Measuring Taxes on Income from Capital

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Abstract

This paper provides a conceptual review of how the impact of taxes on the incentive to invest in the corporate sector can be measured. The focus is on measures derived from economic theory. Two measures are derived – effective marginal and average tax rates – which reflect different forms of investment decisions. A number of extensions to the basic model are examined, including the role of personal taxes, the source of finance and risk. These measures are compared to empirical measures based on observed tax revenues or tax liabilities.

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1 Introduction

This paper reviews a number of different approaches which have been taken in what is now a large literature on measuring the taxation of income from capital. It is not the intention to summarise all approaches, but rather to set out a general framework in which the advantages and disadvantages of alternative approaches can be assessed.

Before beginning to discuss measurement, however, it is useful to identify the purpose of such measurement. What are the economic questions to which a particular measure might provide an answer? This preliminary issue is discussed in Section 2. Two important issues stand out. First, what *is* a tax on capital income? For example, is it a tax which is formally levied on a specific income stream received by owners of capital, or would it include any tax which reduces the income of the owners of capital? Second, is it a measure designed to shed light on the distribution of taxes amongst individuals, or to indicate how the tax might affect the size and composition of the capital stock?

In practice, there have been two main lines of research on the measurement of taxes on income from capital. One line has been based on the original theoretical approach of Jorgenson (1963), which attempts to identify the impact of taxes on the cost of capital – the real required pre-tax rate of return on an investment project. The well-known approach of King and Fullerton (1984) in developing measures of the effective marginal tax rate follows this line of research, although there are several examples of alternative approaches. This general approach is based on the use of parameters enshrined in tax legislation, notably statutory tax rates and the ways in which taxable income is defined.

Recently this approach has been extended to consider discrete investment decisions which may affect the composition of the capital stock (Devereux and Griffith, 1998a, 1998b, 2003). The effective marginal tax rate is not directly relevant in such decisions. Instead, such decisions depend on an effective average tax rate. However, such a measure can also be derived using the parameters of tax legislation itself.

An alternative line of research has been to use data on tax revenues, or the tax liabilities of firms. Data on individual firm tax liabilities are available from company accounting (or tax) records, while data on aggregate tax revenues are available for many countries. To use such data in the creation of tax rates, the tax liability or revenue must be scaled by some measure of the underlying income which is taxed. The result is typically a measure of an average tax rate. In the case of company tax liabilities usually some measure of firm profit is chosen. Various scaling factors have been used in the case of aggregate revenue data. One of the most well-known is the approach of Mendoza et al (1994), in which revenue from taxes on capital are divided by a measure of the operating surplus of the economy.

Recently, too, this type of measure has been developed in a new direction. Gordon et al (2003) propose a measure of the effective marginal tax rate which can be derived from such data, rather than the usual approach of using the parameters of tax legislation. This approach is based on the comparison of actual tax revenue with the revenue which would be collected by a hypothetical tax based solely on economic rent (which would have a zero effective marginal tax rate).

After the preliminary discussion in Section 2, we proceed in Section 3 by setting out the main approaches of economic theory to examining how taxes on capital income affect investment decisions. In the context of a simple model, we derive two broad measures of effective tax rates: a marginal rate which affects the scale of investment, and an average rate which affects discrete choices. In Section 4, we consider a number of further issues which arise in making such effective tax rates operational. In particular, we consider: the role of personal taxes; the impact of using alternative sources of finance; cross-border direct investment; risk; and the extent to which more complex models of the firm can be used. Section 5 then considers an alternative form of effective tax rate, based on observable data on tax payments. The central question here is the extent to which such measures can be used to shed light on the economic decisions set out in Section 3. Section 6 concludes, and provides some reflections on the use of the different measures.

2 What are taxes on income from capital, and why do we want to measure them?

Before addressing the question of how to measures taxes on the income from capital, it is useful to consider why we might be interested in such measurements. In other words, what questions might be answered by measuring such taxes? Only when we have identified the questions should we attempt to provide the answers.

In general, taxes raise two types of concern: the distribution of the burden of the tax across individuals, and the impact of the tax on economic behaviour. Clearly, in attempting to discover distributional effects, we should be concerned with the effective incidence of the tax. Of course, this is very difficult. For example, the effective incidence of a corporation tax may be shared amongst a large number of individuals, depending on the conditions in a number of markets.

But consideration of effective incidence also raises a question about what might be considered to be a tax on the income from capital. That is because the income stream received by owners of capital might be lower in the presence of many taxes, not just those levied directly on that income stream. For example, a wage tax could reduce the income to capital owners if workers were able to bid up the gross wage in order to pass on the tax. An origin-based VAT might give firms located in one country a disadvantage relative to their competitors elsewhere; this too might reduce the net income stream to the owners of capital.

For these reasons, this paper does not address the effective incidence of taxes which may affect the income from capital. As such, it has nothing to say about the distribution of such taxes. Instead, it focuses only on efficiency aspects. Even here, though, similar questions arise. Fundamentally, social welfare is likely to depend on the size and composition of the capital stock located in a jurisdiction. Any taxes which affect decisions which determine these may therefore reduce social welfare (or possibly increase it, in the presence of negative externalities).

But again there is no obvious classification of taxes which may affect the size and composition of the capital stock. Certainly, the link between effective incidence and distortions to the capital stock is tenuous. In a standard model of a small open economy, for example, owners of capital do not bear the effective incidence of taxes on capital income. But their capital investment decisions are affected by such taxes. That may suggest considering only taxes which are formally incident on capital. But that is not sufficient either; the fact that a tax is formally incident on income from capital is neither necessary nor sufficient for it to affect the size or composition of the capital stock. For example, in a small open, capital-importing economy, individual, residence-based taxes on income from capital are likely to affect savings, but are unlikely to affect domestic investment. Further, as noted above, wage taxes which are partly passed on to capital owners may affect investment.

In section 3 below, we review two types of decision concerning investment. The first is the scale of investment undertaken. This is the traditional approach of economic theory, and typically the impact of a tax is measured by its impact on the pre-tax required real rate of return – the cost of capital. If a tax raises the cost of capital, then it is likely to result in lower investment; conversely, if it lowers the required rate of return, then it is likely to result in higher investment. The second is the composition of capital, which can be affected by discrete investment choices – for example, which of two mutually exclusive investments to undertake. The theory indicates that such a decision depends on how taxes affect the post-tax profit of the investments, which can be measured by an effective average tax rate.

But neither of these approaches provides a clear-cut definition of which taxes are relevant in affecting investment decisions. In keeping with most of the literature, this paper in fact focuses only on taxes which are formally incident on income from capital. More specifically, it is primarily concerned with source-based taxes. This approach is most easily justified in the context of a small open economy, which takes the world rate of return (after source-based taxes) as given. This provides convenient no-arbitrage conditions in which the impact of taxes formally on capital income can be clearly identified.

It may be the case that other taxes also affect investment decisions.[1] However, in principle, the impact of such taxes on investment decisions depends also on assumptions regarding market conditions. Here we make the simplest assumption that such taxes do not affect investment decisions. Any alternative should require us to spell out precisely the route by which investment decisions are affected.

Finally, it should be noted that in practice the paper focuses almost exclusively on measuring taxes on capital income derived from the corporate sector. This approach is taken mainly for simplification. Clearly, it is also possible to attempt to measure the taxation of income earned outside the corporate sector. Indeed, the extent to which taxes affect the choice of legal form may be an important issue. However, while the tax treatment of non-corporate enterprises differs from that of companies, most of the principles addressed below apply also to investment undertaken by either form of enterprise.

3 Theory of investment decisions

The discussion of the previous section set out alternative economic questions relating to taxes on the income from capital, and also raised the issue of which taxes should be incorporated in any analysis. As noted above, we make specific choices about the questions to be addressed, and the taxes which should be examined. The choices made here are:

(i) to examine the impact of taxes on the composition and size of the capital stock in a particular jurisdiction; and

(ii) to examine only taxes which are formally incident on the return to capital formally owned by a corporation, although they may be formally levied on the corporation or its shareholders.

3.1 The basic model

The traditional approach to examining the impact of taxes on the level of investment by firms was originally set out in detail by King (1974), drawing on earlier contributions, notably by Jorgenson (1963) and Hall and Jorgenson (1967).

The approach used by King is based on a dynamic model of the firm in the context of a risk-neutral shareholder. Specifically, a capital market arbitrage condition requires that the market value of the equity of the firm at the end of period *t*, denoted V_t be determined by the following condition:

$$\{1+(1-m)i\}V_t = \frac{(1-m^D)}{(1-c)}D_{t+1} - N_{t+1} + V_{t+1} - z(V_{t+1} - N_{t+1} - V_t). \qquad (1)$$

The Appendix gives definitions of the variables used in this paper.

The right hand side of this equation is the post-tax payoff – earned at the end of period *t*+1 - to an individual owning the equity of a firm from the end of period *t*. It consists of net income from dividends, D_{t+1}, after personal tax at rate m^D and a tax credit at rate *c*, less new equity contributed to the firm, N_{t+1}, plus the value of the firm at the end of period *t+1*, V_{t+1}, net of capital gains tax at an effective rate *z* due on any change in the value of the firm. The left hand side is the post-tax return from investing an amount V_t in a deposit paying interest at a nominal rate *i*, on which tax is paid at rate *m*. For a risk neutral investor, these must be equal, which implies that V_t must also be the market value of the equity of the firm at the end of period *t*. Solving for V_t implies

$$V_t = \frac{\gamma D_{t+1} - N_{t+1} + V_{t+1}}{1+\rho} \quad (2)$$

where $\rho = (1-m)i/(1-z)$ is the tax adjusted nominal discount rate and $\gamma = (1-m^D)/(1-c)(1-z)$ is a tax discrimination variable, which captures the impact of tax on a round-trip of paying one unit of dividends financed by one unit of new equity. The role played by γ is discussed further in Section 4.2.

This is related to real investment by the firm through the equality of sources and uses of funds within the firm in each period:

$$D_t = F(K_{t-1})(1-\tau) - q_t I_t + B_t - [1+i(1-\tau)]B_{t-1} + \tau\phi(q_t I_t + K_{t-1}^T) + N_t . \quad (3)$$

We assume that the price of output rises by the inflation rate π in each period, and normalise its price at the end of period *t* to unity. We also normalise the price of the capital stock in period *t* to be unity.

Two further expressions reflect the evolution over time of the capital stock and the valuation of the capital stock for tax purposes:[2]

$$K_t = (1-\delta)K_{t-1} + I_t , \quad (4)$$

and

$$K_t^T = (1-\phi)K_{t-1}^T + (1-\phi)q_{t-1}I_{t-1} . \quad (5)$$

We assume that the firm chooses the capital stock in any period to maximise the wealth of its shareholder, V_t, given by (2), subject to (3), (4) and (5). Within this framework we can study two separate types of decision which the firm may need to make.

3.2 The optimal scale of the capital stock

The first is the traditional decision as to the optimal size of the capital stock. To find this, we combine the four expressions, and then differentiate with respect to K_t. This yields the first order condition for the optimal capital stock:

$$(1-\tau)(1+\pi)F'(K_t) = (1-A)\{\rho + q_{t+1}\delta - (q_{t+1} - 1)\} \quad (6)$$

where

$$A = \frac{\tau\phi(1+\rho)}{\rho+\phi}. \quad (7)$$

The left hand side of (6) is the post-corporation tax net revenue generated in period *t+1* from increasing K_t. Note that the change in the capital stock is only for one period: K_{t+1} is unaffected. The right hand side of (6) represents the cost of increasing K_t. This includes the financial cost of tying funds up in the higher capital stock for one period, the fall in the value of the asset over the period due to depreciation, less any increase in the relative price of capital goods over the period.

For a given cost of increasing K_t for one period, then, (6) can be thought of determining the minimum acceptable real rate of return, $F'(K_t)$. All projects earning a return greater than this should be accepted; all those earning a rate of return less than this should be rejected. It is common to split this required rate of return into two components, reflecting the cost of depreciation and the remaining cost. That is, define *p* to be the pre-tax rate of return on a project, over and above the rate of depreciation, so that $F'(K) = p + \delta$. The cost of capital is defined as the minimum acceptable value of p, denoted $\hat{p}$, where:

$$\hat{p} = \frac{(1-A)}{(1-\tau)(1+\pi)}\left\{\rho + \delta(1+\pi^K) - \pi^K\right\} - \delta. \quad (8)$$

where π^K is the increase in the price of the capital stock, and so $q_{t+1} = 1 + \pi^K$.

This is the basic expression for the cost of capital in much of the investment literature.[3] It is straightforward to see that a rise in the rate of allowances, *A*, reduces the cost of capital, and a rise in the tax rate, τ, increases the cost of capital (although such an increase also raises *A*). Personal taxes are relevant only to the extent to which they affect the discount rate, ρ. In the special case in which the shareholder's tax rate on interest income is equal to his effective tax rate on capital gains, then the discount rate is independent of personal taxes.

In the absence of tax, the cost of capital is simply the real interest rate, *r*. One natural measure of the effective marginal tax rate is therefore the proportionate increase in the cost of capital which arises as a result of taxation:

$$e = \frac{\hat{p} - r}{\hat{p}} \quad (9)$$

There are a number of issues which must be explored further, however, before this measure can be used to assess how taxes affect the incentive to invest. One is the role of personal taxes. A second concerns how the perturbation to the capital stock is financed. So far, the analysis has not allowed the use of debt or new equity to change. The first order condition on the capital stock held both constant; implicitly the incremental investment is therefore financed by a reduction in dividends, and the return is paid to shareholders in the form of dividends. However, there are clearly other possibilities. A third issue is the role of international taxes in the context of foreign direct investment. A fourth is the impact of introducing risk. We discuss each of these in turn in Section 4.

There are, of course, other issues which are not addressed here due to lack of space. One of these is the possibility that tax rates may be expected to change over time. This can arise because, for example, the government has already announced a reform, or because the government has specific measures which generate changes in the tax parameters for a specific investment over time, such as a tax holiday.[4] It could also arise due the asymmetric nature of most taxes; when taxable income is negative, typically it does not generate an immediate tax rebate, but it must be carried forward to some future period to offset against subsequent positive income. If a firm is in such a position in either period *t* or period *t+1*, this can generate large effects on the cost of capital.[5]

3.3 The optimal composition of capital

The approach so far is based on a model in which firms simply choose the optimal size of the capital stock. In effect, the capital stock is assumed to be continuously divisible, so that investment can be undertaken up to the point at which it becomes unprofitable.

However, it is possible to consider other types of decision which firms make with respect to their capital. One important distinction is to consider a firm which has two types of capital. These may reflect different continuously divisible assets used in the production process, in which case the above approach can still be used. However, they may also represent mutually exclusive choices. For example, one type of capital may represent setting up a new plant in the firm's country of residence. Another may represent setting up a plant in some other country. Depending on the cost structure involved in the investment, it may be unprofitable for the firm to build both plants. Instead it must choose between them.[6] This type of decision may therefore affect the composition of the firm's capital stock. And in the case in which that composition represents capital located in different jurisdictions, it can also affect the total capital located in each jurisdiction.

This suggests a two-stage decision making process. In stage 1, the firm makes the discrete choice between mutually exclusive options. In stage 2, it chooses the optimal level of the type of capital chosen in stage 1.[7] In analysing this, suppose that $\hat{V}_t^A$ and $\hat{V}_t^B$ represent the maximised wealth of the shareholder if either option A or option B is undertaken (that is, where in either case the firm chooses the optimal level of the capital stock). Then, consistent with the firm aiming to maximise the wealth of the shareholder, the firm should choose option A if $\hat{V}_t^A > \hat{V}_t^B$ and vice versa.

The role of tax in the stage 1 decision cannot be captured by its impact on the cost of capital, however. To examine the stage 1 decision, we abstract from the stage 2 decision by assuming that the investment is of a fixed size. More specifically, we consider the case of a unit increase in the capital stock in period *t* only, as above, but where the unit increase can be in one of two types of capital. As above, we assume for now that there is no issue of new equity or debt associated with the investment.

It is useful to define the value to the shareholder of a project *i* in the absence of tax as R^*, where the asterisk denotes values in the absence of tax:

$$R^* = -1 + \frac{1}{1+i}\left\{(1+\pi)(p+\delta) + (1+\pi^K)(1-\delta)\right\}. \qquad (10)$$

This is also the net present value in the absence of tax of the economic rent of the project. In the simpler case in which $\pi = \pi^K$, and $1+i = (1+r)(1+\pi)$, (10) reduces to

$$R^* = \frac{p-r}{1+r}. \qquad (11)$$

In the absence of tax, the firm would choose project A over project B if $R^{*A} > R^{*B}$ and vice versa.

In the presence of tax, the choice would be based on the comparison of post-tax values, R^A and R^B. Following the same approach, the post-tax value can be written as

$$R = -\gamma(1-A) + \frac{\gamma}{1+\rho}\left\{(1+\pi)(p+\delta)(1-\tau) + (1+\pi^K)(1-\delta)(1-A)\right\}. \qquad (12)$$

One measure of the impact of tax is to consider a form of effective average tax rate, $\hat{\alpha}$, such that $R = (1-\hat{\alpha})R^*$, or

$$\hat{\alpha} = \frac{R^* - R}{R^*}. \qquad (13)$$

In effect such a tax rate measures the proportion of the economic rent which is taken in tax. The higher is $\hat{\alpha}$, the less likely a project is to be chosen. An alternative measure, which captures the same idea, is to base the effective average tax rate on total income, rather than economic rent. Such a measure is more akin to those commonly based on accounting and aggregate data, described in Section 5. It is defined as:

$$\alpha = \frac{R^* - R}{p/(1+r)} = \hat{\alpha}\left(\frac{p-r}{p}\right). \qquad (14)$$

Clearly, these two measures reflect the same information, since one is a simple transformation of the other. However, they have rather different properties. In particular, it is possible to show that α is a weighted average of the effective marginal tax rate, *e*, and the statutory tax rate adjusted for personal taxes, denoted *t*:[8]

$$\alpha = \left(\frac{\hat{p}}{p}\right)e + \left(1 - \frac{\hat{p}}{p}\right)t \tag{15}$$

where

$$t = 1 - \gamma(1-\tau)\frac{(1+i)}{1+\rho}. \tag{16}$$

The weights in (15) reflect the profitability of the investment. For a marginal investment, $p = \hat{p}$ and so $\alpha = e$. As the profitability of the investment rises, the weight on *e* falls and the weight on *t* rises. As $p \to \infty$, $\alpha \to t$.

As with the effective marginal tax rate, there are several further important issues which need to be raised. These are discussed in Section 4.

3.4 Financial constraints

There is another way in which taxes can affect firms' investment, and that is through the availability of finance. Suppose that the cost of external finance rises with the amount used. In this case, investment can exceed post-tax retained earnings, but a lower tax liability would increase the available internal funds, and thereby reduce the need for external funds. In turn, this would reduce the cost of external funds, and, at the margin, investment would be higher.

In the extreme case in which external finance is prohibitively expensive, then investment is constrained to be no greater than post-tax earnings. From (3), in the absence of debt and new equity finance, the condition that $D_t \geq 0$ implies

$$q_t I_t \leq (1-H)F(K_{t-1}) \tag{17}$$

where

$$H = \tau\left\{\frac{(1-\phi)F(K_{t-1}) - \phi K_{t-1}^T}{(1-\tau\phi)F(K_{t-1})}\right\} \tag{18}$$

Here *H* is a rather different form of average tax rate. In the absence of tax, $H=0$ and investment is constrained by the pre-tax net revenue. In the presence of tax, it is constrained by post-tax net revenue, with $H>0$. This type of effect is quite different from the effects on incentives described above. Although there is now a vast literature examining the possibility of financial constraints on investment (see, for example, Hubbard, 1998, for a survey), this role of tax has been largely ignored. We will not discuss it in any detail here, except to note that it is closely related to the measures of taxation based on observed tax liabilities or revenue, described in Section 5.

4 Other issues

Much of the basic analysis in section 3 is uncontroversial, and is shared by many different approaches to measuring taxes on the income from capital. Where approaches differ tends to be in specific detailed assumptions. We now address the more important issues involved in translating the theory into practical measures of taxation. We discuss a number of issues in turn.

4.1 Personal Taxes

The model set out in Section 3 makes two important assumptions:

- that the market value of the corporation is determined by the no arbitrage condition (1); and
- that the managers of the corporation aim to maximise this market value.

Both of these assumptions are strong and open to question.[9] We address them in turn.

The first problem is not that there may be arbitrage opportunities in financial markets, but rather that it is very difficult – and in practice, impossible – to identify for which economic agent the arbitrage condition holds. To see this, consider a very simple case in which there are two individuals, $i = A, B$, and two assets, $j = 1, 2$. A and B could be residents of different countries, but need not be. The return from each asset is r_j. Let the tax rate for individual i on the income from asset j be m_{ij}. Then – in the absence of risk - individual i will hold both assets only if their post-tax rates of return are the same:

$$s_i = (1 - m_{i1})r_1 = (1 - m_{i2})r_2 . \qquad (19)$$

If the tax rates vary across i and j then this can only hold by chance for both individuals. If it does not hold for both, then one individual – say A - will be at a corner solution, holding only one asset. In that case, the return required on each asset – and hence their price - will be determined by B. That is, B is the “marginal investor”. In this case, the personal tax rates in (1) are those which apply to the marginal shareholder, B.

It is conceivable that the risk characteristics of the two assets are such that both investors would hold both assets even if their tax rates differed. However, this too is very unlikely. Suppose, for example, that for investor i, asset 1 is riskier than asset 2 and so requires a post-tax risk premium relative to asset 2. Given the risk characteristics of the two assets, investor i would only hold both assets if the actual difference in expected post-tax rates of return were equal to this risk premium. Given investor *i*'s tax rates, there is clearly an equivalent condition applying to pre-tax expected rates of return. But given that this is true for both investors, then it could again only be by chance that tax rates were set such that both investors held both assets. In effect, differences in tax rates would have to exactly offset differences in perceived risk characteristics.

If the world really consisted of two investors, then it might be possible to identify the marginal investor. However, it does not. Even within a single closed economy there may be a number of groups of taxpayers with different sets of tax rates. But with an international capital market, the investor may be resident anywhere in the world. And it is likely that the investor will be subject to a residence-based tax on his worldwide income. In that case, the government in which the firm resides, or in which it operates, would not set the tax rate of the marginal investor.

In practice, most investors hold more than one type of asset, so they are not completely at a corner solution. However, this implies that it is very difficult to find out who the marginal investor for any asset is. One approach to doing this would be to attempt to identify the impact on the value of an asset (for example, a share price) of a change in the personal tax rate structure. For example, suppose m_{A1} changes, whilst all other tax rates were left unchanged. Then if A were the marginal shareholder and asset 1 were a company, then there should be a change in the market value of the company; and it would be possible to calculate the change in the market value implied by the tax reform. If B were the marginal shareholder, there would be no such change.

In practice, however, even this approach may not be able to identify the marginal investor, for several reasons. First, it is very hard to identify tax reforms which would enable such a test to be carried out. Second, the tax reform may well affect the underlying expected cash flows of the firm – for example, the firm may choose to invest more because of lower taxation. Thus, the tax reform may lead to a change in *r* as well as the tax rate. Separating out these effects would be very difficult. Third, it may be the case that the identity of the marginal investor changes as a result of the tax reform. Fourth, if the marginal investor is non-resident, then it is difficult to identify which of many possibly relevant tax rates have changed.

The second assumption is equally problematic. It is not necessarily the case that the marginal shareholder has the majority vote amongst the shareholders. In fact, it may be rather unlikely that this would be the case; if there is an investor who only invests in one particular type of asset, then it is quite plausible that he would have a majority vote.

Consider this case a little further. Suppose that the existing structure of taxes leaves B as the marginal shareholder, but A holding the majority of the shares of company 1. A can therefore instruct the managers of the company to act in his interests. Suppose then that A's tax rate changes in such a way that he would prefer more investment, at the cost of a lower marginal rate of return. This might mean that B would no longer want to hold shares in company 1. However, given an almost infinite set of possible investors in a world capital market, it seems quite plausible that there is a least one investor who would be willing to buy B's shares, and who would become the new marginal investor. The market value of the firm would probably change, but it would still not reflect the valuation of the controlling shareholder, A.

This seems to point to the relevant personal tax rates being those of the majority owner of a firm, rather than the "marginal" shareholder. Unfortunately, of course, it may not even be possible to identify the majority owner – indeed there may be no majority owner. This takes us to two different considerations. The first is the nature of voting power – what size of stake is necessary to control decisions? The second set are corporate governance issues more generally – to what extent do boards of directors take into account the personal taxes of any shareholders? Arguably, if directors maximize anything, it is post-corporation tax profit.

For the purposes of this paper, in attempting to define effective rates of tax on capital income, it is necessary to make some assumptions about the relevant personal tax rates. But this discussion calls into question all such assumptions. In particular, with a world capital market, it is not necessarily sensible to assume that the relevant shareholder is a domestic resident. In any case, the marginal shareholder may determine the share price, but may not affect investment decisions.

If boards of directors really wanted to maximize the post-tax wealth of a given shareholder, they would be faced with the same difficulties as outlined here. Perhaps the most plausible assumption is simply that managers do not take personal taxes into account in their investment decisions, either because they do not know whose personal tax rates to take into account, or because no shareholder is sufficiently powerful to require them to do so.

4.2 Sources of Finance

How firms finance their activities has been an active area of research for many years, but it is probably fair to say that many issues in this area have yet to be resolved. The modern literature on this topic began with the Modigliani and Miller (1958) irrelevance theorems, and has since continued with contributions taking account of agency costs, signaling, property rights and financial constraints. There is no space to survey this literature here.[10]

For the purposes of measuring taxes on the income from capital, four main issues arise. First, what forms of finance are available to the firm? Second, should an incremental investment project be assumed to be financed from a single source of finance, or from a mixture of sources? Third, should the underlying cost of finance be allowed to differ according to its source? Fourth, if a single source of finance is assumed, should it be assumed that all positive and negative cash flows in all periods of the investment are identified with the same source? We discuss these issues in turn.

The traditional distinction between sources of finance is that between equity and debt. This distinction is important for tax purposes since they are generally treated differently. Typically, interest payments are deductible in determining corporate profit; they may or may not be taxed when received by lender. Dividend payments differ in that they are typically not deductible in determining corporate profit, although there have been many forms of integration of corporate and personal taxes.

A further important distinction in measuring the impact of taxes on capital income is between two classes of equity finance: new equity and retained earnings. These differ again due to taxation. Consider an investment in an asset which costs the firm \$1. If financed by new equity, this costs the shareholder \$1. However, if cash dividends paid by the firm are reduced by \$1, then the net cost to the shareholder depends on the personal tax which would have been paid had the cash dividend not been reduced. In the model above, this is measured by γ. If $\gamma < 1$, then the net cost is lower with retained earnings. If the proceeds of the investment are paid to shareholders as dividends, then this difference in cost is reflected in a difference in effective tax rates.

In principle, there are many other forms of financial contract under which a firm could raise finance, which may have elements of debt and equity finance. These include, for example, swaps and various forms of options. The literature on measuring effective tax rates has not yet incorporated such forms of finance. However, given a well-defined set of cash flows associated with any form of financing, and a clear set of tax rules which apply to such cash flows, then there is no reason why any particular form of financing could not be modeled. In the remainder of this review, though, we discuss only the more standard forms of finance.

The second issue is whether it is preferable to consider an investment financed by a single source of finance, or by a mix of sources. The former approach is used by papers in the King and Fullerton (1984) tradition. The latter is exemplified by, for example, Boadway, Bruce and Mintz (1984). Either of these approaches can easily be incorporated into measures of effective tax rates. The choice between them depends on which underlying model of corporate finance is used.

One typical approach to analysing sources of finance used by a firm is to begin by allowing costs to differ according to sources of finance. For example, for $\gamma < 1$, it is typically assumed that new equity finance is more expensive than retentions. Debt may initially be the cheapest form of finance due to interest deductibility. However, to formulate a model, it is commonly assumed that the interest rate paid by the firm increases as the proportion of debt increases. (Several other factors could also be taken account of in a complete model).

This type of model favours the King Fullerton approach. That is, as the firm increases its investment in any period, the marginal source of finance changes. It may begin with debt, switch to retained earnings (until dividends reach zero), switch back to debt, and as the interest rate increases, eventually switch to new equity. (This model underlies most studies which incorporate financial constraints). Ex-post, the firm may therefore use all three sources of finance. However, any given increment to investment is likely to be financed from a single source.

An alternative approach is to assume the existence of some other costs, or some general equilibrium, which makes an individual firm indifferent to its choice of finance. A well-known example of such a model is that of Miller (1977). This model essentially derives an equilibrium in which individual investors hold either equity or debt, depending on their personal tax rate. There is a unique aggregate equilibrium which determines the required return on equity, but given this, the cost of finance to any individual firm is independent of its source of finance.

In principle, this might justify an assumption that the firm uses all three sources of finance for a marginal project. However, this model would imply that the cost of all three was the same. The problem in measuring effective tax rates is to make assumptions which allow this to be true. For example, this may include a higher underlying rate of return required on debt, which is offset by tax deductibility of interest. What this model does not justify, however, is a weighted average of sources of finance which have different costs.

The Boadway et al (1984) approach is, however, based on a weighted average where the costs differ according to sources of finance. They use actual costs of debt and equity as observed in the market: the cost of debt finance is the observed interest rate, while the cost of equity finance is calculated using price-earnings ratios from stock market data. They justify this using a model in which both the cost of equity and the cost of debt rise with the debt-equity ratio (see Boadway, 1987). In this model, the firm first selects the debt-equity ratio which minimises the average cost of financial capital. This debt-equity ratio is then used to choose the optimal capital stock.

The fourth issue raised above is whether it should be assumed that the same source of finance is marginal for the whole lifetime of the investment. This question has two aspects, which we consider in turn. First, in considering a one period perturbation in the capital stock, what is an appropriate assumption about the marginal source of finance when the asset is purchased (in period t) and when the return is earned (in period $t+1$)? In the context of equity finance, the answer to this was most clearly specified by Edwards and Keen (1984), drawing on Auerbach (1979).

We have already argued that the cost to the shareholder of a \$1 investment is \$1 if the investment is financed by new equity, and \$$\gamma$ if it is financed by retained earnings. Conversely, a return of say \$$1+p$ paid out as a dividend is worth \$$\gamma (1+p)$ to the shareholder, while the same return used to reduce new share issues is worth \$$1+p$. This implies that it is important to specify the marginal source of finance in both periods. Suppose, for example, that new equity is the marginal source of finance in both periods. Then the dividend tax, represented by γ is irrelevant; dividend payments are not affected by the investment. On the other hand, suppose that retained earnings are the marginal source of finance in both periods. Then both the cost of the investment and the return depend on γ; in deriving the cost of capital, these two effects cancel out, so that the cost of capital is again independent of γ. This is reflected in the analysis in Section 3.

The dividend tax therefore only affects the cost of capital if the marginal source of finance changes between the two periods. The most common case analysed is that in which the marginal source of finance in period t is new equity, while in period $t+1$ it is retained earnings. In this case, the dividend tax tends to raise the cost of capital. But the opposite is equally plausible; and in this case, the dividend tax tends to reduce the cost of capital.

The second aspect of this issue is how cash flows in subsequent periods are financed. Such cash flows can arise even with a one period perturbation of the capital stock, since there may be some effect on depreciation allowances indefinitely. In effect, this determines the discount rate to be applied in determining the present value of such allowances. In the model above, the shareholder's discount rate ρ should be used for all discounting. However, if all cash flows subsequent to period $t+1$ are assumed to be reflected in changes in debt issued and repaid, then it can be shown that the net effect is equivalent to the appropriate discount rate being the net of tax nominal interest rate, $(1-\tau)i$. This is equivalent to the approach taken by King and Fullerton (1984), who treat this as the firm's discount rate[11]. However, it is rather more difficult to take this approach for new equity finance, since it is necessary to define in each period the impact on new equity and dividends. It turns out that only in very extreme cases can the approach of King and Fullerton be justified in this case (such an approach is followed in Sorensen, 1990, and OECD, 1991).

An alternative approach is to assume that the marginal source of finance is retained earnings in all periods other than period *t*. Devereux and Griffith (1998b, 2003) explicitly make this assumption. In this case, the definition of *R* in (12) holds only for investment financed by retained earnings. If either debt or new equity is used, then an additional term must be added to reflect the tax consequences. This is defined as

$$F = \gamma dB_t \left\{1 - \frac{1+i(1-\tau)}{1+\rho}\right\} - (1-\gamma)dN_t \left\{1 - \frac{1}{1+\rho}\right\} \qquad (20)$$

where dB_t is the change in debt in period *t*, dN_t is the change in new equity in period *t* and all other terms are as defined above.

This approach allows the whole of the cost of investment to be met from a single source of finance, or for up to all three sources to be used. In this case, the shareholder's discount rate is used. Clearly, *F* becomes relevant in determining both the cost of capital and the effective average tax rate.

4.3 Foreign direct investment

The analysis so far has considered only the case in which the firm invests domestically. In practice, multinational companies may produce in other countries. This raises an extra layer of complication in calculating effective tax rates. The extra complication arises from taxes which may be levied by either the host or home country on cash flows between the parent company and the affiliate. Such taxes may include withholding taxes levied by the host country on dividends and interest paid to the parent, and also additional taxes levied by the home country on receipts of income from the host country.

This taxation can also be complicated by complex international transactions, possibly designed to take advantage of specific tax rules. For example, profits may be repatriated through an intermediary company in a country with a beneficial tax regime, or profits from high and low taxed countries may be mixed to avoid paying any home country tax.

In principle, as with the domestic case, effective tax rates can be calculated for any investment with well-defined cash flows and a well-defined tax system. However, in practice the vast array of alternative means of organising cross-border investment flows means that it is very difficult to provide a comprehensive analysis. Analysis of effective tax rates in such a setting has been carried out by Alworth (1988), Keen (1991), OECD (1991) and Devereux and Griffith (2003). It has been extended to consider more complex cross-border financial arrangements by Devereux, Lammersen and Spengel (2000). The principle approach is to consider a parent company in country *i* which has a wholly owned subsidiary in country *j*. The subsidiary can be financed by the parent in the same three ways as the parent. Such an approach permits comparison of the effective tax rates facing multinational firms compared with purely domestic firms.

There are relatively few issues of principle which arise in extending the basic approach set out in Section 3 to cross border investment. Given the more complex structure, there are additional assumptions to be made regarding, for example, the ways in which the affiliate is financed. And of course, the structure of the tax regime is more complex; for example, allowance should be made for the different ways in which foreign source income is taxed by the home country. However, these extensions arise only from making the form of investment more complex. As noted elsewhere, the basic framework described here can be extended almost indefinitely to encompass more complex models. But because there are few general points of principle involved, we do not discuss this extension any further.

4.4 Risk

Most of the literature on measuring taxes on income from capital has ignored risk. This is an important omission, since historically, the return on risky assets has far exceeded that on safe assets, implying that the risk premium is large.

To analyse the impact of taxes in the presence of risk, we draw on Devereux (2002). We begin with a general way of pricing risky assets, using the fundamental asset pricing approach of Cochrane (2001). This defines the current market value of a stochastic cash flow $\tilde{x}$ arising in one period's time as

$$V[\tilde{x}] = E(\tilde{m}\tilde{x}). \qquad (21)$$

Throughout, we indicate a stochastic variable with a tilde. In this expression, $\tilde{m}$ is a stochastic discount factor, which can be generated from a simple two-period model of consumption, in which the investor optimally allocates consumption over periods t and t+1. Given a utility function *u(c)*, where *c* is consumption, and a rate of time preference, β, then

$$\tilde{m} = \beta \frac{u'(\tilde{c}_{t+1})}{u'(c_t)}. \qquad (22)$$

If there were no uncertainty and no inflation, then $\tilde{m}$ would simply reflect the risk-free rate of interest, *r* - that is, $\tilde{m} = 1/(1+r)$. More generally, $E(\tilde{m}) = 1/(1+r)$. Using this, and expanding the expected value of the product of $\tilde{m}$ and $\tilde{x}$, we can also write:

$$\begin{aligned} V[\tilde{x}] &= E(\tilde{m})E(\tilde{x}) + \text{cov}(\tilde{m},\tilde{x}) \\ &= \frac{E(\tilde{x})}{1+r} + \text{cov}(\tilde{m},\tilde{x}). \end{aligned} \qquad (23)$$

The first term on the RHS of this expression is the value of receiving a certain $E(\tilde{x})$ next period. The second term captures the effect of risk. Note that, given strict concavity of the utility function, $\mathrm{cov}(\tilde{m},\tilde{x})$ has the opposite sign to $\mathrm{cov}(\tilde{c}_{t+1},\tilde{x})$. Hence if $\tilde{x}$ is positively correlated with $\tilde{c}_{t+1}$, then $\mathrm{cov}(\tilde{m},\tilde{x})<0$, implying a lower $V[\tilde{x}]$.

Now return to the investment considered in Section 3, and make both the financial return and economic depreciation stochastic. To simplify, assume that there is no inflation and ignore personal taxes. In this case, in the absence of tax, the NPV of the project is

$$\begin{aligned} R^* &= -1+V[1+\tilde{p}] \\ &= -\frac{r}{1+r}+\frac{E(\tilde{p})}{1+r}+\mathrm{cov}(\tilde{m},\tilde{p}) \end{aligned} \tag{24}$$

Note that here the non-stochastic part of the return in period t+1 can be discounted at the risk-free rate, *r*. The cost of capital in the absence of tax is then

$$c^* = r+\lambda \tag{25}$$

where $\lambda=-(1+r)\mathrm{cov}(\tilde{m},\tilde{p})$ is the risk premium (which is positive if $\tilde{p}$ is positively correlated with $\tilde{c}_{t+1}$).

In the presence of tax, the NPV of the project, given in (12), becomes:

$$R=-(1-A)+(1-\tau)V[\tilde{p}^T+\tilde{\delta}]+(1-A)V[1-\tilde{\delta}]. \tag{26}$$

where, for reasons explained below, we use $\tilde{p}^T$ to denote the stochastic financial return in the presence of tax. Assume that the tax system is known and constant. Using the formulation in (23), *R* can be written as:

$$R=-\frac{r(1-A)}{1+r}+\frac{(1-\tau)E(\tilde{p}^T)}{1+r}-\frac{(\tau-A)E(\tilde{\delta})}{1+r}+(1-\tau)\mathrm{cov}(\tilde{p}^T,\tilde{m})+(\tau-A)\mathrm{cov}(\tilde{K},\tilde{m}) \tag{27}$$

where $\tilde{K}=1-\tilde{\delta}$ is the value of the asset in period *t+1*. Now find the cost of capital – ie. the value of $E(\tilde{p})$ for which $R=0$. Solving from (27) yields:

$$R = 0 \Rightarrow E(\widetilde{p}^T) = \frac{(1-A)}{(1-\tau)}\left\{r + E(\widetilde{\delta})\right\} - E(\widetilde{\delta}) + \lambda^T + \frac{(\tau - A)}{(1-\tau)}\mu \qquad (28)$$

where $\lambda^T = -(1+r)\,\mathrm{cov}(\widetilde{p}^T, \widetilde{m})$ and $\mu = -(1+r)\,\mathrm{cov}(\widetilde{K}, \widetilde{m})$. Apart from the last two terms of the RHS, this is equivalent to the definition of the cost of capital in the absence of risk, given in (8). Clearly, the last two terms represent the risk premium in the presence of tax. For $\mathrm{cov}(\widetilde{c}_{t+1}, \widetilde{p}^T) > 0$, the additional risk associated with the financial return increases the required expected return, as in the absence of tax. If $\mathrm{cov}(\widetilde{c}_{t+1}, \widetilde{K}) > 0$, then $\mu > 0$, which implies that the last term, generated by the capital risk, also increases the required expected return.

Leaving this last term aside, consider the relationship between λ and λ^T. This depends on the relationship between $\widetilde{p}$ and $\widetilde{p}^T$ where each of these is defined for a marginal investment. That is, an investment earning $\widetilde{p}$ is marginal in the absence of tax, and an investment earning $\widetilde{p}^T$ is marginal in the presence of tax. In the absence of risk, these are scalars which can easily be compared to each other. However, in the presence of risk, it is necessary to take into account the whole distribution of each of these returns.

To see this, consider the case of a simple linear relationship:

$$\widetilde{p}^T = a + b\widetilde{p}\,. \qquad (29)$$

where *a* and *b* are scalars. For any value of *b* it is possible to find a value of *a* such that $\widetilde{p}$ represents a marginal investment in the absence of tax, and $\widetilde{p}^T$ represents a marginal investment in the presence of tax. Specifically, this holds for any combination of *a* and *b* for which

$$b = \frac{(1-A)}{(1-\tau)} - \frac{a}{r} + \frac{(1+r)}{r}\frac{(\tau - A)}{(1-\tau)}V[\widetilde{\delta}]. \qquad (30)$$

This implies that *b* can take any value. And this is important, since (29) implies that the risk premium in the presence of tax is

$$\lambda^T = b\lambda\,. \qquad (31)$$

To see the implications of this, consider two special cases. To make things clearer, let the depreciation rate be non-stochastic, so that $\mu = 0$; this has no impact on the main results.

(a) $b = 1 \Rightarrow a = \left(\frac{\tau - A}{1-\tau}\right)\left\{r + (1+r)\delta\right\}$

This implies that the cost of capital in the presence of tax is

$$R = 0 \Rightarrow E(\tilde{p}^T) = \frac{(1-A)}{(1-\tau)}\{r+\delta\} - \delta + \lambda \qquad (32)$$

Here the risk premium is identical to the case in the absence of tax. The risk free element of the cost of capital is grossed up by the factor $(1-A)/(1-\tau)$. However, the risk premium is unchanged. Given that the risk premium is the likely to be considerably larger than the risk free rate of interest, this implies that the tax has only a small impact on the overall cost of capital.[12]

(b) $b = \dfrac{1-A}{1-\tau} \Rightarrow a = \left(\dfrac{\tau - A}{1-\tau}\right)(1+r)\delta$

This implies that the cost of capital in the presence of tax is

$$R = 0 \Rightarrow E(\tilde{p}^T) = \frac{(1-A)}{(1-\tau)}\{r+\lambda+\delta\} - \delta \qquad (33)$$

This is a quite different case, since the risk premium is grossed up by the same factor as the risk-free rate, $(1-A)/(1-\tau)$.

In analysing the impact of taxes on the cost of capital in the presence of risk, it is therefore vital to specify the distribution of returns from available investments. Expression (32) says that only the risk-free rate of return need be grossed up as long as the risk of the marginal project in the presence of tax is the same as the risk of the marginal project in the absence of tax. However, this is a special case. Expression (33) presents another special case, in which both the risk-free rate of return and the risk premium must be grossed up by the same factor.

There is no obvious way to choose between these approaches, or indeed, between these and any other assumption made about the value of *b*. Given that the impact of tax as measured by the effect on the cost of capital depends on an arbitrary assumption about the distribution of returns for investments which are marginal in the presence and absence of tax, then arguably it would be better to use another approach altogether.

One possibility, for example, would be to consider an investment which is marginal in the presence of tax, and simply compute its NPV in the absence of tax. The greater the NPV in the presence of tax (as long as it is positive), the greater the distorting impact of the tax.[13] Note that this is the approach followed in the derivation of the effective average tax rate in Section 3. In that case, the firm is choosing between two given investment projects; there is no need in this case to consider hypothetical alternative marginal projects.

4.5 A model firm approach

One criticism of the approach set out in Section 3, and discussed at length in this section is that it typically makes very simple assumptions regarding the nature of the firm's activities. For example, it typically deals with only the most rudimentary elements of the tax regime. And it does not model other costs involved in making an incremental investment.

Of course, this is a criticism of practice, rather than theory. In principle, there is no reason why any well specified investment project could not be modeled, with the ensuing tax liabilities – calculated at any chosen level of sophistication – used to generate estimates of effective tax rates. There is a tradeoff, however; the more specialised the investment project, and the more specialised the nature of the tax regime, then the less general will be the ensuing effective tax rates.

An example of an approach which takes the literature in this direction is the European Tax Analyser model (Jacobs and Spengel, 1996, 2002), which extends the model firm approach of OECD (1985). The basic idea is to generate a much more detailed model of a hypothetical firm, which incorporates a large number of accounting items from the balance sheet and profit and loss account. As an example, the asset in the model include intangible assets, three types of tangible fixed assets, three types of financial assets, inventories, and trade debtors. As well as the elements of the tax mentioned above, this model incorporates the rules for valuing inventories, the taxation of corporate capital gains, employee pension schemes, provisions for bad debts and loss relief.

Within this framework, one approach would be to explicitly model an incremental investment of the form described in Section 3, but in rather more detail. The basic approach in Section 3 could be used to generate the same measures of effective marginal and average tax rates.

This is quite similar to the approach actually taken by the authors. However, they make assumptions about the whole range of activities of the hypothetical firm over a ten year life span. In effect, they compute the NPV of net income generated in the presence and absence of tax.[14] They use the difference between these two values to generate a measure akin to the effective average tax rate described in Section 3. The main difference in principle between the two approaches is that the ensuing effective tax rate is the relevant effective tax rate only if the whole 10 year life of the firm is seen as a specific investment decision; that is, one of a number of mutually discrete opportunities available to the firm at the outset. For example, if the firm had a specific ten year investment, which could be undertaken in one of two countries, then the effective tax rate computed would be the relevant measure in the decision of in which country to locate.

While this approach in principle takes into account much more detailed analysis of the firm, it also necessarily needs to make some very specific assumptions. One for example, is the role of the cost of labour, and specifically the incidence of wage taxes and relief for pension contributions. Holding the gross wage cost to be constant across countries implies strong assumptions about effective incidence.

5 Other Approaches

While the previous two sections have set out many of the issues arising in attempting to construct measures of effective tax rates based on the basic theoretical model, much of the empirical literature has taken a completely different approach. This approach is not to identify cash flows associated with any specific type of investment, but rather to look at the ratio of tax payments to some measure of capital income in a single period.

Such an approach can take many forms. Empirical work using individual firms, for example, has used accounting ratios as a measure of an effective tax rate. For example, Kemsley (1998), Altshuler et al (2001) and Grubert and Mutti (2000), all follow this type of approach in considering cross border investment. At a more aggregated level, a similar approach has been used with industry or national level data. For example, Grubert & Mutti (1991), Hines and Rice (1994) and Swenson (1994) all use US data on the aggregate activities of affiliates of multinational companies. Using such data permits the derivation of a measure of an effective tax rate for, say, the affiliates of US firms operating in another country.

At a more aggregated level still, measures have been derived using aggregate tax revenue in a given year as a ratio of some measure of capital income. Probably the most well-known paper advocating such an approach is Mendoza et al (1994). This splits all tax revenues in a country into three categories: taxes on consumption, labour and capital. The last of these is divided by the operating surplus of the economy to generate a form of effective tax rate on capital.

Such measures certainly have some advantages over the measures discussed in previous sections. Given data on tax payments and some measure of capital income, they are relatively easy to compute. And such data is fairly readily available for a large number of countries and time periods; by contrast, it is rather harder to collect reliable data on provisions of the tax regimes in some countries.

Further, data specifically on tax payments (or liabilities) automatically weight different activities according to their contribution to taxable income – for example, investment in different types of asset and using different forms of finance. They also reflect a wide range of provisions of tax regimes which cannot easily be taken into account in basing measures on the tax rules themselves. These include a large number of special features of tax regimes, as well as features of the international tax system. There is a problem with international activity, however. That is, company accounts may record the worldwide profits and tax liabilities of the firm; these may not reflect the tax regime of any one country.[15]

However, an important question in using such measures is what they are actually measuring. To begin to answer this, consider this form of tax rate applied to the simple model of the firm analysed in Section 3 of this paper. Expression (3) implies that the taxes paid by the firm in period t are

$$T_t = \tau\left\{F(K_{t-1}) - iB_{t-1} - \phi_t K_{t-1}^T)\right\}. \tag{34}$$

A typical measure of accounting profit would be

$$\Pi_t = F(K_{t-1}) - iB_{t-1} - \delta K_{t-1}, \tag{35}$$

where δ is here assumed to be the accounting rate of depreciation, as well as the true economic rate of depreciation. It is also assumed here for simplicity that assets cannot be depreciated for tax purposes in the year in which they are purchased.

A typical accounting measure of an average tax rate is $Z_t = T_t / \Pi_t$. It is clear from (34) and (35) that in the special case in which the allowance rate in the tax system is equal to that in the accounts (and always has been, so that $K_{t-1} = K_{t-1}^T$), then this rate is equal to the statutory rate: $Z_t = \tau$. In a sense this is obvious; tax revenue is defined by multiplying taxable profit by the statutory rate; dividing tax revenue by taxable profit (as in this case) yields the statutory rate.

But this begs two important questions. The first concerns the measure of income which is used to scale the tax liability. The second concerns the relationship with either of the measures generated from the theory and described above. We discuss each of these in turn.

5.1 An alternative measure of income

First, suppose $Z_t \neq \tau$: what does this tell us? In the simple model outlined here, and with a stable tax system, this implies that $\phi \neq \delta$ and hence $K_{t-1} \neq K_{t-1}^T$. In countries where the capital allowance rate is fixed by legislation, this is quite likely to be the case.

But the interpretation of this is important. Using Z_t as an effective tax rate implicitly assumes that Π_t is, in some sense, a "true" measure of profit. If $Z_t \neq \tau$, then the implication is that the tax base is deliberately too large or too small. And this clearly may be the case. But another interpretation is possible. Suppose that the government designs its tax system to identify the right level of profit as precisely as possible. And it defines capital allowance rates in legislation precisely because accounting profits can be manipulated: a firm may use low depreciation rates in order to boost profits. In this case, it might be thought that the measure of taxable profit might be more reliable. If $Z_t \neq \tau$, then perhaps accounting profits are incorrectly measured.

In the context of effective tax rates based on company accounts, this argument may not seem completely convincing. After all, each firm is different, and has a different mix of assets. Given proper accounting standards, it is hard for firms to consistently manipulate their profits. A tax regime which does not allow a great deal of flexibility in determining profits may seem more likely to incorrectly assess profit. However, the argument may be more convincing for other data sources. For example, national accounts typically use arbitrary measures of depreciation. Here it seems likely that the tax regime might be able to define the level of profit in the economy rather better than official statisticians.

But the general point is clear: unless we are confident of the base of the effective tax rate measure, then it is hard to interpret the case in which $Z_t \neq \tau$. To some extent, similar problems arise in computing the effective tax rates defined in Sections 3 and 4. They too depend on assumptions about the true economic depreciation rate. Further, in that case, no depreciation rate is observed; the researcher must choose a value. However, those measures at least provide a more reliable basis for comparison across countries and time. That is, the hypothetical investment studied above can be held constant across different tax regimes, in order to compute effective tax rates. If the tax rate is based on an observed valuation of profit, then there may be differences in measurement practices, say between countries (because of differences in accounting standards, for example), which may lead to a misleading comparison of effective tax rates.

5.2 Comparison with effective rates implied by theory

The second important question is, supposing that we trust the base of the effective tax rate measure, do we learn anything about investment incentives? There are two parts to this question, corresponding to analysis based on the cost of capital and marginal investment projects, and analysis of discrete choices.

5.2.1 An observable effective average tax rate?

We begin with a comparison with the effective average tax rate of Section 3, on the grounds that the tax rates described here certainly seem more akin to an average, rather than a marginal rate. Taking the definition of α in (14), and ignoring personal taxes, the effective average tax rate can be written as:[16]

$$\alpha = \tau + \frac{\tau(\delta - \phi)}{p}\frac{r}{(r+\phi)}. \tag{36}$$

To make a direct comparison with *Z* as defined above, we ignore debt, normalise the end of period *t-1* capital stock to unity, and write $F(K_{t-1}) = p + \delta$. In this case:

$$Z_t = \tau + \frac{\tau(\delta - \phi)}{p} K_{t-1}^T. \tag{37}$$

There is one special case in which these two measures are immediately identical: $\phi = \delta$, which implies that $\alpha = Z_t = \tau$. However, this simply returns us to the case in which taxable profit is equal to accounting profit; this case is so special, in fact, that the effective marginal tax rate is also equal to τ.

In general, however, these definitions are quite different from each other, even given the strong assumptions required to make them this comparable. In particular, K_{t-1}^{T} depends on the past history of investment. For example, if the firm's investment has grown at rate *g* in every period, then (continuing to set $K_{t-1} = 1$)

$$K_{t-1}^{T} = \frac{g+\delta}{g+\phi}. \qquad (38)$$

In general, then, even in the simplest conditions, without debt or personal taxes, these two concepts of the average tax rate are quite different from each other. In fact, δ would need to be rather smaller than *r* for there to be a positive value of *g* which made these two measures equal to each other.

Of course, this should not be surprising. The effective average tax rate defined in Section 3 is a forward-looking concept, applying to a well-specified investment project. The average tax rate defined as the ratio of current tax liabilities as a proportion of current profit depends on the history of investment, as well as the history of the tax system.

5.2.2 An observable effective marginal tax rate?

In general, it should be clear that Z_t does not correspond to an effective marginal tax rate. For one thing, it can be applied to any project, not only one which is marginal. However, the paper by Gordon et al in chapter 4 of this volume proposes a new method of generating a measure of an effective marginal tax rate, based on the use of observable tax revenues. Specifically, the idea is to compare revenue generated under the actual tax regime with what would have been generated under a regime which taxed only economic rent.[17]

To understand this approach, it is useful to return to the simple investment analysed in section 3. Ignoring personal taxes and inflation, for simplicity, then the value in period *t+1* of all taxes associated with the investment is[18]

$$T = \tau(p+\delta) - A(r+\delta). \qquad (39)$$

By contrast, a tax based solely on economic rent would generate tax payments with a period *t+1* value of

$$E = \tau(p-r). \qquad (40)$$

This would be true of any tax based on economic rent generated over the life of the project. The difference between these two is

$$T - E = (\tau - A)(r + \delta) . \quad (41)$$

Returning to the expression for the cost of capital in (8), in the absence of inflation and personal taxes, then it is straightforward to show that

$$\hat{p} - r = \frac{(\tau - A)(r + \delta)}{1 - \tau} = \frac{T - E}{1 - \tau} . \quad (42)$$

It is therefore straightforward to construct an effective marginal tax rate as

$$\varepsilon = \frac{\hat{p} - r}{\hat{p}} = \frac{T - E}{T - E + (1 - \tau)r} . \quad (43)$$

The proposal by Gordon et al (2002) is to construct this measure of the effective marginal tax rate as follows: (i) observe actual tax revenues, T, in some period (ii) construct an estimate of E for the same period; (iii) adjust using τ and r as in (43). Their proposed is more detailed than described here though; it allows for personal taxes and taxes on unincorporated businesses.

Such a measure has the advantages of using observable data discussed above. However, it also has the disadvantages of using data in any given period – even if an average is taken over several years. To see this, it is only necessary to observe that the derivation above used all the tax payments generated by the investment discounted to their period *t+1* value. But in using this measure, the timing of tax payments matters. To see this, compare the tax profiles of two tax systems, both levied on economic rent. A cash flow tax generates tax payments of

period t: $T_t^{CF} = -\tau$

period $t+1$: $T_{t+1}^{CF} = \tau(1 + p)$

A tax based on economic rent as it accrues would generate tax payments of

period t: $T_t^{AR} = 0$

period $t+1$: $T_{t+1}^{AR} = \tau(p - r)$

Although these generate the same net present value of tax payments, they have a very different profile. Suppose for example, that the actual tax was a cash flow tax, but that the tax on accrued economic rent was used as the benchmark tax. Then – in the absence of any other activity within the firm - the Gordon et al (2002) measure would generate an effective tax rate of $\tau/(1-\tau)r$ in period t and $-\tau(1+r)/(1-\tau)r$ in period $t+1$. With discounting, these sum to zero, as would be expected. However, this suggests that in practice careful use would need to be made of the measure, in particular in the way in which the effective tax rate varied over time.

6 Conclusions and reflections on the use of alternative measures

This paper has reviewed alternative approaches to measuring the taxation of income from capital. It has focused on measures designed to capture the effects of taxation on economic decisions which determine the size and composition of the capital stock. It has not discussed issues of effective incidence, except to the extent of making assumptions as to which specific taxes to study.

The main focus of the paper has been to discuss measures derived from economic theory. In empirical work, these tend to be based on the legal parameters of tax regimes, rather than on observed tax revenues or tax liabilities (although the GKS measure is arguably an exception). The basic model described yields two measures, reflecting two alternative forms of investment decision. An effective marginal tax rate is relevant for decisions concerning the scale of the capital stock. An effective average tax rate is relevant for discrete investment choices.

As with any economic model, a central question is whether measures derived from the model accurately reflect the complexities of the real world. Section 4 is devoted to examining extensions of the basic model set up in Section 3, which aims to investigate some of the more complex characteristics both of investments and of tax regimes. Particular attention is paid to the role of personal taxes, the source of finance of the investment, the extent to which taxes on foreign direct investment are modeled, the risk of the investment, and the extent to which more complex models of firm behaviour are incorporated.

However, a review of the basic modeling approaches cannot ultimately decide how useful such measures are. Rather such a question can only be answered empirically. Since we do not know the "true" values of these measures, then it is difficult to assess the measures simply by examining the estimated series themselves. Some progress might be made through empirical evidence that actual investment behaviour responds to changes in particular measures.

The last section of the paper examines the popular approach of deriving empirical measures of effective tax rates based on observed tax revenues or tax liabilities. Typically these measures are not based on a theoretical model of investment. Researchers have used such measures at least partly since they are relatively easily available. But easy availability is not a very good criterion for selecting a measure – especially a measure not derived from a theoretical model. The usefulness of such measures therefore depends on whether they can end up being at least as correlated with the underlying "true" measure as the more sophisticated measures based on economic theory.

It is certainly possible that in some instances this may be the case. For example, in examining tax rates on cross border investment, measures based on the parameters of the legal tax regime may not capture the possibilities available for shifting profit between jurisdictions. In such a case, it is possible that measures based on observed tax revenues could be closer to "true" values.

But in general, such ad hoc measures should be treated with considerable caution. A typical "average" tax rate is likely to be a poor approximation of an effective marginal tax rate, simply because it is does not capture investment incentives at the margin. It is even likely to be a poor approximation to an effective average tax rate since it is based on historic data, rather than matching the forward-looking nature of an investment project. The performance of such measures in empirical models of investment is also more difficult to assess. This is because the measures themselves depend on the scale and nature of investment and are hence endogenous. Dealing with such endogeneity can prove to be very difficult.

In fact, it is not even clear that such measures dominate using the statutory tax rate, at least as an approximation to an effective average tax rate. The measure of the effective tax rates derived in Section 3 varies according to the rate of profit earned on the investment project, but – in the absence of personal taxes – it converges to the statutory corporation tax rate as the rate of profit rises. We might therefore expect the effective average tax rate to be positively correlated with the statutory tax rate. This may not always be true of ad hoc measures.

One important empirical issue is whether the measures described in this paper yield very different measures of taxation. Suppose that the differences examined here turn out to be small empirically: then we might generate the reassuring conclusion that any of these measures is likely to be a good approximation of "true" tax rates. If this were true, we could simply use the most convenient measure. This question is addressed in this volume by Devereux and Klemm (2003). Unfortunately for empirical researchers, there is little evidence in favour of this reassuring conclusion. It *does* matter how measures of tax rates are constructed. Choosing between them is then ultimately a matter of judgment, taking into account the correspondence with theory, and the correspondence with the real world.

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APPENDIX: DEFINITIONS OF VARIABLES

V_t	market value of the equity of the firm at the end of period t
D_t	cash dividends paid by the firm at the end of period t
N_t	new equity issued by the firm at the end of period t
K_t	capital stock at the end of period t
I_t	investment in period t
$F(K_{t-1})$	net output generated at the end of period t
B_t	one period debt issued at the end of period t
r	real rate of interest
i	nominal rate of interest
π	inflation rate in price of output
π^K	inflation rate in price of capital
q_t	relative price of capital goods at the end of period t
δ	economic depreciation rate
τ	statutory corporation tax rate
ϕ	capital allowance rate
K_t^T	value of the capital stock for tax purposes at the end of period t
A	present value of allowances per unit of investment
ρ	nominal, tax adjusted, discount rate
γ	tax discrimination variable
m	personal tax rate on interest income
m^D	personal tax rate on dividend income
c	tax credit on dividend income
z	personal effective capital gains tax rate
p	pre-tax rate of return on investment
$\hat{p}$	cost of capital
e	effective marginal tax rate
R^*	net present value of investment project in the absence of tax
R	net present value of investment project in the presence of tax
α	effective average tax rate
$\hat{\alpha}$	alternative measure of effective average tax rate
t	statutory corporation tax rate, adjusted for personal taxes
H	one period average tax rate
F	net present value of financial flows
$\widetilde{m}$	stochastic discount factor
$\widetilde{x}$	stochastic cash flow
c_t	consumption in period t

$u(c_t)$	utility in period t
β	rate of time preference
c^*	cost of capital in the absence of tax, but in the presence of risk
$\tilde{p}^T$	stochastic financial return in the presence of tax
λ	risk premium in the absence of tax
λ^T	risk premium in the presence of tax
μ	premium for capital risk
Π_t	accounting profit in period t
Z_t	average tax rate based on accounting data
T	tax payments associated with investment project
E	tax payments on investment project generated by a tax on economic rent
ε	Gordon et al (2003) measure of effective marginal tax rate

ENDNOTES

[1] Some attempts have been made to incorporate other taxes into the type of measures discussed in this paper. See, for example, McKenzie, Mintz and Scharf (1997).

[2] Note that the formulation in (5) applies only to a specific form of depreciation allowances. Other forms are also used; in addition, there may be investment tax credits. However, all of these can be incorporated into a more general formulation of A, and do not change the general formulation in (6).

[3] Note that this is not the only possible formulation of the impact of taxes on the marginal investment decision. An alternative approach – and equivalent in theory - is to work with marginal q. See, for example, Poterba and Summers (1983).

[4] See Mintz (1990) for an analysis of tax holidays.

[5] This is explored by, for example, Devereux (1987) and Robson (1990). Cross sectional variation in the cost of capital resulting from such asymmetries is exploited in models of investment in Devereux (1989) and Devereux et al (1992).

[6] A number of models of multinational firm behaviour are based on this type of approach. See, for example, Horstman and Markusen (1992) and Motta (1992).

[7] The company may decide at some preliminary stage to build, for example, a factory. However, the precise size of the factory may depend on the tax regime in the country in which it is built.

[8] More details can be found in Devereux and Griffith (2002). Note that in the absence of personal taxes, $T = \tau$.

[9] Of course, it is also possible to consider investment in non-corporate form. This is not pursued in this paper.

[10] The literature is too vast to give even a representative flavour. However, some useful references are Harris and Raviv (1991), Hart (1995) and Hubbard (1998).

[11] They consider an investment which lasts forever, although with an exponentially declining product.

[12] This is the result found by Gordon (1985) and Bulow and Summers (1984); implicitly, then, they assume that the underlying risk of the two marginal projects is the same.

[13] The opposite of this would be to consider an investment which is marginal in the absence, and compute its NPV in the presence of tax.

[14] Actually, the end-of-year-10 value is computed, but this is effectively the same.

[15] Further discussion of this point is contained in Devereux and Klemm (2003).

[16] This uses $A = \tau\phi/(r+\phi)$, which represents the case in which there is no inflation, and in which no depreciation allowance is permitted in the year in which the investment is incurred. This is assumed here in order to make a simpler comparison between the two forms of tax rate.

[17] Gordon and Slemrod (1983) and Gordon et al (2001) use this approach to analyse the extent to which the USA collects more revenue that it would under such a tax.

[18] This includes any allowances claimed in any other period, converted into a period *t+1* value.

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