gains ($m^i = z = 0$), the effective average tax rate for a marginal international investment is equal to the effective marginal tax rate, $R_n = 0 \Rightarrow EATR_n = EMTR_n$.

Proof. This is most easily seen for the case of purchasing power parity, although the proposition is not limited to this case. In this case, simplifying (4.3) for $E(1+p_n) = (1+p)$ yields:

$$R_n = 0 \Rightarrow \tilde{p}_n = \frac{rg(1-s_{jn})(1-A_n) + dg(1-s_{jn})(t_n - A_n) - (F + F_n)(1+r)}{g(1+s_{jn})(1-t_n)} \tag{4.3a}$$

Using this expression, for a marginal investment, (4.8) can be written as

$$EATR_n = 1 - \gamma(1-\sigma_{jn})(1-\tau_n) - \frac{\{r - \tilde{p}_n \gamma(1-\sigma_{jn})(1-\tau_n)\}}{\tilde{p}_n} .$$

Rearranging yields:

$$EATR_n = \frac{\tilde{p}_n - r}{\tilde{p}_n} = EMTR_n .$$

In the absence of purchasing power parity, but with $m^i = z = 0$, using the definition of $\tilde{p}_n$ from (4.3) yields the same result. □

Proposition 2a In the absence of personal taxes on interest income and capital gains ($m^i = z = 0$), the effective average tax rate for a very profitable investment approaches an "adjusted" statutory tax rate: $p_n \to \infty \Rightarrow EATR_n \to 1 - g(1-s_{jn})(1-t_n)$.

Proof Immediate from (4.8). The absence of purchasing power parity would clearly not affect this result.□

Proposition 3a In the absence of personal taxes on interest income and capital gains ($m^i = z = 0$), the effective average tax rate increases with profitability if and only if the "adjusted" statutory tax rate exceeds the effective marginal tax rate, ie. $\partial EATR_n / \partial p_n > 0 \Leftrightarrow EMTR_n < 1 - \gamma(1-\sigma_{jn})(1-\tau_n)$.

Proof. This is again most easily shown for the case of purchasing power parity, although this is not necessary for the proposition to hold. Differentiating (4.8) with respect to p_n implies:

$$\partial EATR_n \big/ \partial p_n > 0 \Leftrightarrow r\left[1-g(1-s_{jn})(1-A_n)\right]-gd(1-s_{jn})(t_n-A_n)+(F+F_n)(1+r)>0$$

Using the expression for $\tilde{p}_n$ in (4.3a) this can be written as:

$$\partial EATR_n \big/ \partial p_n > 0 \Leftrightarrow r > \gamma(1-\sigma_{jn})(1-\tau)\tilde{p}_n .$$

Substituting the expression: $EMTR_n = 1 - r / \tilde{p}_n$ and rearranging yields:

$$\partial EATR_n \big/ \partial p_n > 0 \Leftrightarrow EMTR_n < 1-\gamma(1-\sigma_{jn})(1-\tau_n) . \square$$

The $EATR$ for international investment can thus also be seen as reflecting the whole schedule of taxes from a marginal investment to a highly profitable investment. Finally, just as the $EATR$ for a retained-earnings financed domestic investment depends on the dividend tax rate γ, so the $EATR$ for a retained earnings-financed international investment also depends on the tax rate on dividends paid from the subsidiary to the parent, σ_{jn}.

Proposition 4a In contrast to the *EMTR*,[11] the $EATR$ for international investment financed by retained earnings is *not* independent of the tax rate on dividends paid by the subsidiary to the parent (σ_{jn}).

Proof. Immediate from (4.8). $\square$

5 EMPIRICAL APPLICATION

In this section some of the properties of the EATR are examined using data on the tax treatment of investment in six assets in four countries - Germany, Japan, the UK and the

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[11] See Hartman (1985).

USA – over the period 1979-1997. A description of the tax systems and the assumptions used to calculate the effective tax rates is given in the Appendix B.[12]

5.1 Tax schedules in Germany, Japan, the UK and USA

The four panels of Figure 2.1 each illustrate the development of the domestic corporation tax system over the period 1979 to 1997 for each country. In each case, the personal tax rates of the marginal investor are assumed to be zero. The tax rates shown in each panel are: the statutory tax rate on retained earnings; the *EMTR* for domestic investment in plant and machinery financed by retained earnings; the adjusted statutory tax rate, $1-g\left(1-t_j\right)$, and values of the *EATR*, for the same investment for profitability rates of 30%, 70% and 100%, p = 0.3, 0.7, 1.0.

Figure 2.1 illustrates several of the properties of the EATR discussed above. At lower levels of profitability the EATR tends to follow a similar pattern to the EMTR, while at higher levels of profitability it tends to follow a similar pattern to the adjusted statutory tax rate. However, the relative magnitude of the *EMTR* and the adjusted statutory tax rate varies both between countries and over time. In Germany, for example, the EMTR is strongly correlated with the statutory tax rate, and is always higher than the adjusted statutory tax rate, $1-g\left(1-t_j\right)$. Although the statutory tax rate in Germany has been consistently high, Germany operated a system close to full integration throughout this period and thus g was also high, implying a very low value of $1-g\left(1-t_j\right)$. The opposite is true of the USA, where the 1986 reforms had the effect of reducing the statutory tax rate but increasing the *EMTR*. Since the USA operated a classical system over the whole

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[12] A more detailed descriptions of the tax systems in each of these countries is given in Chennells and Griffith (1997).

period, $\gamma = 1$ in the absence of personal taxes, and so $1 - g(1 - t_j) = t_j$. Hence at low rates of profit, the $EATR$ increased following the 1986 reforms; but at high rates of profit it fell.

This process was even more extreme in the UK, where the 1984 reforms reduced the statutory tax rate in stages from 52% to 35%, but at the same time reduced depreciation allowances, summarised here by A. The combination of these reforms led to an increase in the EMTR, but a reduction in the adjusted statutory tax rate: in fact these two rates crossed in 1984. As a consequence, before the 1984 reforms the EATR increased with profitability; but after the 1984 reforms, the reverse was true. The 1997 reforms reduced g to 1.0 for tax-exempt shareholders, raising $1 - g(1 - t_j)$ to the statutory tax rate, and switching the sign of $\partial EATR / \partial p$ back again.

The position in Japan has various elements of those seen in the other countries. For example, like Germany the EMTR is positively correlated with the statutory tax rate. Also like Germany, in the first half of the period, the EMTR was above the adjusted statutory tax rate, implying that the EATR was lower for higher rates of profit. However, in 1991, g fell from 1.27 to 1.0 for tax-exempt shareholders. Like the 1997 reform in the UK this raised $1 - g(1 - t_j)$ equal to τ_j and had the effect of switching the sign of $\partial EATR / \partial p$.

5.2 Alternative production technologies

One of the economic situations in which it was argued above that the EATR may affect investment is in the choice between a number of alternative discrete methods of production. If these alternative methods use different assets, or the same assets in different proportions, then the EATR may affect firms' choice between technologies. To explore this, for each country using the 1997 tax system, the four panels of Figure 2.2 plot the EATR for domestic investment financed by retained earnings in six different assets – industrial buildings, industrial plant and machinery, inventories, current R&D expenditure, R&D buildings and R&D plant and machinery – against the rate of profit of the investment, summarised by *p*. Tax systems in all four countries treat these assets differently from each other by allowing different rates of depreciation and in some cases by giving additional allowances or tax credits. Each line in the figure begins at the point where the project is marginal – that is $p = \tilde{p}$ and the EATR is equal to the EMTR.[13]

The most notable feature of Figure 2.2 is that in all countries, as profitability increases, the EATR for investment in different assets converges to $1 - g(1 - t_j)$, which is independent of tax depreciation rates and credits (summarised by *A*). The reason is clear: as profitability increases, the value of depreciation allowances and other tax credits becomes smaller relative to the tax on the return. That is, variations in *A* across assets become less important. This suggests that studies which use the EMTR to examine the distortions in production technology may exaggerate the differences in the relevant effective tax rate faced by investors in these assets. In turn, this implies that estimates of the impact of tax on asset choice using the EMTR rather than the EATR may underestimate the true structural coefficients.

5.3 Choice of location of production

Another of the economic situations discussed above is the choice between alternative locations for production. This issue is addressed empirically in Devereux and Griffith

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[13] For presentation reasons the line for R&D current expenditure for the USA does not start at the cost of capital, but at 10% profitability. This is because the EMTR for this investment is very large and negative.

(1998) and is illustrated here in two ways: by considering how the tax rate varies across location choices facing a US-resident firm deciding where to locate production; and by considering how it varies for foreign-resident firms investing in the USA. In calculating the effective tax rates shown in Figures 2.3 and 2.4 the parent firm is assumed to be financed by retained earnings but alternative forms of transfer between the parent and the subsidiary are allowed.

5.3.1 Investment by US-resident firm

The first of these questions is examined in detail in Devereux and Griffith (1998) where a firm level panel is used to estimate the impact of the $EATR$ on the location decision of US firms serving the European market. The empirical results indicate that the $EATR$ plays a direct and significant role in determining firms' location choices.

The 4 panels of Figure 2.3 plot the $EATR$ against the rate of profit of an investment in 1997. Panel (a) shows the position of a domestic firm undertaking investment in plant and machinery financed by retained earnings. The other panels show the $EATR$ faced by a US parent investing in plant and machinery in each of the 4 countries, each for a different form of financing of the foreign subsidiary (the line representing domestic investment in the USA is the same in each of the 4 panels). As in Figure 2.2, each line begins at the marginal investment, $p_n = \tilde{p}_n$.

Panel (a) shows the EATR for 1997, corresponding to Figure 2.1. The German domestic EATR falls as the rate of profit increases, while the domestic EATR in the other three countries increases with the rate of profit. Panel (b) shows the case of a subsidiary of a US parent locating in each country financed by retained earnings. As noted in Proposition 4 above, the EMTR in this case is independent of the overall tax rate (including US tax) on dividends paid by the subsidiary to the parent, σ_{jn}. Hence, at the margin for tax exempt shareholders of the parent firm, only source country taxes affect the EMTR. However, this is in general not true for the EATR. Although the ranking of the EATR across the four possible locations does not change as the rate of profit increases, the differences between them do vary. For example, at a high rate of profit, Japan has a substantially higher EATR than the other three countries, all of which are close to each other. At the margin, however, the EATR in Japan is only marginally higher than that in Germany, both of which are substantially higher than those in the UK and USA.

Panels (c) and (d) investigate alternative methods of the parent financing the subsidiary, by new equity and debt respectively, thereby introducing the F_n terms from (4.2) and Table A.4. In most cases introducing these extra terms increases the EATR, indicating that international investment financed by both new equity and debt is more heavily taxed overall than investment financed by retained earnings. An exception to this is the case of new equity investment into Germany, which benefits from the high level of *g* applying to US parents investing in Germany.[14] Note though, that this benefit is greatest at low rates of profit; this is because the benefit to new equity investment depends on the cost of the investment, but not on the rate of profit earned. This implies again that the EMTR – computed for a marginal investment - represents an extreme case in comparing alternative forms of finance.

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[14] US parents do not receive the same integration tax credit as German resident shareholders; however, they do benefit from the German split rate corporation tax, which, in effect, also generates a high value of *g* relative to other forms of investment.

5.3.2 Investment by foreign-resident firm

The panels in Figure 2.4 provide similar information to those in Figure 2.3 but show the tax rate on investment into the USA by parent companies in each of the other countries. For comparison, panel (a) repeats the position for domestic investment. In the other panels, the parent firm is financed by retained earnings, and the EATR is again shown separately for each of the three ways in which the subsidiary may be financed: retained earnings in panel (b), new equity in panel (c), and debt in panel (d).

Panel (b) illustrates Proposition 4 from Section 3.4. The EMTR for international investment financed by retained earnings depends only on source country taxation; this implies that it is the same for investment by each of the foreign subsidiaries investing in the USA, as well as for domestic firms. Since at this point the EMTR is equal to the EATR, the position of all four potential investors is the same at this point. However, as the expected rate of profit, p_n, increases the EATRs vary by location of investor. In particular, while the EATR for domestic investment and inward investment from Japan and the UK increases with p_n, the reverse is true for inward investment from Germany. The position for Germany is due to the high value of *g*, which under the circumstances assumed here, implies that German shareholders can, in effect, claim back much of the tax paid in the USA.[15]

Panels (c) and (d) reflect the additional tax costs and benefits from the F_n terms in Table 2.4. These panels provide a striking illustration of the differences across investors in the EATR faced at different rates of profit. For example, for marginal investment financed

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[15] This requires the German parent to pay dividends out of domestic income for tax purposes, but in effect financed from foreign source income. See Weichenreider (1996, 1997) for a fuller analysis of this possibility.

by debt (panel (d)), Germany appears substantially disadvantaged relative to other investors: this is because interest paid from the USA to Germany receives relief at the relatively low US statutory tax rate, but is taxed at the relatively high German tax rate. However, at higher rates of profit, the importance of this factor (which is unrelated to the rate of profit) is outweighed by the benefit of the high g in Germany, so that the EATR for German investors in the USA becomes substantially lower than the EATRs for other investors in the USA.

6 SUMMARY

This paper has investigated the role of taxation in cases in which an investor faces a choice between two or more mutually exclusive projects that earn more than the minimum required rate of return. It is argued that there are a number of circumstances in which such a choice is likely to occur, including choice of location and choice of technology. The choice of which project to undertake depends on the level of the post-tax economic rent that would be earned from each option. The impact of taxation on the choice cannot therefore be measured in the standard way by analysing a marginal investment. Instead, the impact depends on the proportion of economic rent captured in tax.

A new measure - an effective average tax rate (EATR) – is proposed, which attempts to summarise the impact of tax in such choices, and which builds on the standard approach to measuring the effective marginal tax rate (EMTR). This measure of the EATR has several attractive properties including that, for a marginal investment, it is equal to the EMTR. It can therefore be interpreted as summarising the distribution of tax rates for an investment project over a range of profitability; the EMTR represents the special case of a marginal investment. Estimates of the EATR are presented for four countries –

Germany, Japan, UK and USA - over the period 1979-1997. They illustrate several features of the EATR.

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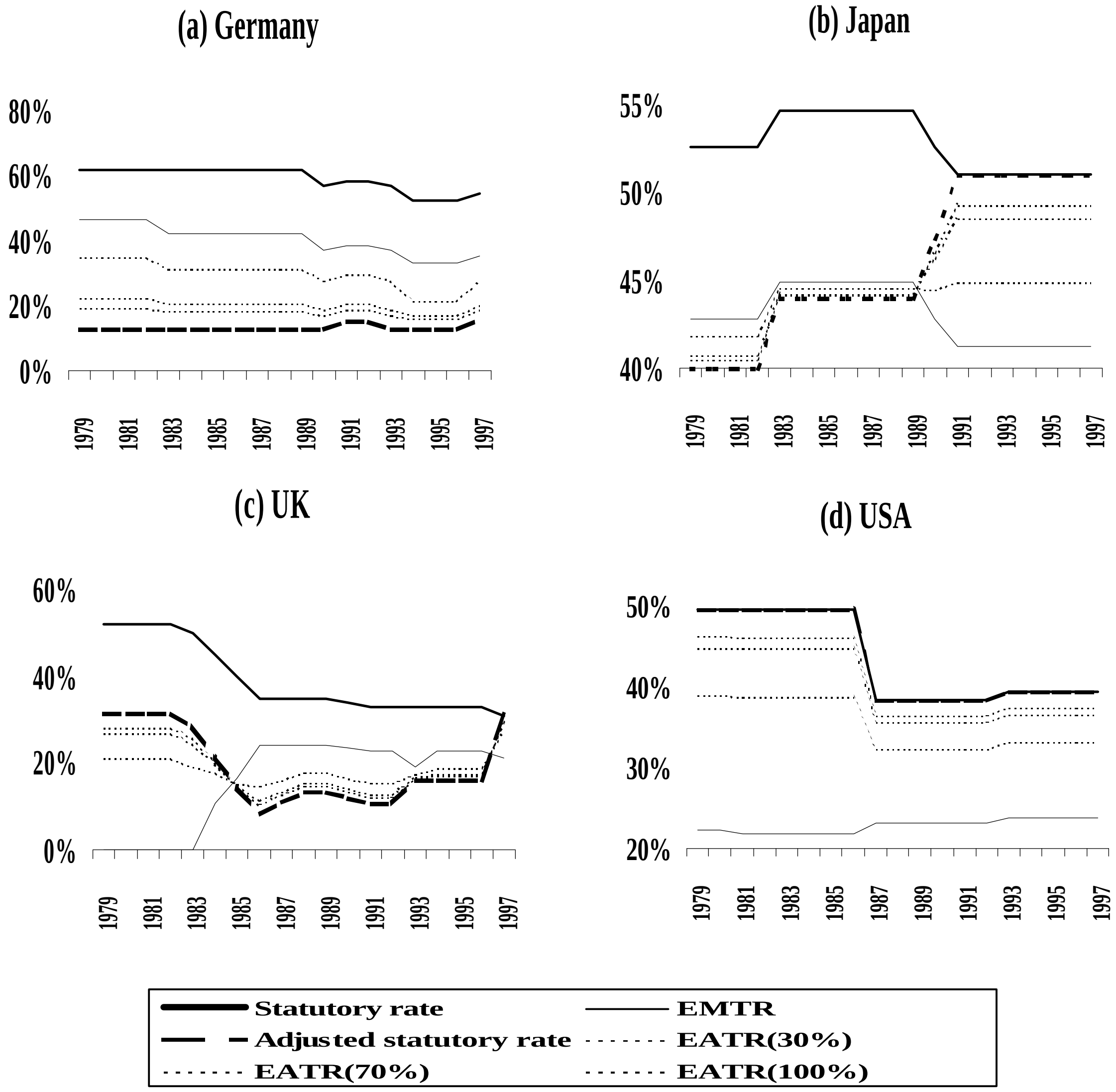

Figure 2.1: Tax rates on investment in plant and machinery financed by retained earnings

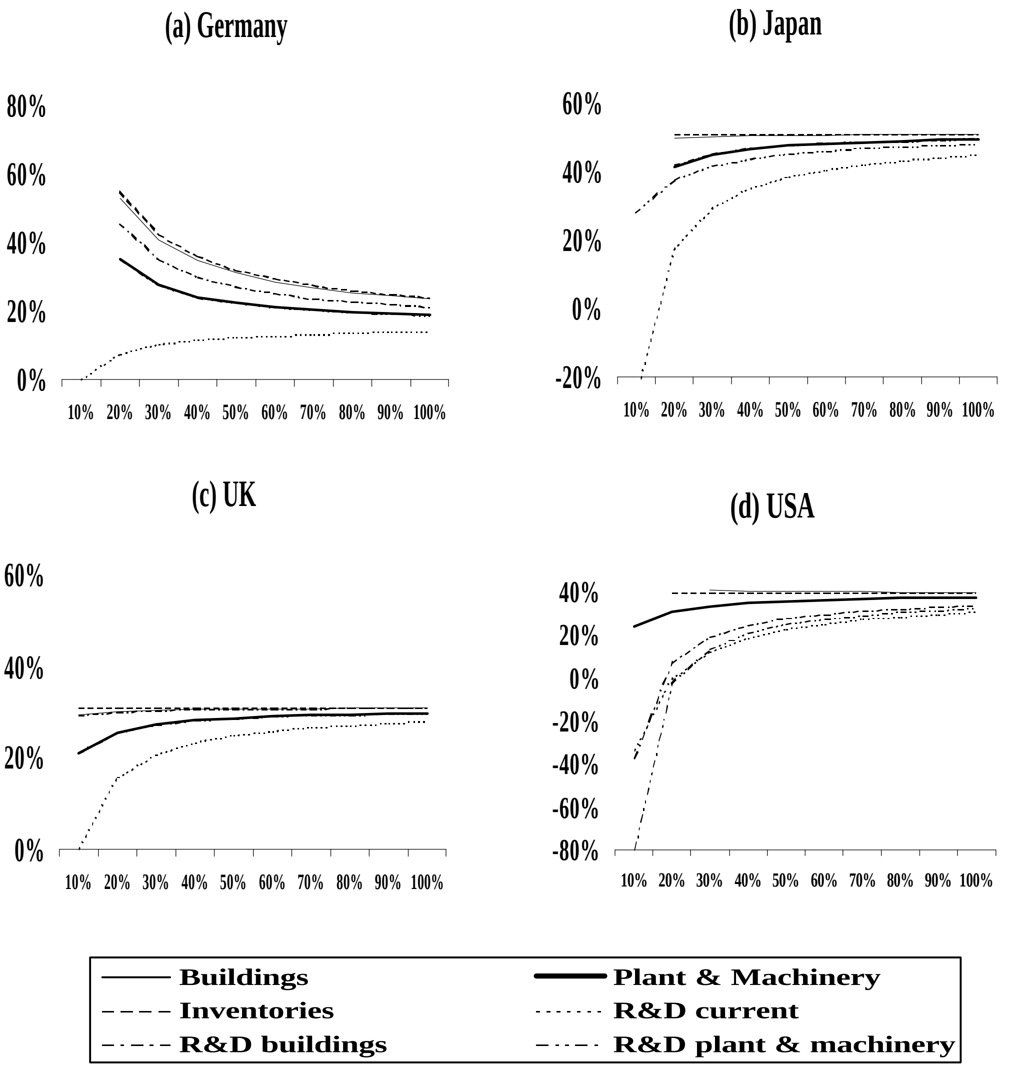

Figure 2.2: EATR in 1997 on investment in different assets
financed by retained earnings

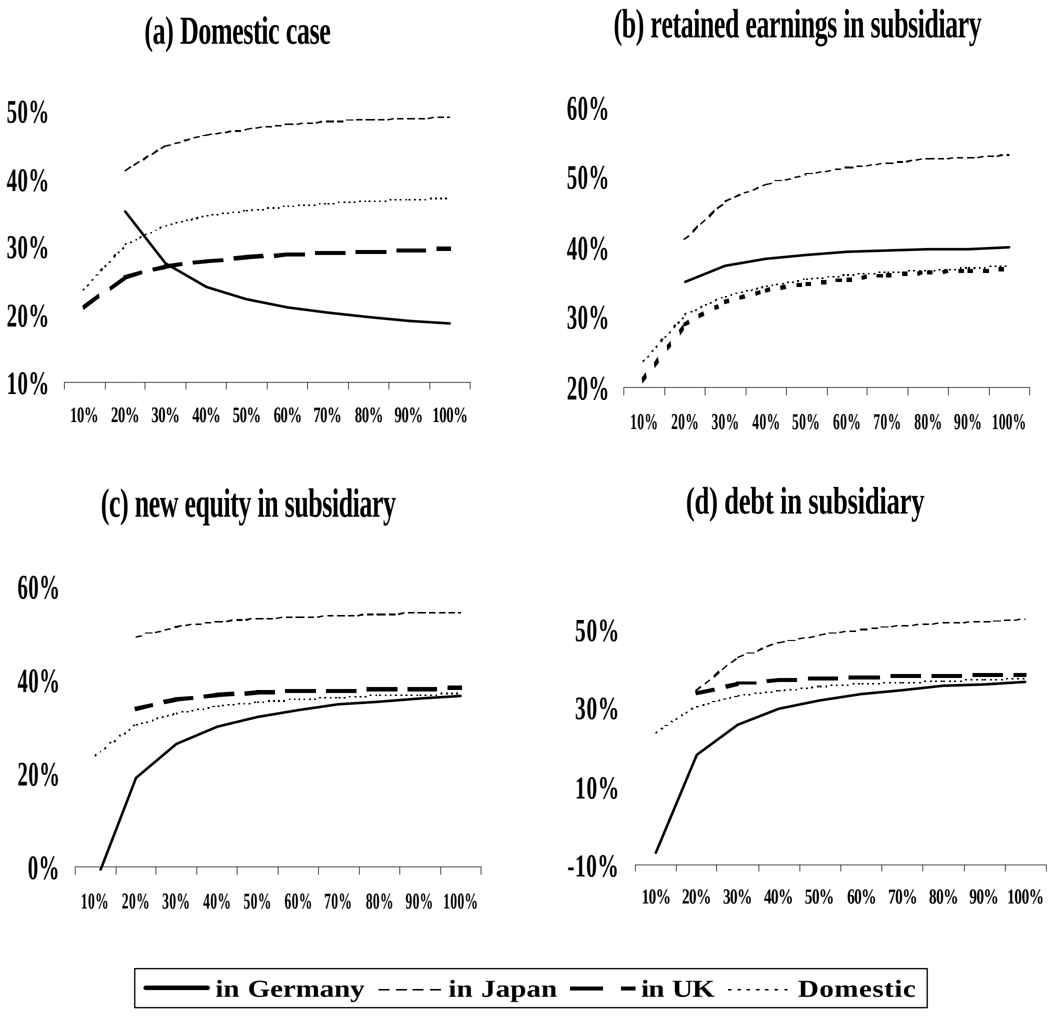

Figure 2.3: EATR in 1997 on investment in plant and machinery financed by retained earnings in the parent by a domestic firm (panel (a)) and a US-resident firm (panels (b) to (d))

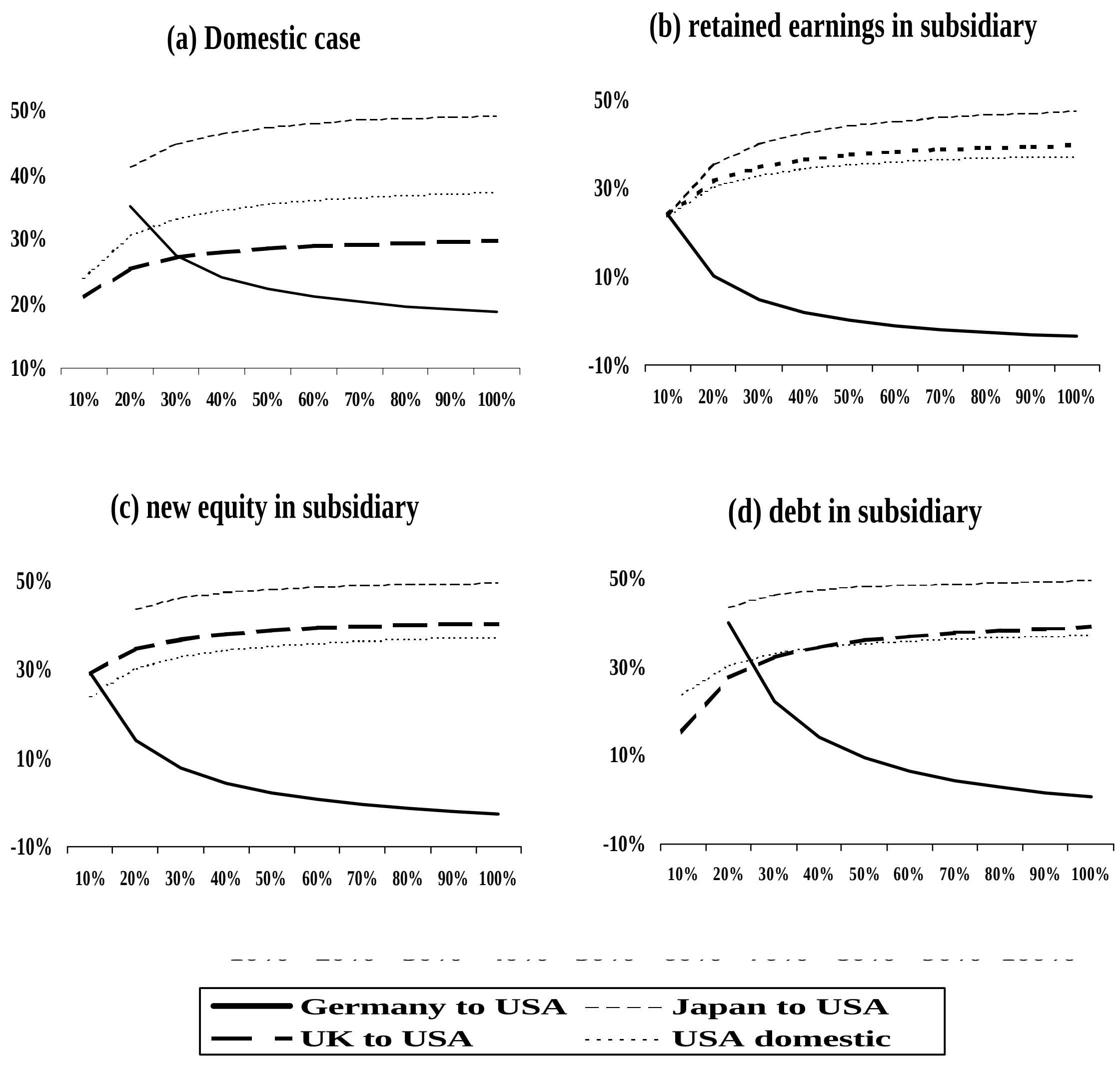

Figure 2.4: EATR in 1997 on investment in plant and machinery financed by retained earnings in the parent by a domestic firm (panel (a)) and a foreign-resident firm (panels (b) to (d))

Appendix A: Formal model of international investment

A.1 Description of the tax systems

Divide the taxes paid by the firm into two parts, those paid to the government in the residence country on the subsidiary firm s earnings (T_{jt}) and those paid to the government in the source country on the subsidiary firm s earnings ($\hat{T}_{nt}$),

$$T_t = T_{jt} + \hat{T}_{nt}, \tag{A.1}$$

where the hat indicates that the variable is denoted in the foreign currency. The exchange rate in period *t* is normalised to be unity. The exchange rate in period *t+1* is defined as E, and in period $t+s$ is E^s. Thus, the expected change in the exchange rate, and other economic variables, is assumed to be constant over time. Definitions of the tax parameters are as in the text; a subscript *j* indicates the rate in the residence country and a subscript *n* indicates the rate in the source country.

Tax is paid to the government in the residence country on its dividend and interest payments from the subsidiary, net of interest payments by the parent, but including any withholding taxes on dividends paid by the parent:

$$T_{jt} = c_j D_{jt} + k_j \hat{D}_{nt} + l_j i\hat{B}_{nt-1} - t_j iB_{jt-1} \tag{A.2}$$

where the definitions of new tax variables are given in Table A.1, and definitions of non-tax variables are summarised in Table A.2.

Tax is paid to the government in the source country on the subsidiary firm s earnings, again net of interest payments to the parent, but including any withholding taxes levied on dividend or interest payments to the parent,

$$\hat{T}_{nt} = t_n \left[\hat{\Pi}(K_{nt-1}) - f_n \left(\hat{K}^T_{nt-1} + \hat{I}_{nt}\right)\right] + (v_n - t_n) i\hat{B}_{nt-1} + c_n \hat{D}_{nt}. \tag{A.3}$$

Table A.1: Tax parameters

Taxation of dividend payments		
c_j, c_n	withholding tax rate on gross dividends paid by the parent (j) and by the subsidiary (n)	
s_j	imputation credit on dividends received by the ultimate shareholder from the parent	
	$c_j = s_j$	classical system
	$c_j < s_j$	partial imputation system
	$c_j > s_j$	net withholding tax
k_j	residence country tax rate on dividends received by the parent from the subsidiary	
	$= 0$	Exemption
	$= \max\left\{\left[\frac{t_j - t_n}{1 - t_n} - c_n\right], 0\right\}$	partial credit with deferral
	$= t_j (1 - c_n)$	deduction with deferral
s_{jn}	overall tax rate on dividend payments from the subsidiary to the parent	
	$= c_n$	Exemption
	$= \max\left\{\left[\frac{t_j - t_n}{1 - t_n}\right], c_n\right\}$	partial credit with deferral
	$= t_j (1 - c_n) + c_n$	deduction with deferral
Taxation of interest payments		
v_n	withholding tax rate on interest payments made by the subsidiary (n) to the parent	
l_j	residence country tax rate on interest payments received by the parent from the subsidiary	
	$= 0$	Exemption
	$= \max\{(t_j - v_n), 0\}$	partial credit with deferral
	$= t_j (1 - v_n)$	Deduction with deferral
w_{jn}	overall tax rate on interest payments from the subsidiary to the parent	
	$= v_n - t_n$	Exemption
	$= \max\{t_j, v_n\} - t_n$	partial credit with deferral
	$= t_j (1 - v_n) + v_n - t_n$	deduction with deferral

Table A.2: Definition of non-tax variables

i	nominal interest rate in the presence of tax
V_t	net present value of the firm to the ultimate shareholder in period t
$N_{jt}, \hat{N}_{nt}$	new equity issued by the parent (j) and issued by the subsidiary to the parent (n) in period t
$D_{jt}, \hat{D}_{nt}$	Dividends paid by the parent to the ultimate shareholder (j) and from the subsidiary to the parent (n) in period t gross of withholding tax at the firm level, but before imputation credit at the shareholder level
$\hat{\Pi}_n$	net income of subsidiary (n)
$\hat{K}_{nt-1}$	the value of the capital stock at the end of period t-1, beginning of period t of subsidiary (n)
$\hat{I}_{nt}$	Investment made in period t of subsidiary (n)
$B_{jt}, \hat{B}_{nt}$	one-period debt borrowed by the parent (j), and borrowed by the subsidiary from the parent (n) in period t
d	Economic depreciation rate
r	ultimate share holder s discount rate
p_j, p_n	expected inflation in the parent (j) and subsidiary (n) country
E	expected exchange rate in period t+1, $E_{t+s} = E^s$
^	denotes a variable in the currency of the source (n) country

An allowance is given on investment at the end of the first and subsequent periods. If the allowance is given on a declining balance basis the equation of motion of the tax written down value of the subsidiary s capital stocks is:

$$\hat{K}^T_{nt} = (1 - f_n)\{\hat{K}^T_{nt-1} + \hat{I}_{nt}\}. \qquad \text{(A.4)}$$

Combining (A.2) and (A.3) gives a general expression for total corporate level taxes paid in period *t*:

$$T_j = t_n \hat{\Pi}(K_{nt-1}) - t_n f_n \lfloor \hat{K}^T_{nt-1} + \hat{I}_{nt} \rfloor - t_j iB_{jt-1} + w_{jn} i\hat{B}_{nt-1} + s_{jn}\hat{D}_{nt} + c_j D_{jt}. \qquad \text{(A.5)}$$

A.2 The model

Consider a value-maximising parent firm. As in the main text, the value of the firm can be derived from the capital market equilibrium condition as,

$$(1 - r)V_t = gD_{jt} + V_{t+1} - N_{jt} \qquad \text{(A.6)}$$

where the tax discrimination term is here defined as $g = \frac{(1-m^d_j)(1-c_j)}{(1-z_j)(1-s_j)}$. As in the domestic case, an expression for the value of D_{jt} must be derived, which incorporates the activities of both the parent firm and the subsidiary. Using the equality of sources and uses of funds in the parent, dividends paid by the parent, D_{jt} , are given by

$$\begin{aligned}(1-c_j)D_{jt} &= B_{jt}-(1-i)B_{jt-1}+N_{jt}-T_{jt} \\ &\quad -\hat{B}_{nt}-\hat{N}_{nt}+[1+i(1-v_n)]\hat{B}_{nt-1}+(1-c_n)\hat{D}_{nt}\end{aligned} \tag{A.7}$$

Note that the parent is assumed to raise all its finance in the residence country *j*. The equivalent expression for dividends paid by the subsidiary to the parent, $\hat{D}_{nt}$, is,

$$(1-c_n)\hat{D}_{nt} = \Pi(\hat{K}_{nt-1})+\hat{B}_{nt}-[1+i(1-v_n)]\hat{B}_{nt-1}+\hat{N}_{nt}-\hat{I}_{nt}-\hat{T}_{nt}\,. \tag{A.8}$$

The subsidiary raises all its finance from the parent; it does not issue either debt or equity in the source country. As for the domestic case, we simplify the analysis by assuming that there is no specific price change for capital goods relative to output; we choose units such that the price of output is equal to the price of capital goods, and normalise this to be unity in period t. In period t+1 the price in the foreign currency is $(1+p_n)$. Combining, (A.7), (A.8), (A.2) and (A.3) and rearranging gives a general expression for dividends paid by the parent,

$$\begin{aligned}D_{jt} &= (1-s_{jn})(1-t_n)\Pi(\hat{K}_{nt-1})+N_{jt}-s_{jn}\hat{N}_{nt}+B_{jt}-[1+i(1-t_j)]B_{jt-1} \\ &\quad -s_{jn}\hat{B}_{nt}+[s_{jn}(1+i(1-t_n))-w_{jn}i]\hat{B}_{nt-1} \\ &\quad -(1-s_{jn})(1-t_n f_n)\hat{I}_{nt}+(1-s_{jn})t_n f_n\hat{K}^T_{nt-1}\end{aligned} \tag{A.9}$$

The equations of motion of the value of the capital stock is given by

$$\hat{K}_{nt} = (1-d)(1+p_n)\hat{K}_{nt-1}+\hat{I}_{nt}\,. \tag{A.10}$$

The net present value of the tax depreciation allowances per unit of investment, A_n, where depreciation is given on a declining balance basis was given in equation (3.6) for the domestic case. Where tax depreciation is allowed at rate f_n on a straight line basis it is given by,

$$A_n = \frac{f_n t_n(1+r_n)}{1+r_n-E}\left[1-\frac{E^N}{(1+r_n)^N}\right]. \tag{A.11}$$

A.3 Measuring effective tax rates

As in the domestic case, we consider a perturbation of the capital stock in one period, $d\hat{K}_{nt} = 1, \quad d\hat{K}_{nt+s} = 0, \ \forall s \neq 0$, achieved by perturbing investment in the subsidiary by,

$$d\hat{I}_{nt} = 1, \qquad d\hat{I}_{nt+1} = -(1-d)(1+p_n). \tag{A.12}$$

The perturbation to the capital stock at the end of period *t*, yields a return in the form of higher net output in period $t+1$ of $(p_n + d)$. The nominal change in net income before tax is:

$$d\hat{\Pi}_{nt+1} = (p_n + d)(1+p_n). \tag{A.13}$$

The international investment can be financed in one of seven ways: the parent firm retains funds to finance retentions in the subsidiary; the parent firm retains funds and issues new equity to the subsidiary; the parent firm retains funds and lends to the subsidiary; the parent firm raises new equity and purchases new equity from the subsidiary; the parent firm raises new equity and lends to the subsidiary; the parent firm borrows and purchases new equity from the subsidiary; and the parent firm borrows and lends to the subsidiary. The impact on the net flows to the ultimate shareholder of the parent firm can be found by combining the relevant elements of Table A.3, which corresponds to Table 3.1 for the domestic case.

Table A.3: Financial constraints on investment

Source of finance	Domestic	Foreign
Retained Earnings	$dN_{jt+s} = dB_{jt+s} = 0 \quad \forall s$	$d\hat{N}_{nt+s} = d\hat{B}_{nt+s} = 0 \quad \forall s$
New Equity	$dB_{jt+s} = 0, \forall s$ $dN_{jt} = 1 - f_n t_n, dN_{jt+1} = -dN_{jt}$ $dN_{jt+s} = 0, \ \forall s \geq 2$	$d\hat{B}_{nt+s} = 0, \forall s$ $d\hat{N}_{nt} = 1 - f_n t_n, d\hat{N}_{nt+1} = -d\hat{N}_{nt+1}$ $d\hat{N}_{nt+s} = 0, \ \forall s \geq 2$
Debt	$dN_{jt+s} = 0 \quad \forall s$ $dB_{jt} = 1 - f_n t_n, dB_{jt+s} = 0, \forall s \geq 1$	$d\hat{N}_{nt+s} = 0 \quad \forall s$ $d\hat{B}_{nt} = 1 - f_n t_n, d\hat{B}_{nt+s} = 0, \forall s \geq 1$

The economic rent of the new project, defined as R, is the net present value of the change in the value of the firm, and is identical to (3.8). As in the domestic case, we implement this definition by deriving the change in dividends and new equity in each period. This can be usefully split into three parts (we drop time subscripts for expositional purposes): (i) the rent attributable to the investment in the subsidiary financed by retained earnings (R_n^{RE}); (ii) the additional cost of the parent raising external finance (F_j); and (iii) the additional cost of the subsidiary of raising finance from the parent (F_n). The economic rent earned from an investment by the subsidiary is given by $R_n = R_n^{RE} + F_j + F_n$. R_n^{RE} is defined in (4.1), F_j in (3.10) and F_n in (4.2). The values of F_j, F_n are given in Table A.4 for the different sources of finance.

Table A.4: Values of F_j, F_n for alternative forms of investment

Source of parent finance	
Retained Earnings	$F_j = 0$
New Equity	$F_j = \frac{-r(1-g)}{(1+r)}(1-f_n t_n)$
Debt	$F_j = \frac{g(1-f_n t_n)}{(1+r)}\{r - i(1-t_j)\}$
Source of subsidiary finance	
Retained Earnings	$F_n = 0$
New Equity	$F_n = \frac{g s_{jn}}{(1+r)}(1-f_n t_n)[E-(1+r)]$
Debt	$F_n = \frac{g(1-f_n t_n)}{(1+r)}\{s_{jn}[E(1+i(1-t_n))-(1+r)]-Ew_{jn}i\}$

Setting $R = 0$ and solving for p_n, the cost of capital for an international investment, defined as $\tilde{p}_n$, yields equation (4.3).

The EATR is defined in equation (4.5). Substituting for R_n^* from (4.4) and for R_n using the expressions for R_n^{RE} from (4.1) permits the EATR to be derived for a given value of p_n:

$$EATR_n = \frac{R_n^* - R_n}{\left(\frac{E(1+p_n)p_n}{1+i}\right)} = \frac{\frac{E(1+p_n)(1+p_n)-(1+i)}{(1+i)}}{\left(\frac{E(1+p_n)p_n}{1+i}\right)}$$

$$- \frac{\frac{g(1-s_{jn})}{(1+r)}\{(p_n+d)E(1+p_n)(1-t_n)-[(1+r)-(1-d)(1+p_n)](1-A_n)\}_n}{\left(\frac{E(1+p_n)p_n}{1+i}\right)} \quad \text{(A.14)}$$

$$- \frac{F_j + F_n}{\left(\frac{E(1+p_n)p_n}{1+i}\right)}$$

This can be computed for different forms of finance and hence different values of F_j and F_n using the expression in Table A.4. The corresponding general expression for the EATR of a domestic investment is,

$$EATR_j = \frac{R_j^* - R_j}{\left(\frac{p}{1+r}\right)} = \frac{\left(\frac{p-r}{1+r}\right)}{\left(\frac{p}{1+r}\right)} \quad \text{(A.15)}$$

$$- \frac{\frac{g}{(1+r)}\{(p+d)(1+p_j)(1-t_j)-[(1+r)-(1-d)(1+p_j)](1-A_j)\}+F_j}{\left(\frac{p}{1+r}\right)}.$$

APPENDIX B: TAX DATA

The information on corporate tax systems comes largely from Chennells and Griffith (1997) and on the tax treatment of R&D from Bloom, Chennells, Griffith and Van Reenen (1999).

Statutory tax rates

Three statutory tax rates are shown below: the headline rate, and two statutory tax rates - one applying to retained earnings, and the other to distributed profits - which include all other taxes on corporate income. The headline rate is the national corporate income tax rate on retained earnings. This rate does not include any surcharges or local taxes. The statutory tax rates on retained earnings and distributed profits are the ones used in the calculations presented and include surcharges and other special taxes that are levied on corporate income at the national level. They also include an estimate of corporate income tax levied at the local level. Local taxes only include local corporate income taxes, they do not include taxes on property. In many countries local taxes are deductible from the national tax and this is taken into account. The tax rates are based on the rates in force at 31 December.

Depreciation Allowances

Where there are several alternatives for the firm to choose from, the most generous form of capital allowance is used. Where a switch from declining balance to straight line is allowed it is assumed that this is made as soon as the value of the straight line depreciation exceeds that of the declining balance. Where the depreciation rate is based on the life-time of the asset, it is assumed that plant and machinery lasts for 8 years and buildings for 25 years. None of the countries considered here indexes allowances for inflation. In the calculations shown in this appendix a fixed nominal discount rate of 10% has been used for illustrative purposes.

For illustrative purposes, the measure of the net present value (NPV) of allowances given in the tables below are calculated using equations (3.6) and (A.11) generalised to allow for time-varying depreciation rates.[1] The number reported is A/t so that a value of unity indicates that the full cost of the investment can be offset immediately.

Structure of Tax Systems

There are some elements of tax systems which remain relatively unchanged over time, including the treatment of inventories, the method of integrating corporate and personal taxation for the treatment of dividend income, and the treatment of foreign source income.

The method by which firms are allowed to value inventories will affect their profit rate (and therefore tax rate) in the presence of inflation. There are at least two commonly used methods, FIFO (first in, first out) and LIFO (last in, last out). During periods of high inflation, FIFO will value profits higher than LIFO and thus increase the effective tax rate. In many countries firms can choose which method they want to use. Firms may want to use FIFO to increase reported profits (particularly in one book countries), while for tax reasons they would prefer to use LIFO. It is assumed that firms use LIFO unless this is explicitly disallowed. Table B.1 shows the systems used in each of the five countries.

Table B.1: Valuation Method for Inventories

France	FIFO
Germany	LIFO
Japan	LIFO
UK	FIFO
USA	LIFO

Income from corporate profits can be the subject of taxation at two levels, the corporate level and the personal income tax level. There are a variety of approaches that countries have adopted to try and alleviate this double taxation through the integration of the personal and corporate income tax systems. Table B.2. summarises these approaches into one of three categories: split rate systems, imputation systems, and classical systems. Under a split rate system there are two different statutory tax rates, one that applies to retained earnings, the other to distributed earnings. The lower rate on distributed profits acts to compensate, usually only partially, for the personal income tax levied on the dividend income. An imputation system is one in which some portion of corporate income taxes

[1] See OECD (1991).

paid on distributed profits can be offset against the individual personal income tax liability. Under some systems this comes in the form of a credit which can be refunded if, for example, the individual is tax-exempt. The rates of imputation given below are expressed as a share of the gross dividend (i.e. the cash dividend plus its associated tax credit). A classical system makes no allowance for double taxation, so that dividend income is subject to corporate income tax and taxed again as personal income.

Table B.2: Method of Integrating Corporate and Personal Income Taxes

France	Partial imputation system which gives shareholders a credit of 33% (called the *avoir fiscal*).
Germany	Germany operates a split rate system and an imputation system, the credit is 36% until 1994 when it drops to 30%.
Japan	Split rate system until 1990, partial shareholder relief system thereafter.
UK	Imputation system, the credit is 30% until 1985, 29% in 1986, 27% in 1987, 25% from 1988 to 1992 and 20% from 1993.
USA	Classical system.

The treatment of repatriated income from foreign sources, in the form of dividend or interest income, will affect the tax rates on international investments. The systems in place in these five countries are shown in Table B.3.

Table B.3: Treatment of Foreign Source Income

	Interest	Dividends
France	Credit	Exempt (95%)
Germany	Credit	Exempt
Japan	Credit	Credit
UK	Credit	Credit
USA	Credit	Credit

The most common methods of dealing with foreign income are the credit method and the exemption method. The former grants a credit for foreign taxes paid by the subsidiary against the tax which would have been owed on that income by the parent had the investment been wholly domestic. The credit method has several variations, according to whether foreign source income is considered on a country by country basis or a world-wide basis, or according to different classes of income. However, only investments into a single country are considered here so these are effectively the same. The exemption method exempts foreign income in the hands of the parent, so that the tax paid in the country which is the source of the profits, the withholding tax paid when the subsidiary transfers the income to the parent, and personal taxes owed by investors in the parent company are the only taxes levied. One other alternative modelled here is a deduction system, which allows the tax paid on foreign source income to be deducted from the tax base, when calculating the payment owed in the residence country.

France

The statutory rate on retained earnings in France has fallen steadily over the period. The value of depreciation allowances have remained basically the same, although between 1981 and 1985 an additional initial allowance was given on investment in plant and machinery.

Table B.4: French Tax Rates and NPV of Allowances

Year	Headline tax rate	Statutory tax rate on retentions (distributions)	g	NPV of Allowances (buildings)	NPV of Allowances (plant & machinery)
1979	50.0	50.0 (50.0)	1.5	0.38	0.81
1980	50.0	50.0 (50.0)	1.5	0.38	0.81
1981	50.0	50.0 (50.0)	1.5	0.38	0.87
1982	50.0	50.0 (50.0)	1.5	0.38	0.87
1983	50.0	50.0 (50.0)	1.5	0.38	0.87
1984	50.0	50.0 (50.0)	1.5	0.38	0.87
1985	50.0	50.0 (50.0)	1.5	0.38	0.87
1986	45.0	45.0 (50.0)	1.5	0.38	0.81
1987	45.0	45.0 (45.0)	1.5	0.38	0.81
1988	42.0	42.0 (42.0)	1.5	0.38	0.81
1989	39.0	39.0 (42.0)	1.5	0.38	0.81
1990	37.0	37.0 (42.0)	1.5	0.38	0.81
1991	34.0	34.0 (42.0)	1.5	0.38	0.81
1992	34.0	34.0 (34.0)	1.5	0.38	0.81
1993	33.3	33.3 (33.3)	1.5	0.38	0.81
1994	33.3	33.3 (33.3)	1.5	0.38	0.81

Source: Chennells and Griffith (1997).

France has no withholding tax on interest income after 1986, at rates of 10 or 15% prior to 1986. Withholding taxes on dividend income are usually 10 or 15%, and the tax credit on dividends, the *avoir fiscal*, is not usually given to foreign parent companies. France operates a credit system for interest income arising from foreign sources, but exempts 95% of dividend income. Both the USA and UK levied withholding taxes of 10% on interest being returned to France, reduced to zero in 1990. The USA imposes a 5% withholding tax on dividends returning to France; the UK does not tax these payments.

In 1983 a 25% tax credit was introduced on the real increase in qualifying R&D expenditure over last year, with a FF3 million per year cap. The credit rate was increased to 50% in 1985 and the cap raised to FF5 million, leading to a further fall in the marginal tax wedge. In 1988 firms were given two alternative choices. The first was a 50% credit on the increase over the previous year's expenditure, up to a maximum of FF5 million (increased to FF10 million in certain cases). Alternatively, for the years 1988, 1989, and 1990 they could receive a 30% credit on the increase over their 1987 expenditure, up to a maximum of FF3 million. This latter option is worth more to firms expecting to increase their R&D spending and is what is modelled. Although the headline rate of credit fell (from 50% to 30%), the value of the effective subsidy to R&D increased sharply because the base used to calculate the increase in R&D expenditure was fixed at the 1987 level. This eliminates the impact of current R&D spending on the calculation of the future base. In 1991 the credit returned to 50% on the increase in real expenditure, but the base was extended to the most recent two years and the cap raised to FF40 million. This reduced the effective value of the subsidy due, since the base reverted to a moving average. From 1983 to 1986 expenditure on buildings used for scientific research was given an accelerated depreciation allowance of 50% straight line.

Germany

Throughout most of the period, the German statutory tax rate has been the highest of the countries considered here, although a significant decrease in 1994 meant that it fell slightly below Japan. However, a surcharge reintroduced in 1995 increases the rate again. Germany operates a split rate system with the statutory rate on distributed profits set significantly lower than that on retained earnings. There have been two reductions in the statutory rate, one in 1990 and the other in 1994. Depreciation allowances on buildings have become more generous over time, while on plant and machinery they have increased only slightly.

Table B.5: German Tax Rates and NPV of Allowances

Year	Headline Rate	Statutory tax rate on retentions (distributions)	g	NPV of Allowances (buildings)	NPV of Allowances (plant & machinery)
1979	56.0	61.8 (44.4)	2.27	0.26	0.76
1980	56.0	61.8 (44.4)	2.27	0.26	0.76
1981	56.0	61.8 (44.4)	2.27	0.26	0.76
1982	56.0	61.8 (44.4)	2.27	0.26	0.76
1983	56.0	61.8 (44.4)	2.27	0.32	0.80
1984	56.0	61.8 (44.4)	2.27	0.32	0.80
1985	56.0	61.8 (44.4)	2.27	0.49	0.80
1986	56.0	61.8 (44.4)	2.27	0.49	0.80
1987	56.0	61.8 (44.4)	2.27	0.49	0.80
1988	56.0	61.8 (44.4)	2.27	0.49	0.80
1989	56.0	61.8 (44.4)	2.27	0.49	0.80
1990	50.0	56.6 (44.4)	2.00	0.49	0.80
1991	50.0	58.2 (45.6)	2.03	0.49	0.80
1992	50.0	58.2 (45.6)	2.03	0.49	0.80
1993	50.0	56.6 (44.4)	2.00	0.49	0.80
1994	45.0	52.2 (39.2)	1.82	0.49	0.80
1995	45.0	52.2 (39.2)	1.82	0.49	0.80
1996	45.0	52.2 (39.2)	1.82	0.49	0.80
1997	45.0	54.7 (41.0)	1.87		0.80

Notes: The statutory rate on retained earnings and (distributed profits) includes local taxes and a Solidarity Surcharge of 3.75% on individual and corporation tax for 1991 and 1992, a surcharge on corporate income tax only of 7.5% was introduced in 1995. A local municipal trade tax is levied at a rate varying from 9 to 20%. A rate of 13.1% is assumed throughout the period based on OECD 1991. The trade tax is deductible.
Source: Chennells and Griffith (1997).

France, Japan and the US operate credit systems for the treatment of income from Germany. Germany exempts interest income returned to these countries, but levies withholding taxes on dividends at various rates, falling from 25% in 1979 to between 5 and 15% by 1994. Germany gives a credit for taxes paid on interest income earned abroad, and exempts dividend income. Although the USA levies a withholding tax of 5% on dividends being returned to Germany (15% prior to 1992), it does not impose a withholding tax on interest. Neither the UK nor France withholds tax on dividend or interest payments made to Germany.[2]

There are currently no special tax allowances for R&D in Germany. Between 1983 and 1989 industrial buildings and plant and machinery enjoyed limited accelerated depreciation provisions. A building that was at least two-thirds used for R&D purposes could be depreciated at up to 15% of the cost over five years; or 10% if only one-third used for

[2] However, unlike its treatment of many European countries, the UK does not grant the dividend tax credit for dividends remitted to Germany.

R&D. Plant and machinery used exclusively for R&D, could receive an additional 8% allowance of up to 40% of the initial cost over five years.

Japan

Japan has, throughout the period, maintained one of the highest tax rates, under almost any of the measures considered. The statutory corporate income tax rate in Japan is made up of a number of taxes. Using 1995 as an example year, the headline rate was 37.5%, but there are two local taxes to account for: the enterprise tax and the inhabitants tax . The enterprise tax is deductible (from the income base that it is calculated on), while the inhabitants is not. The enterprise tax applies to corporate income and depends upon the size of the firm, and the standard rate in the highest income range is used here (12%). The inhabitants tax applies to the firm s corporate income tax liability, and ranges from 5% to 20.7%. Using the lowest rate for Tokyo (17.3%), gives us:

Taxable profits	100
Enterprise tax @12%, base is (100-ET) so effective rate is 10.88%	-10.88
Corporate income tax base	89.12
Corporate income tax @37.5%	-33.42
	55.70
Inhabitants tax @17.3% of corporate income tax	9.64
	46.06

The total tax paid is 53.94%, and subtracting the corporate income tax of 37.5% gives one (non-deductible) effective local tax rate of 16.44%. The system of taxation in other years is similar, but the rates of tax change.

Until 1990, Japan operated a split rate system with the statutory rate on distributed profits lower than that on retained earnings. The underlying headline rates of tax on retained and distributed earnings have gradually equalised, through falls in the former and increases in the latter. The statutory rate of corporate income tax on retained earnings in Japan, including the local taxes described above, rose slightly in the mid-1980s, then fell back by the end of the period. There have been very few changes to depreciation allowances.

Table B.6: Japanese Tax Rates and NPV of Allowances

Year	Headline Rate	Statutory tax rate on retentions (distributions)	g	NPV of Allowances (buildings)	NPV of Allowances (plant & machinery)
1979	40.0	52.7 (40.2)	1.27	0.29	0.70
1980	40.0	52.7 (40.2)	1.27	0.29	0.70
1981	40.0	52.7 (40.2)	1.27	0.29	0.70
1982	40.0	52.7 (40.2)	1.27	0.29	0.70
1983	43.0	52.7 (40.2)	1.24	0.30	0.70
1984	42.0	52.7 (40.2)	1.24	0.30	0.70
1985	52.0	52.7 (40.2)	1.24	0.30	0.70
1986	43.3	56.2 (45.7)	1.24	0.30	0.70
1987	43.3	56.2 (45.7)	1.24	0.30	0.70
1988	43.3	56.2 (45.7)	1.24	0.30	0.70
1989	42.0	54.8 (44.3)	1.24	0.30	0.70
1990	40.0	52.7 (47.5)	1.11	0.30	0.70
1991	37.5	54.8 (54.8)	1.00	0.30	0.70
1992	37.5	54.8 (54.8)	1.00	0.30	0.70
1993	37.5	54.8 (54.8)	1.00	0.30	0.70
1994	37.5	53.9 (53.9)	1.00	0.30	0.70
1995	37.5	53.9 (53.9)	1.00	0.30	0.70
1996	37.5	53.9 (53.9)	1.00	0.30	0.70
1997	37.5	53.9 (53.9)	1.00	0.30	0.70

Notes: The statutory rate on retained earnings and (distributed profits) includes local taxes as described above and a surcharge of 2.5% from 1991 to 1994.
Source: Chennells and Griffith (1997).

Japan imposes a withholding taxes on dividend and interest income of 10% on US multinationals investing in Japan. The USA imposes equivalent withholding taxes on interest and dividend income paid to Japan, at 10%. Japan operates a world-wide credit system for foreign source income.

Japanese firms can claim a 20% credit on R&D spending exceeding the largest previous annual R&D expenditure. The credit is limited to 10% of tax due before the credit. Buildings and plant and machinery used for R&D activity are also eligible for accelerated depreciation allowances. Several additional special credits are also available, although they are not modelled here.[3]

UK

The UK experienced one major reform to the corporate income tax system during the period, in 1984. This combined a substantial reduction in rate of corporate income tax with

[3] These include a 6% credit for small and medium sized firms, a 7% credit for investment to promote basic technology and a 6% credit on R&D carried out in co-operation with government.

reductions in the allowances available on plant and machinery and buildings, in a move away from an expenditure-based tax.[4]

Table B.7: UK Tax Rates and NPV of Allowances

Year	Headline Rate	Statutory tax rate on retentions (distributions)	g	NPV of Allowances (buildings)	NPV of Allowances (plant & machinery)
1979	52.0	52.0 (52.0)	1.43	0.73	1.00
1980	52.0	52.0 (52.0)	1.43	0.73	1.00
1981	52.0	52.0 (52.0)	1.43	0.91	1.00
1982	52.0	52.0 (52.0)	1.43	0.91	1.00
1983	50.0	50.0 (50.0)	1.43	0.91	1.00
1984	45.0	45.0 (45.0)	1.43	0.73	0.93
1985	40.0	40.0 (40.0)	1.43	0.51	0.87
1986	35.0	35.0 (35.0)	1.41	0.32	0.73
1987	35.0	35.0 (35.0)	1.37	0.32	0.73
1988	35.0	35.0 (35.0)	1.33	0.32	0.73
1989	35.0	35.0 (35.0)	1.33	0.32	0.73
1990	34.0	34.0 (34.0)	1.33	0.32	0.73
1991	33.0	33.0 (33.0)	1.33	0.32	0.73
1992	33.0	33.0 (33.0)	1.33	0.32	0.73
1993	33.0	33.0 (33.0)	1.25	0.47	0.79
1994	33.0	33.0 (33.0)	1.25	0.32	0.73
1995	33.0	33.0 (33.0)	1.25	0.32	0.73
1996	33.0	33.0 (33.0)	1.25	0.32	0.73
1997	31.0	31.0 (31.0)	1.00	0.32	0.73

Notes: No local corporate income taxes or surcharges are levied.
Source: Chennells and Griffith (1997).

The UK imposes various rates of withholding tax on interest income on the countries in our sample, most commonly zero or 10% in recent years. Withholding taxes on dividend income are also levied, but the countries covered here either face a zero rate, or in fact receive an imputation credit of 50% of the dividend tax payment made to the UK revenue (which is then added to dividend received and a withholding tax of five or 10% is imposed). The USA does not impose withholding taxes on dividends and interest on payments returning to the UK. The UK operates a credit system for foreign source income.

Capital expenditure on equipment and buildings used for R&D in the UK can qualify for a 100% first year allowances under the Scientific Research Allowance. Current expenditure receives no special treatment.

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[4] Note that if account is taken of the fact that the changes to the tax system were pre-announced, through a consultative period, the tax wedge would show a different pattern in 1984 and 1985, when it would fall

USA

The USA has had two major tax reforms during this period, the Economic Recovery Tax Act of 1981 and Economic Recovery Act of 1986. The 1981 Act introduced a new system of depreciation allowances, although this change did not affect the generosity of allowances on plant and machinery. The statutory tax rate on corporate income was reduced from 46% to 34% as part of the wide ranging tax reform in 1986. This reform also broadened the base by making depreciation allowances on both buildings and plant and machinery less generous through the Modified Accelerated Cost Recovery System (MACRS). In addition, an investment tax credit of 10% on investment in plant and machinery was abolished.

Table B.8: US Tax Rates and NPV of Allowances

Year	Headline Rate	Statutory tax rate on retentions (distributions)	g	NPV of Allowances (buildings)	NPV of Allowances (plant & machinery)
1979	46.0	49.6 (49.6)	1.00	0.43	0.87
1980	46.0	49.6 (49.6)	1.00	0.43	0.87
1981	46.0	49.6 (49.6)	1.00	0.56	0.87
1982	46.0	49.6 (49.6)	1.00	0.56	0.87
1983	46.0	49.6 (49.6)	1.00	0.56	0.87
1984	46.0	49.6 (49.6)	1.00	0.56	0.87
1985	46.0	49.6 (49.6)	1.00	0.56	0.87
1986	46.0	49.6 (49.6)	1.00	0.56	0.87
1987	34.0	38.4 (38.4)	1.00	0.26	0.78
1988	34.0	38.4 (38.4)	1.00	0.26	0.78
1989	34.0	38.4 (38.4)	1.00	0.26	0.78
1990	34.0	38.4 (38.4)	1.00	0.26	0.78
1991	34.0	38.4 (38.4)	1.00	0.26	0.78
1992	34.0	38.4 (38.4)	1.00	0.26	0.78
1993	35.0	39.3 (39.3)	1.00	0.21	0.78
1994	35.0	39.3 (39.3)	1.00	0.21	0.78
1995	35.0	39.3 (39.3)	1.00	0.21	0.78
1996	35.0	39.3 (39.3)	1.00	0.21	0.78
1997	35.0	39.3 (39.3)	1.00	0.21	0.78

Notes: The statutory rate on retained earnings and (distributed profits) includes an average of state corporate income taxes of 6.6%, which is deductible from federal taxes, for every year.
Source: Chennells and Griffith (1997).

The USA imposes a withholding tax on interest income of 10% on payments to Japan (but zero for the UK). Dividend income also faces a withholding tax of 10% for payments to Japan, and 5% for the UK. The USA operates a credit system for foreign source income.[5]

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dramatically. This is because the announcement that future allowances will be lower and would be offset against a lower tax rate, reduces the effective tax rate for current investment.

[5] The US operates a more complicated credit system than the other countries covered in this report (see Arnold, Li and Sandler (1996) for details.). Despite that, this system is modelled in the same as other credit

Canada imposed a withholding tax on interest income paid to the USA of 15% (falling to 10% in 1992), and prior to 1986 France levied one of 10%. The UK did not withhold tax on interest income, and granted a partial tax credit on dividend income (see UK section). Dividend withholding taxes by Canada have fallen from 15% to 7% over the period, while France has levied a constant 5%.

Since 1954 all R&D expenditure has been fully deductible. The Economic Recovery Tax Act of 1981 introduced a tax credit on incremental R&D expenditure which has remained in place, although there have been many subsequent changes to its design, and the credit has never been made a permanent feature of the tax system. The rules governing the operation of the US tax credit are complex and are only sketched out here. A detailed explanation can be found in Hines (1994) and Hall (1995). In particular, the foreign allocation rules are not modelled as only domestic investment in R&D is considered. The statutory rate of the credit was 25% between 1981 and 1985 and has been 20% since then. From 1981 until 1990 incremental expenditure was defined as spending above the average of the last three years expenditure. In 1990 the definition of the base changed to the three year average ratio of R&D over sales (up to a maximum of 16%) times sales. In addition, the rules governing the deductibility of the credit have change. Before 1988 corporation tax was not levied on the R&D tax credit itself. In 1988 50% of the credit was made taxable income and from 1989 onwards 100% was made taxable income.

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systems. The fact that the US pools foreign source income does not affect the calculations since this method only considers an investment in one country at a time. The US system attempts to redefine the base on which foreign taxes were levied to bring them in line with US definitions. This would make a difference to our calculations, but this has not been modelled.