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Effective Tax Rates and the User Cost of Capital when Interest Rates are Low

John Creedy*and Norman Gemmell†

Abstract

Interest rates are a key component of both user cost and effective tax rate measures of company taxation, and each is regularly used in empirical tests of tax impacts on investment. However, it is shown that when interest rates are low the two measures are not monotonically related. Using a simulated sample of observations, this feature is found to generate perverse estimates of the effects of taxation on the investment plans of firms.

JEL: H25, H32.

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1 Introduction

Following the seminal papers of Hall and Jorgensen (1967), Auerbach (1979, 1983) and King and Fullerton (1984), the concept of the *user cost of capital* has become a standard approach to assessing how the cost of financing a firm's investment, and its tax treatment, affect the firm's investment decision. The user cost concept refers to the capital rental, the before-tax rate of return, at the firm's profit-maximising position. The user cost is thus such that the after-tax cost of capital is equal to the after-tax rate of return, so that it is intimately related to the effective marginal tax rate (defined as the proportional difference between before- and after-tax rates of return). It may therefore be expected that both the user cost and the effective marginal tax rate increase as real and nominal interest rates increase. When modelling investment behaviour, some studies have used the effective marginal tax rate as an independent variable, while others have used user cost measures and, given this anticipated relationship between the two concepts, the choice would appear at first sight to be innocuous.

However, this paper shows that when real interest rates are low the user cost of capital and its analogue the effective marginal tax rate are not even approximately monotonically related (section 2). As a result, in a low-interest environment, empirical tests of the relationship between taxation and investment are capable of generating very different outcomes depending on which measure is used (section 3). In the current environment where interest rates are very low, and are likely to remain low for some time, this complexity is potentially important.

2 The User Cost and Effective Tax Rates

2.1 User Cost

Hall and Jorgensen (1967) established that, in the case of a profit-maximising firm, the value of an additional dollar of investment, the capital rental, is equal in equilibrium to its cost, measured by the rate of interest. This rental associated with the profit-maximising position is referred to as the *user cost* of capital. In the simplest case, where there is no taxation and no inflation or capital gains, the gross-of-depreciation user cost, c_g , is given by:

$$c_g = r + \delta \tag{1}$$

where δ is the geometric rate of economic depreciation per period, and r is the real rate of interest available in the market. A net-of-depreciation equivalent, the *net user cost*, c_n , is simply $c_n = c_g - \delta$. Hence, in this special case, $c_n = r$.

Taxation complicates the user cost calculation in a number of ways. In addition to the statutory tax rate (here assumed to be constant) applied to investment income, the existence of fiscal depreciation allowances and tax credits – valued at ξ per dollar of investment – implies that the cost of a dollar of capital is effectively reduced to $1 - \xi$. Suppose the statutory marginal corporate tax rate applied to taxable income is τ . The relevant interest rate is therefore the after-tax real rate, given by $r^* = r(1 - \tau)$. The equilibrium condition defining the user cost now requires that the after-tax cost of capital, $r^*(1 - \xi)$, associated with the effective investment of $1 - \xi$ is equal to the after-tax rate of return. The latter is the after-tax rental, $c_g(1 - \tau)$, arising from the real before-tax gross user cost, c_g , minus depreciation of $\delta(1 - \xi)$. From this condition the gross user cost is obtained as:

$$c_g = \frac{(r^* + \delta)(1 - \xi)}{1 - \tau} \quad (2)$$

This result, using different terminology, corresponds to the original statement by Hall and Jorgenson (1967, p. 393).

Two typical components of the ξ term are a *fiscal* depreciation allowance at the geometric rate, δ' , and ‘special allowances’ or ‘loadings’, k . Here, k is the proportion of the investment eligible for these allowances. It is sometimes specified as a tax credit, τk . It can be shown that total fiscal depreciation can be expressed in present value terms as $\xi = \tau(k + Z)$, where $Z = \delta' / (i + \delta')$, and i is the nominal interest rate.¹ Substituting into (2) then gives a user cost expression for c_g in terms of the real after-tax rate of interest and fiscal parameters:

$$c_g = (r^* + \delta) \{1 - \tau(k + Z)\} \frac{1}{1 - \tau} \quad (3)$$

Using the relationship between the real rate, r^* , the nominal after-tax rate of interest, i^* , and the inflation rate, π , given by:

$$r^* = \frac{i^* - \pi}{1 + \pi} \quad (4)$$

equation (3) can be rewritten as:

$$c_g = \left(\frac{i^* - \pi}{1 + \pi} + \delta \right) \{1 - \tau(k + Z)\} \frac{1}{1 - \tau} \quad (5)$$

with, as before, $c_n = c_g - \delta$.

2.2 The Effective Marginal Tax Rate

The effective marginal tax rate is generally defined as the proportional difference between relevant before- and after-tax rates of return. Defining \tilde{p} as the required equilibrium pre-tax

¹See Creedy and Gemmill (2016) for a derivation and survey of results.

real rate of return that is necessary to produce a post-tax real rate of return of r^* , the tax-inclusive effective rate, $EMTR$ is expressed as:

$$EMTR = \frac{\tilde{p} - r^*}{\tilde{p}} \quad (6)$$

Since c_n is the before-tax rental which ensures that the after-tax-and-depreciation return from the marginal investment is equal to the after-tax real rate of return, r^* , the user cost, c_n , is equivalent to \tilde{p} . This allows (6) to be rewritten as:

$$EMTR = 1 - \frac{r^*}{c_n} \quad (7)$$

and using (4), this relationship between the effective tax rate and the user cost becomes:

$$EMTR = 1 - \frac{i^* - \pi}{(1 + \pi)c_n} \quad (8)$$

Inspection of (8) shows that in considering variations in $EMTR$ with c_n there is a singularity where $c_n = 0$. Importantly, the net user cost, c_n , is not restricted to take only positive values. From (5), if depreciation allowances and tax credits are generous relative to economic depreciation, and statutory corporate rates are high, this can lead to net subsidies to some forms of investment, resulting in $c_n < 0$.

Similarly, given that c_n varies systematically with the nominal interest rate, i^* , as shown by (5), there is a singularity in the relationship between the $EMTR$ and the nominal interest rate. Depending on whether i^* is greater than or less than π , there are both positive and negative asymptotes. Hence the effective marginal tax rate and the net user cost can move in opposite directions as the nominal interest rate increases.

2.3 Variation in EMTRs with Interest and Inflation Rates

Examples of the large variation in the $EMTR$ with the nominal before-tax interest rate, i , where $i^* = i(1 - \tau)$, are shown in Figure 1 for two values of the inflation rate, $\pi = 0.02$ and $\pi = 0.04$. The $EMTR$ profiles are obtained for $\tau = 0.3$, $k = 0.2$ and $\delta = \delta' = 0.15$. For low values of i , and the low inflation rate, the $EMTR$ is increasing and above the statutory rate, as it moves towards the asymptote at the singularity. At higher nominal interest rates the $EMTR$ is increasing from its asymptote but below the statutory tax rate.

This relationship is highly sensitive to the inflation rate, as can be seen by a comparison with the profile for $\pi = 0.04$, where the nature of the variation is reversed: the $EMTR$ is decreasing from its asymptote but above the statutory tax rate.² These highly nonlinear

²For examples of profiles with similar characteristics, see King and Fullerton (1984, p. 288).

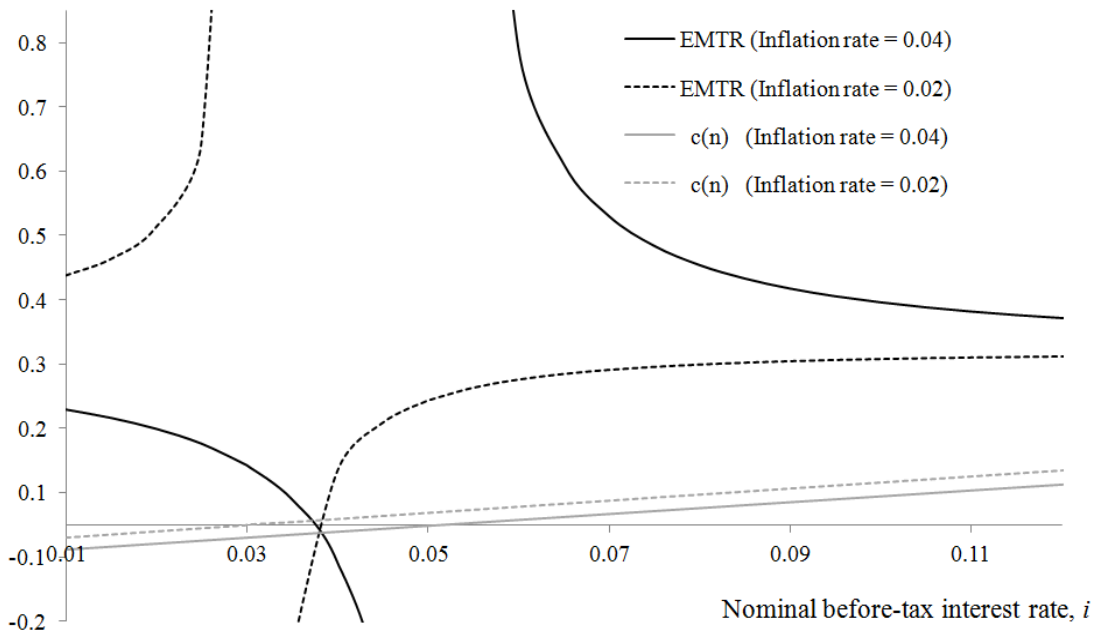


Figure 1: Net User Cost, EMTR and the Nominal Interest Rate

relationships between the $EMTR$ and i do not simply occur in association with negative real interest rates. For example, the singularity for the $EMTR$ ($\pi = 0.02$) profile occurs around a nominal before-tax interest rate of, $i = 0.03$.

Figure 1 also confirms the linear upward sloping relationship of c_n with respect to i , which, like the $EMTR$ profiles, become approximately linear as nominal interest rates rise towards 10 per cent or higher. However, at some inflation rates the slopes of the $EMTR$ and c_n profiles can take opposite signs. As a result, in empirical contexts where interest rates vary (for example, at the firm level where borrowing costs vary across firms), testing for tax effects on investment using one of these two alternative measures could yield differently signed effects despite being based on an identical tax system; this is explored further in Section 3.

The non-monotonic relationships observed between c_n and $EMTR$ in Figure 1 are also observed when depreciation rates, δ , rather than interest rates, are allowed to vary. This also seems likely to be observed in cross-sectional data where firms in different industries and with different asset structures experience quite different overall depreciation rates. These affect c_n and $EMTR$ in quite different ways.

2.4 An Effective Average Tax Rate

Devereux and Griffith (2003) argued that for models of investment *location* decisions an effective *average* tax rate, $EATR$, is the relevant tax rate. Of course, for a marginal investment, $EATR = EMTR$, but the investment location literature has generally argued that, at least for large multinational investments, location choices represent a search for maximum economic rent, p , that can be obtained from a given location. This, in turn, requires some redefinition of the $EATR$ to reflect the taxation of both the intramarginal and the economic rent components of the overall return on the investment. Following Creedy and Gemmell (2016), this can be expressed as:

$$EATR = \frac{(c_n - r^*) + \tau(p - c_n)}{p} \quad (9)$$

$$= \frac{c_n}{p} - \frac{i^* - \pi}{(1 + \pi)p} + \frac{\tau(p - c_n)}{p} \quad (10)$$

Equation (9) shows that the tax payable on this investment is composed of the tax on the intramarginal component, $(c_n - r^*)$, that is the difference between the pre-tax and post-tax marginal returns, plus the tax on the rent component, $\tau(p - c_n)$. This is expressed as a fraction of the total return on this non-marginal investment, p . Further, from (10), if there are no rents available, such that $p = c_n$, comparison with (8) shows that effective average and marginal rates are equal.

Consider the relationship between $EATR$ and c_n . For a marginal investment this is clearly identical to the type of profile depicted in Figure 1. For a non-marginal investment earning rents, such that $p > c_n$, (10) can be seen to take a similar form to (8). Again, this implies that a singularity is expected in the relationship between $EATR$ and i , being positive or negative depending on whether i^* is greater than or less than π .

3 Investment and the User Cost

This section demonstrates how attempts to estimate an investment function which allows for the effects of taxation can be substantially influenced by the choice between the $EMTR$ and the user cost in situations where the nominal interest rate is low.

3.1 The Investment Function

The importance of non-monotonic and non-linear relationships between c_n , $EMTR$ and $EATR$ arises from their use in empirical analyses as alternative measures to capture the impact of taxation on corporate investment. Econometric studies have used either a marginal or an average tax rate (for example, Kemsley, 1998; Barrios *et al.*, 2012; Krzepkowski,

2013) or user cost (Eggarr *et al.*, 2009; Bond and Xing, 2015) as their measure of tax effects on investment, or investment location, in an econometric specification.³ However, the analysis above suggests that while this choice may be innocuous when interest rates are at moderate to high levels, it is not innocuous when interest rates are relatively low.

To see this, consider a model of investment in which investors respond to the user cost of capital in a simple linear fashion, with:⁴

$$I_j = \alpha + \beta c_j + X_j + \varepsilon_j \quad (11)$$

where I_j is an investment measure for firm j , c_j is a firm-specific net user cost measure, X_j is a vector of controls, and ε_j is a random error term independently distributed as $N(0, \sigma_\varepsilon^2)$. Various specifications adopted in the existing empirical literature, such as Eggarr *et al.* (2009) and Bond and Xing (2015), have taken similar quasi-linear forms.

With borrowing costs expected to vary across firms reflecting, for example, differences in credit worthiness and profitability, this generates variations in c_j across firms. Of course, this specification assumes that firms respond to a user cost measure of taxation, rather than an effective tax rate.⁵ This raises the question: given the non-monotonic relationships described earlier, what happens to estimates of the impact of taxation on investment if $EMTR_j$ or $EATR_j$ is substituted in (11) for the user cost, c_j ?

To explore this question, hypothetical data are constructed for a range of values for the user cost, c_j . The resulting values of I_j are then generated using equation (11), with assumed values for α , β , and σ_ε . This allows the relationship in (11), with known econometric properties, to be compared with an equivalent regression in which the c_j are replaced by corresponding values of $EMTR_j$.

3.2 Comparisons using a Simulated Sample

To examine the impact of differences in interest rates on I_j , via their effects on c_j , values of i were simulated over the range 0.001 (that is, 0.1 per cent) to 0.081 in equal increments of 0.002, giving 41 observations. Equivalent observations for c_j were generated using (5) with parameters set as follows: $\pi = 0.02$, $\tau = 0.3$, $k = 0.2$, and $\delta = \delta' = 0.10$ (yielding

³See Devereux (2007) for a review of evidence on EMTR/EATR effects on investment location, up to around 2005. Devereux and Liu (2014) also include an average tax rate measure as a right-hand-side variable in their econometric model of incorporation.

⁴Bond and Xing (2015) decompose the user cost term into its tax and non-tax components, entering each separately into an investment regression.

⁵As Bond and Xing (2015) show, this type of specification (but in log-linear form), drops out of a standard Hall-Jorgenson model of optimal investment by a profit-maximizing firm with a Cobb-Douglas production function. This also allows the tax component of the user cost to be formally separated out from the non-tax component.

$Z = 0.833$). Since a value of $i = 0.019$ is very close to the singularity in this case (yielding extreme values of $EMTR_j$), this was replaced with two values $i = 0.018$ and $i = 0.020$, giving a total sample of 42 observations for the investment regressions. Values for I_j were then obtained using (11) and setting $\alpha = 1$, $\beta = -0.5$ and σ_ε^2 set equal to 5 per cent of the variance, σ_c^2 , of the 42 generated values of the net user cost.⁶

Figure 2 illustrates the data, plotting I_j against c_j . Here the investment variable, I_j , is expressed in index form, such that $I_j = 100$ at the maximum nominal interest rate of $i = 0.081$. This turns out to be the lowest value of I_j although, depending on values of ε_j , it is not of course necessarily the lowest. As shown in Table 1, regression (1) displays the expected pattern of a strong negatively-sloped linear relationship between I_j and c_j . The parameter estimates are $\hat{\alpha} = 0.999$ and $\hat{\beta} = -0.478$ and, with a modestly sized random error component, the value of $R^2 = 0.90$.

Equivalent values for $EMTR_j$ are constructed from the c_j in Figure 2 using equation (8). When these are used instead on the right-hand-side of (11), the outcome is quite different, as seen in Figure 3 and Table 1.

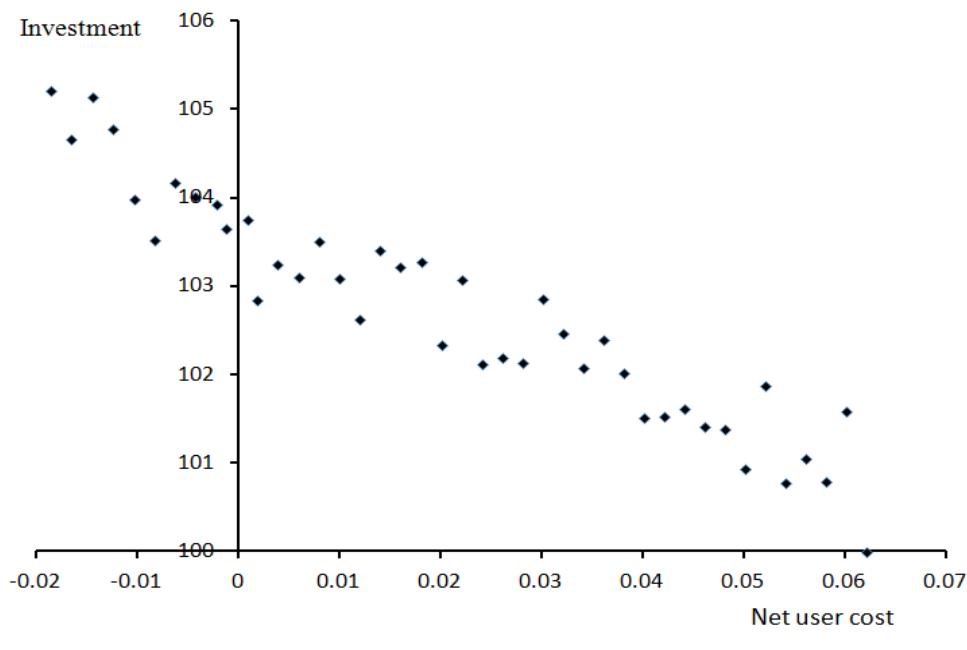


Figure 2: Investment and Net User Cost

Over the range of I_j from 100 to around 102, the relationship with $EMTR_j$ in Figure

⁶Bond and Xing (2015) obtain elasticities of investment with respect to the (log of) the tax component of the user cost of between -0.3 and -0.7 . They can use logs in their case because the tax component is always positive in their dataset.

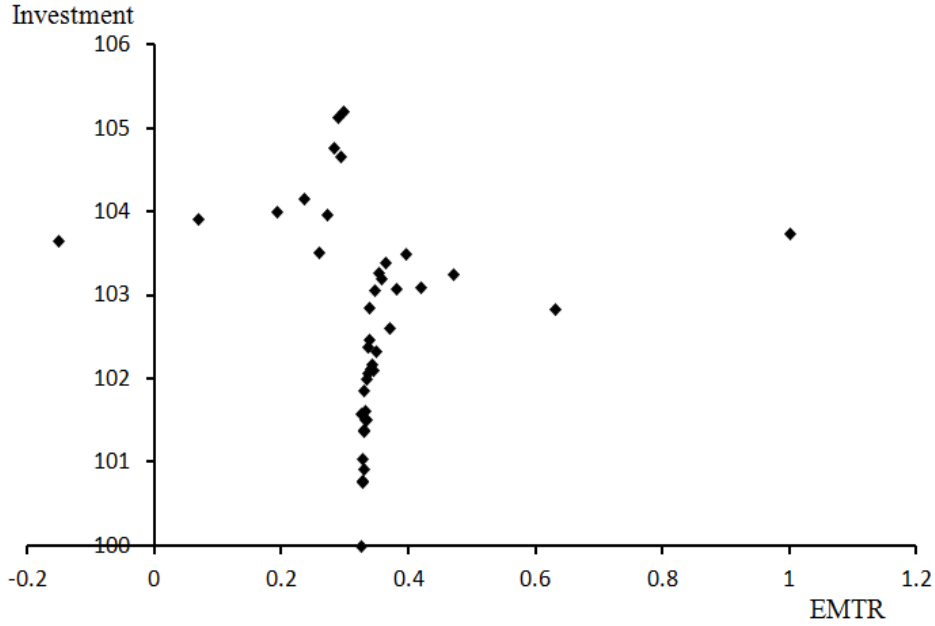


Figure 3: Investment and EMTR

3 appears to suggest a much closer fit. However this simply reflects the scales in the two figures. Table 1, regressions (3) and (4), confirm similar statistical fits. The relationship appears approximately vertical, and beyond $I_j \approx 102$ it becomes subject to large errors, mainly due to the singularity and strong nonlinear properties inherent in the relationship where interest rates are low. Table 1, regression (2) confirms an overall regression fit of only $R^2 = 0.01$, with $\hat{\beta}$ not significantly different from zero. However, there is a significant positive slope over the sub-sample of low I_j values, as shown in regression (4).

Regressions (3) to (6) highlight the difference between the two sets of regressions when interest rates are high or low. Using a threshold nominal interest rate of $i = 0.038$ to split the sample into approximately equal sub-samples, it can be seen that when interest rates are relatively high, as in regressions (3) and (4), the two tax variables perform similarly in terms of fit but with the $EMTR_j$ producing a counter-intuitive positive slope. By contrast, when interest rates are low, as in regressions (5) and (6), the $EMTR_j$ produces a poor fit, with a negatively sloped, but statistically insignificant, parameter. However, regression (5) confirms that c_j continues reliably to identify the constructed relationship with I_j .

These results would of course be reversed if investors respond to an effective tax rate rather than the user cost measure. But the key point is that the presence of a singularity at low interest rates in the relationship between $EMTRs$ (and $EATR_s$) and the user cost ensures that, if treated as apparently equivalent empirical proxies for taxation impacts on

Table 1: User Cost and EMTR Regressions

Dependent variable: I_j	Sample					
	(1) All obs.	(2) All obs.	(3) $i > 0.038$	(4) $i > 0.038$	(5) $i < 0.038$	(6) $i < 0.038$
constant	0.999 (1260.1)	0.991 (212.0)	0.999 (357.6)	0.712 (15.4)	0.999 (1143.0)	1.002 (340.8)
c_j	-0.478 (-19.29)		-0.463 (-7.13)		-0.537 (-6.67)	
$EMTR_j$		-0.006 (-0.50)		0.802 (5.81)		-0.008 (-1.13)
N	42	42	22	22	20	20
R^2	0.903	0.006	0.718	0.628	0.712	0.066

Note: t -ratios are in parentheses below parameter estimates

investment, quite different results could be generated.

4 Conclusions

Interest rates are a key component of both user cost and effective tax rate measures of company taxation, and each is commonly used in empirical tests of tax impacts on investment. This paper has shown that when interest rates are low the two measures are a long way from being monotonically related to each other. As a result, when examining the empirical impact of taxation on investment in a low interest rate environment, the choice of tax proxy – user cost, $EMTR$ or $EATR$ – is likely to have substantively different, but previously unrecognised, effects on these estimated relationships.

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