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DUAL INCOME TAXATION: THE CHOICE OF THE IMPUTED RATE OF RETURN*

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In this article we study a crucial aspect of a Dual Tax System: the choice of the imputed rate of return. Under interest rate uncertainty, its optimal value will be shown to depend on the nature of investment. Following Fane (1987), if investment is reversible, the imputation rate ensuring neutrality is proportional to the interest rate on default-free bonds. If, instead, investment is irreversible, the imputation rate must be higher, in order to compensate for the discouraging effects of irreversibility. (JEL: H25)

1. Introduction

In the existing literature on corporate tax neutrality there are two traditional potentially neutral tax designs. The first one defines true economic profits as its tax base, and is called 'imputed income method' (see Samuelson, 1964). The second one, proposed by Brown (1948), is the cash-flow method. Unfortunately, both methods are hard to implement. The former is informationally very demanding, since it requires the knowledge of the rate of return for each firm-specific investment (see Sandmo, 1979). The latter is an attractive device with some practical disadvantages, such as difficulties in containing tax evasion and tax avoidance. From the point of view of the taxing authorities, moreover, the cash-flow tax is hard to implement since it may require tax payments to expanding firms as well. For these reasons, Boadway and Bruce (1984) proposed 'a simple and general result on the design of a neutral and inflation-proof business tax' (p. 232). According to this rule, the business tax base is given by the firm's current earnings, net of the accounting depreciation rate (applied to the accounting capital stock) and of the nominal cost of finance. As argued by Boadway and Bruce (1984), however, each firm may have a different value of the nominal cost of finance, which must reflect the investment-specific riskiness, and which is not directly observable.

Fane (1987) took an important step forward, and found that the Boadway and Bruce (1984) general neutrality principle holds even under uncertainty, provided that the tax credit and liabilities are sure to be redeemed and that the tax rate is known and constant. But, more importantly, he proved that such a neutrality de-

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sign could be achieved by simply setting the deductible nominal cost of finance equal to the risk-free nominal interest rate. 'Since government bonds provide an (almost) certain nominal return', he argued, 'it is not difficult to estimate the risk-free interest rate' (p. 99), and the tax design turns to be much less informationally demanding.

Given the above results, in 1991 the IFS Capital Taxes Group proposed the introduction of the *Allowance for Corporate Equity* (hereafter ACE), in the UK corporate taxation. According to this proposal, the corporate tax base should be set equal to the firm's current earnings net of: i) an arbitrary tax allowance for capital depreciation (not necessarily the cost of economic depreciation) and ii) the opportunity cost of finance.[1] Moreover, it should entail a symmetric treatment of profits and losses. Clearly, this proposal is not only based on the theoretical results of Boadway and Bruce (1984), but also on those of Fane (1987). According to the IFS proposal, in fact, the opportunity cost of finance should be set equal to the default-free interest rate, thereby making the government 'a sleeping partner in the risky project, sharing in the return, but also sharing some of the risk' (Devereux and Freeman, 1991, p. 8). Recently, Bond and Devereux (1995) have proven that the ACE system is neutral even when income, capital and bankruptcy risk are introduced. They have also proven that the rate of relief ensuring neutrality remains the nominal interest rate on default-free bonds.

The choice of the relevant opportunity cost of finance is an important topic not only on theoretical grounds but also on tax policy grounds. In the 1990's, in fact, the Nordic countries (see Sørensen, 1998), and, more recently, Italy (see Bordignon et al., 1999) introduced a dual corporate tax system.[2] Moreover, a form of ACE taxation was adopted in Croatia in 1994 (see Rose and Wiswesser, 1998), under the name of Interest Adjusted Income Tax (IAIT). According to these tax designs, companies' earnings are split into the following two components:

– an imputed return on new investments financed with equity capital, called the 'ordinary return';
– the residual taxable profits, namely profits less the ordinary return.

The ordinary return, approximating the opportunity cost of new equity capital, is calculated by applying a nominal interest rate to equity capital. According to this dual system, the ordinary return is taxed at a lower rate than the residual taxable profits.[3]

One of the most controversial aspects of these systems is the choice of the imputation rate. On the one hand, Denmark sets the imputed rate of return equal to the average market interest rate on bonds. On the other hand, both the other Nordic countries and Italy prefer to introduce a risk premium. Finally, under the IAIT the imputed rate of return is set equal to the growth rate of manufacturing prices plus 500 basis points.

In this article we will show that the choice of the appropriate imputed rate depends on the characteristics of the dual taxation, on the existence of interest rate uncertainty and, above all, on the nature of investment. As we know, in fact, investment is, at least partially, irreversible. Irreversibility may arise from 'lemon effects', and from capital specificity (see Dixit and Pindyck, 1994, and Trigeorgis, 1996). Even when brand-new capital can be employed in different productions, in fact, it may become specific once installed. Furthermore, irreversibility may be caused by industry comovement as well: when a firm can resell its capital, but the potential buyers operating in the same industry are subject to the same market conditions, this comovement obliges the firm to resort to out-

[1] *For further details on this proposal see IFS Capital Taxes Group (1991), Devereux and Freeman (1991), and Isaac (1997).*

[2] *Under the Nordic systems, the dual design is applied only to small companies, when labour and capital incomes accrue jointly. Under the Italian system, instead, this tax design covers all kinds of business activities (except those activities where simplified accounts are kept). On these grounds, the Italian Dual Income Tax (DIT) is similar to the ACE system, which proposes the taxation of extra-profits at a higher rate than normal profits, regardless of the organisational form involved.*

[3] *Of course, the ACE system can be considered as a special case of the dual system where the lower tax rate is null.*

siders. Due to reconversion costs, the firm can sell the capital at a considerably lower price than an insider would be willing to pay if it did not face the same bad conditions as the seller.

When investment is reversible, namely when investment can be resold without any additional cost, the imputed rate of return ensuring neutrality is proportional to the interest rate on default-free bonds. This result is shown by Fane (1987), and Bond and Devereux (1995). When, instead, investment is irreversible and the firm can decide when investing, the imputation rate must be higher, in order to compensate for the discouraging effects of investment irreversibility.

The article is structured as follows. Section 2 introduces a simple discrete-time model with a bivariate distribution of interest rates. Section 3 shows the neutrality results and section 4 discusses the results obtained. In the Appendix, we show a generalisation of the results, where uncertainty does not vanish after one period, but lasts to infinity.

2. *The model*

In this section we analyse the effects of interest rate uncertainty on the firm's investment decision. We introduce a simple discrete-time model of a competitive risk-neutral firm. For simplicity, we omit all the other sources of uncertainty (studied by Bond and Devereux, 1995) and assume that the firm's lifetime is infinite.[4]

The structure of the model is as follows. Given an investment of 1 €, at the end of each period, the firm will receive a constant cash flow Π in perpetuity. The short-term interest rate is a bivariate stochastic variable. Given its initial value r, at time 1 it will either rise to r_2 with probability $(1–q)$ or drop to r_1 with probability q. For simplicity, uncertainty vanishes at time 1 and the interest rate will remain constant forever. Note that with this assumption the model is reduced to a two-period framework. The first period lasts until time 1 and the second period lasts from time 1 to infinity. This simplifying assumption will be removed in the Appendix, where we will assume an uncertain term structure scenario lasting to infinity.

Let us finally assume the following inequalities

$$[r_2/(1+r_2)] > \Pi > [r_1/(1+r_1)].$$

In other words, if the ex-post rate of return of the entrepreneurial investment is less than the rate of return of a short-term bond, the financial investment is preferred to the entrepreneurial one and vice versa. This implies that an increase (decrease) in the short-term interest rate will represent bad (good) news for the firm.

We compare two different cases, which are both characterised by irreversibility: in the first case, the representative firm can decide whether investing at time 0 or never. In the second case, instead, the representative firm can decide whether investing at time 0 or waiting until time 1, when uncertainty vanishes[5].

When investment is irreversible and the firm cannot postpone investment, the firm will invest if the expected net present value at time 0 of its project, net of its investment cost, is positive

$$(1)\quad NPV_0 = \left\{ q \cdot \sum_{t=1}^{\infty} \frac{1}{(1+r_1)^{t-1}} + (1-q) \cdot \sum_{t=1}^{\infty} \frac{1}{(1+r_2)^{t-1}} \right\} \cdot \frac{\Pi}{1+r} - 1 > 0,$$

which can be rewritten as

$$(1')\quad NPV_0 = \frac{\Pi}{r_c} - 1 > 0,$$

where $$\frac{1}{r_c} = \left\{ \frac{1}{1+r} \cdot \left[q \cdot \frac{1+r_1}{r_1} + (1-q) \cdot \frac{1+r_2}{r_2} \right] \right\}.$$

Note that r_c is the current consol rate of a long-term bond. If there exist perfect capital markets, its value today ($1/r_c$) is equal to its discounted expected value one period from today plus one coupon payment. As shown in the RHS of the above equality, therefore, its value is giv-

[4] *Note that assuming a finite business lifetime would not change the quality of the results.*

[5] *Note that, under reversibility, if inequality $\Pi_0 > r$ holds, the firm invests and produces at time 0. If, at time 1, the interest rate decreases, the firm will go on producing. If, instead, the interest rate rises, the firm will stop and resell its capital without any loss.*

en by the weighted average of the state-contingent prices (discounted one period ahead) of the short-term bond in the good and bad state, namely $\frac{1+r_1}{r_1}$ and $\frac{1+r_2}{r_2}$. The weights are represented by the probabilities of the events, q and $(1–q)$, respectively.[6] The rule expressed by inequality (1') is straightforward: If the present discounted value of future cash flows Π/r_c is greater than the investment cost, then the firm undertakes investment.

With some exceptions[7], the existing literature on corporate taxation (including Fane, 1987, and Bond and Devereux, 1995) employs the above Net-Present-Value rule to check whether neutrality holds. As argued by Dixit and Pindyck (1994), however, this rule is correct only on condition that either investment is reversible or it is irreversible, but the firm cannot delay it. Both the reversible case and the now-or-never case are seldom realistic. In particular, when investment is irreversible, the firm is not usually obliged to invest at time 0. Rather, it can decide to observe the realisation of the future, and wait until time 1, when uncertainty is resolved. This implies that the firm is endowed with an option to delay (see Ingersoll and Ross, 1992, and Trigeorgis, 1996). In this case, the positive value of NPV_0 is no longer a sufficient condition for investing at time 0 to be the optimal strategy. To decide when to invest (i.e. when exercising the option), in fact, the firm must compare NPV_0 with its expected net present value at time 1

$$(2)\quad NPV_1 = \frac{q}{1+r}\cdot\left\{\sum_{t=1}^{\infty}\frac{1}{(1+r_1)^{t-1}}\cdot\Pi-1\right\} = \frac{q}{1+r}\cdot\left(\frac{\Pi}{r_1}-1\right).$$

As can be noted, NPV_1 does not account for the ‘bad news’ (i.e. the increase to r_2), since a rational firm would not enter at time 1, after an increase in the interest rate.[8]

Under investment irreversibility, the firm chooses its optimal investment time by comparing NPV_0 with NPV_1. If, therefore, inequality $NPV_0 > NPV_1 > 0$ holds, then immediate investment is preferred. If, instead, $NPV_1 > NPV_0 > 0$, postponing investment is more profitable. Equating (1) to (2) we obtain the trigger value of the short-term interest rate (see Ingersoll and Ross, 1992)

$$r^* = \frac{r_2+(1-q)}{r_2}\cdot\Pi-(1-q) = \Pi-(1-q)\cdot\frac{r_2-\Pi}{r_2}.$$

If, therefore, the current interest rate r is less than the trigger value r^*, then immediate investment is undertaken and vice versa. As can be seen, r^* depends only on the unfavourable events (namely on the probability and the seriousness of bad news). Hence, this result is an application of Bernanke’s (1983) *Bad News Principle* (BNP), which shows that it is the ability to avoid the effects of bad outcomes that leads the firm to decide whether waiting or not.[9]

For a better understanding of the firm’s behaviour, we can rewrite the firm’s decision rule by using equations (1) and (2), thereby obtaining

$$NPV_0 - NPV_1 = \frac{1-q+r}{1+r}\cdot\left(\frac{\Pi}{r_m}-1\right)\geq 0,$$

where $r_m = \frac{r+(1-q)}{r_2+(1-q)}\cdot r_2$. As can be seen, the firm’s decision rule is based on the comparison between the present discounted value of future cash flows and the investment cost. When the representative firm holds the option to wait, however, the firm’s discount rate is different: easy computations show that $r_m > r_c$.

Like r_c, the rate r_m has an economic meaning. In fact, r_m can be obtained by solving the following equation

$$(3)\quad \frac{1}{r_m} = \frac{1}{1+r}\cdot\left[q\cdot\frac{1+r_m}{r_m}+(1-q)\cdot\frac{1+r_2}{r_2}\right].$$

6 *For further details on the definition of the state-contingent prices see Backus et al. (1998, p.16).*

7 *See Niemann (1999) for a survey.*

8 *For further information on this point see Dixit and Pindyck (1994, pp. 40–41) and Trigeorgis (1996, pp. 197–199).*

9 *As pointed out by Bernanke (1983), under investment irreversibility “the impact of downside uncertainty on investment has nothing to do with preferences ... The negative effect of uncertainty is instead closely related to the search theory result that a greater dispersion of outcomes, by increasing the value of information, lengthens the optimal search time” [p. 93].*

The explanation of equation (3) is simple. The LHS is the current price of the long-term consol bond issued for financing the firm's investment. Similarly to the definition of r_c, the RHS is the weighted average of the state-contingent prices (discounted one period ahead) in the good and bad state. Contrary to the former case (where r_c was the discount rate), the state-contingent price in the good state is not $\frac{1+r_1}{r_1}$ but rather $\frac{1+r_m}{r_m}$ $\left(\text{with } \frac{1+r_1}{r_1} > \frac{1+r_m}{r_m}\right)$. To understand this different evaluation of the good news, let us describe the behaviour of the representative firm. On the one hand, the firm may decide to delay investment in order to capture the decrease in the interest rate. On the other hand, the firm is attracted by the immediate payoff. To exploit both these opportunities, it might, in principle, finance its immediate investment by borrowing in a bond, which incorporates a prepayment option. Therefore, if the interest rate decreases to r_1, the firm can exercise the prepayment option, thereby returning the principle. Then, it issues a new bond at the current rate r_1. If capital markets are perfect, therefore, the value of the prepayment option is given by the difference $\left[\frac{1+r_1}{r_1} - \frac{1+r_m}{r_m}\right]$ and the effects of the good news are thus neutralised. If, instead, the interest rate rises to r_2, the firm faces a reduction in its NPV and the mortgage rate will be equal to $r_m = r_2$.[10]

Note that the choice of r_m as the relevant discount rate does not imply that the firm is obliged to use debt instead of equity to finance its investment. According to the Modigliani-Miller theorem, if there exist perfect capital markets, equity-financing is equivalent to debt-financing, namely an equity-debt swap does not alter the value of the firm.

Finally, it is worth noting that neither r_c nor r_m are computed by the firm. If capital markets are perfect, in fact, both of them are given by the existing prices of a default-free long-term (Treasury) bond and of a callable bond, respectively. Berk (1999) defines this latter bond as a 'mortgage bond', which is equivalent to a portfolio consisting of a long position in a non-callable consol bond (i.e. Treasury bonds) and a short position in an American call option (the prepayment option) on the same bond.[11]

3. *The neutrality results*

Let us next introduce taxation. Under a dual tax system, current earnings Π are split into two components: the ordinary return and, if any, the residual taxable profits. For simplicity, we assume that profits and losses are treated symmetrically.

To compute the ordinary return we define the imputed rate of return as r_E, and let τ_l and τ_h be the tax rate on the ordinary return and that on the residual profits (with $\tau_l < \tau_h$), respectively. In order to keep the model as simple as possible, finally, we assume that the project is fully equity-financed.

Taxes are paid at the end of each period. If the firm cannot postpone investment (namely, it may invest either at time 0 or never), the net present value of the expected tax burden is

$$(4)\quad T_0 = \left\{ q \cdot \sum_{t=1}^{\infty} \frac{1}{(1+r_1)^{t-1}} + (1-q) \cdot \sum_{t=1}^{\infty} \frac{1}{(1+r_2)^{t-1}} \right\} \cdot \frac{[\tau_l r_E + \tau_h(\Pi - r_E)]}{1+r} = \frac{[\tau_l r_E + \tau_h(\Pi - r_E)]}{r_c}.$$

Clearly, if $\tau_l = 0$, we turn to the ACE scheme.

Before analysing the effects of the dual tax scheme on investment, let us define neutrality. As argued by Johansson (1969): 'One way of defining "neutral" corporate taxation is in terms of identical ranking in a pre-tax and in a post-tax profitability analysis. Corporate income taxation is neutral, if the concept of income used for taxation purposes is such that identical ranking of alternative investments is obtained in a

[10] *This implies that the current price of the bond is* $(1 + r_2) / r_2$.

[11] *Berk (1999) also argues that such mortgage obligations exist and are listed in the US markets. They are 30 years bonds, guaranteed by the US government. Thus, their prices do not account for default risk.*

pre-tax and post-tax profitability analysis.' [p. 104]. As we know, the firm's decision depends on the sign of the post-tax net present value of its project at time 0**.** Namely, if $NPV_0 - T_0$ is positive, investing is profitable. Following Brown (1948), given a generic tax rate μ, therefore, a tax system is neutral (namely there exists an identical ranking in a pre-tax and in a post-tax profitability analysis) if the post-tax net present value is (1–μ) times the pre-tax net present value

$$(5)\; NPV_0 - T_0 = (1-\mu)\cdot NPV_0 .$$

Using equations (1) and (4), we obtain the post-tax net present value of the project

$$(6)\; NPV_0 - T_0 = (1-\tau_h)\left(\frac{\Pi}{r_c}-1\right)+\left((\tau_h-\tau_l)\frac{r_E}{r_c}-\tau_h\right).$$

In order to obtain neutrality, therefore, the second term in the RHS must be null. Therefore, setting $r_E^* = \frac{\tau_h}{\tau_h - \tau_l}\cdot r_c$ equation (6) reduces to the neutrality condition (5) (with $\mu=\tau_h$)

$$NPV_0 - T_0 = (1-\tau_h)\left(\frac{\Pi}{r_c}-1\right).$$

This result is similar to that obtained by Fane (1987), who argues that the benchmark interest rate must be the nominal interest rate on government bonds since 'tax credits are equivalent bonds, and the building-up of tax credits by a firm is therefore equivalent to its using equity finance to pay-off debt' (p. 101). Since such equity-debt swaps do not alter the value of the firm, the result turns out to be an application of the Modigliani-Miller theorem. Note, however, that, under reversibility, the imputation rate must be proportional to the current short-term rate. When capital can be resold without any loss, in fact, production is profitable if the net cash flow is greater than the cost of capital, namely if $\Pi - [\tau_l r_E + \tau_h(\Pi - r_E)] > r_t, \forall t$. Easy computations show that the neutral imputation rate must be equal to $r_E = [\tau_h/(\tau_h-\tau_l)]r_t, \forall t \geq 0$. When, instead, investment is irreversible and the firm cannot postpone it, the appropriate imputation rate must be proportional to the long-term interest rate on the consol bond r_c.

Under a dual tax system, the neutral imputation rate is higher than the current consol rate r_c, due to the different treatment of the ordinary and residual returns.[12] However, the positive differential (r_E–r_c) is independent of any stochastic factor, and cannot be interpreted as a risk premium.[13] To better understand this point, let us consider two opposite cases. In the first case, we assume that the firm's return is greater than the ordinary return. Thus, the tax burden on residual profits is τ_h times the residual profits. In the second case, instead, the firm's return is less than the ordinary return, and the firm receives a subsidy. Despite this negative result, the firm must pay taxes on the ordinary income in any case. Therefore, the net transfer to the firm is equal to (τ_h – τ_l) times the difference between the effective and the ordinary return, which is negative. To obtain neutrality, we thus compare the tax burden in the good state with the net transfer in the bad state. As shown in equation (6), therefore, the present discounted value of the tax benefit due to the deduction of the investment cost under dual taxation, $(\tau_h - \tau_l)\frac{r_E}{r_c}$, is equal to that obtained under a cash-flow system with rate τ_h, thereby obtaining r_E^*.

Let us now turn to the latter case, where investment is irreversible, but the firm can postpone it. In order to find the value of r_E ensuring neutrality, we must compute the net present value of the expected tax burden when the firm invests at time 1

$$(7)\; T_1 = \frac{q}{1+r}\cdot\left\{\sum_{t=1}^{\infty}\frac{1}{(1+r_1)^t}\cdot[\tau_l r_E + \tau_h(\Pi - r_E)]\right\}.$$

To check whether neutrality holds, however, the Brown condition must be modified, in order to account for the firm's option to wait. This modified condition arises from the comparison between the immediate undertaking of investment and its postponement. This implies that if we have

$$(8)\; (NPV_0 - T_0) - (NPV_1 - T_1) = (1-\mu)(NPV_0 - NPV_1),$$

[12] *Under the ACE system, instead, the appropriate imputation rate is obtained by simply setting $\tau_1 = 0$, thereby obtaining* $r_E = r_c$ *(see Bond and Devereux, 1995).*

[13] *Under income uncertainty, the choice of a greater ordinary return than the market rate of interest is due to the*

then the trigger value r^* will be the same as that without taxation. According to condition (8), on the one hand, an increase in the tax rate reduces the present value of future discounted profits and induces the firm to delay investment. On the other hand, the increase in the tax rate causes a decrease in the opportunity cost of investing at time 0, thereby encouraging investment. Thus, neutrality holds if the net effect of these counteracting factors is null (see Niemann, 1999).

Substituting equations (1), (2), (4), and (7) into condition (8) we thus obtain

$$(9)\ (NPV_0 - T_0) - (NPV_1 - T_1) = \frac{1-q+r}{1+r} \cdot \left\{ (1-\tau_h)\frac{\Pi}{r_m} - \left[1-(\tau_h - \tau_l)\frac{r_E}{r_m} \right] \right\}.$$

Note that if we set $r_E = \frac{\tau_h}{\tau_h - \tau_l} \cdot r_c$, i.e. the imputed return ensuring neutrality in the former case, a distortion takes place. Since $r_c < r_m$, in fact, we have an inequality

$$(NPV_0 - T_0) - (NPV_1 - T_1) = \frac{1-q+r}{1+r} \cdot \left\{ (1-\tau_h)\frac{\Pi}{r_m} - \left(1-\frac{r_c}{r_m}\tau_h \right) \right\} < (1-\tau_h) \cdot (NPV_0 - NPV_1).$$

As can be seen, the present value of the tax credit, discounted with r_c, is less than that guaranteed by the cash-flow taxation, namely the firm underinvests.[14] In order to eliminate this distortion at time 0, we must set $r_E^* = \frac{\tau_h}{\tau_h - \tau_l} \cdot r_m$, thereby obtaining the modified Brown condition

$$(NPV_0 - T_0) - (NPV_1 - T_1) = (1-\tau_h) \cdot \frac{1-q+r}{1+r} \cdot \left(\frac{\Pi}{r_m} - I \right) = (1-\tau_h) \cdot (NPV_0 - NPV_1).$$

The explanation of this result is straightforward: to ensure neutrality, the government must take into account the same discount rate as that used by the firm, namely r_m. Thus, the neutrality result is, again, an application of the Modigliani-Miller theorem. However, this theorem now holds on condition that the alternative bond for the equity-debt swaps incorporates the prepayment option.

To get a clearer picture of this result, let us decompose the appropriate imputation rate as follows

$$(10)\ r_E^* = r_c + \frac{\tau_l}{\tau_h - \tau_l} \cdot r_c + \frac{\tau_h}{\tau_h - \tau_l} \cdot (r_m - r_c).$$

The first term of (10) is the interest rate on default-free long-term bonds. The second term is the compensation for the dual treatment of the firm's earnings. When the firm is endowed with an option to wait, however, a third term must be added. Since it depends on the differential $(r_m - r_c)$, it represents a risk premium. In particular, the higher the differential $(\tau_h - \tau_l)$, the lower the risk premium ensuring neutrality.

Setting $\tau_l = 0$, one obtains the neutral ACE imputation rate $r_E^* = r_m > r_c$. This rate is higher than that recommended by Bond and Devereux (1995), since they did not account for the risk premium due to irreversibility.

Note that r_E^* is the neutral imputation rate at time 0. Although the same neutrality rule holds for $t > 0$, the result is trivial when uncertainty vanishes. In this case, in fact, the differential between the short- and long-term interest rates is null (i.e. $r_m = r_c = r_i$ with i =1,2). If, therefore, the firm found it profitable to wait until uncertainty is resolved (namely at time 1), the neutral imputation rate is proportional to the current rate. Note, however, that investment is undertaken only if the interest rate drops to r_1. Thus, the neutral imputation rate will be $r_E^* = \frac{\tau_h}{\tau_h - \tau_l} \cdot r_1$.

Finally, it is worth noting that the above results do not depend on the bivariate stochastic

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asymmetric treatment of ordinary and residual returns. As explained by Panteghini (1998), however, no risk premium should be taken into account.

[14] *A similar result would be obtained if we set the imputation rate proportional to the short-term rate at time 0, namely* $r_E = \frac{\tau_h}{\tau_h - \tau_l} \cdot r$. *In this case, underinvestment would be given by the following inequality*

$$(NPV_0 - T_0) - (NPV_1 - T_1) = \frac{1-q+r}{1+r} \cdot \left\{ (1-\tau_h)\frac{\Pi}{r_m} - \left(1-\frac{r}{r_m}\tau_h \right) \right\} < (1-\tau_h) \cdot (NPV_0 - NPV_1).$$

process assumed. In the Appendix, we show that they hold even when the interest rate follows a generic stochastic process and uncertainty does not vanish after one period. Therefore, the neutral imputation rate must be proportional to the mortgage rate in order to take into account the firm's option to wait. If, otherwise, we set the imputation rate proportional to the current consol rate we would obtain underinvestment.

4. Conclusion

The simple model employed in this article deals with the choice of the appropriate imputation rate under a dual income tax scheme. As we have shown, the rate ensuring neutrality depends on the nature of the firm's investment. Following Fane (1987), if investment is reversible, the imputation rate ensuring neutrality is proportional to the short-term interest rate on default-free bonds. If, instead, investment is irreversible, the imputation rate must be higher, in order to compensate for the discouraging effects of irreversibility. In particular, the imputation rate must be proportional either to the mortgage or to the consol rate, depending on whether the firm holds the option to wait or not. It is worth noting that, if capital markets are perfect, the appropriate discount rates (r_m and r_c) are not computed by the firm. Rather, they represent the interest rates of two kinds of bonds which are priced in the existing capital markets.

The results obtained in Fane (1987) and in this article deal with the benchmark cases of full reversibility and full irreversibility, respectively. However, they are sufficient to suggest that, in an intermediate case, the greater the investment irreversibility the higher the imputation rate.

References

Backus, D., S. Foresi, and C. Telmer (1998). "Discrete-Time Models of Bond Pricing." NBER Working Paper No. 6736.

Berk, J. (1999). "A Simple Approach for Deciding When to Invest." *American Economic Review* 89, 1319–1326.

Bernanke, B.S. (1983). "Irreversibility, Uncertainty, and Cyclical Investment." *The Quarterly Journal of Economics*, pp. 85–103.

Boadway, R., and N. Bruce (1984). "A General Proposition on the Design of a Neutral Business Tax." *Journal of Public Economics* 24, 231–239.

Bond, S.R., and M.P. Devereux (1995). "On the Design of a Neutral Business Tax under Uncertainty." *Journal of Public Economics* 58, 57–71.

Bordignon, M., S. Giannini, and P. Panteghini (1999). "Corporate Taxation in Italy: An Analysis of the 1998 Reform." *FinanzArchiv* 56, 335–362.

Brown, E.C. (1948). "Business-Income Taxation and Investment Incentives." In *Income, Employment and Public Policy. Essays in Honor of A.H. Hansen*. Eds. L.A. Meltzer, E.D. Domar et al.. New York: W.W. Norton & co.

Devereux, M.P., and H. Freeman (1991). "A General Neutral Profits Tax." *Fiscal Studies*, pp.1–15, August.

Dixit, A., and R.S. Pindyck (1994). *Investment under Uncertainty*. Princeton University Press.

Fane, G. (1987). "Neutral Taxation under Uncertainty." *Journal of Public Economics* 33, 95–105.

IFS (ed.) (1991). *Equity for Companies: a Corporation Tax for the 1990s*. A Report of the IFS Capital Taxes Group chaired by M. Gammie. The Institute for Fiscal Studies, Commentary 26, London.

Ingersoll, J.E., and S.A. Ross (1992). "Waiting to Invest: Investment and Uncertainty." *Journal of Business* 65, 1–29, vol. 65.

Isaac, J. (1997). "A Comment on the Viability of the Allowance for Corporate Equity." *Fiscal Studies* 18, 303–318.

Johansson, S.E. (1969). "Income Taxes and Investment Decisions." *Swedish Journal of Economics* 71, 104–110.

Niemann, R. (1999). "Neutral Taxation under Uncertainty – A Real Options Theory." *FinanzArchiv* 56, 51–66.

Panteghini, P.M. (1998). "Alcune Considerazioni sulla Dual Income Tax Italiana." *Rivista di Diritto Finanziario e Scienza delle Finanze* 57, 3–14.

Rose, M., and R. Wiswesser (1998). "Tax Reform in Transition Economies: Experiences from the Croatian Tax Reform Process of the 1990's." In *Public Finance in a Changing World*. Ed. P.B. Sørensen. London: MacMillan Press, 257–278.

Samuelson, P.A. (1964). "Tax Deductibility of Economic Depreciation to Insure Invariant Valuations." *Journal of Political Economy* 72, 604–606.

Sandmo, A. (1979). "A Note on the Neutrality of the Cash Flow Corporation Tax." *Economics Letters* 4, 173–6.

Sørensen, P.B. (ed.) (1998). *Tax Policy and the Nordic Countries*. London: Macmillan Press.

Trigeorgis, L. (1996). *Real Options, Managerial Flexibility and Strategy in Resource Allocation*. The MIT Press.

Appendix

In this Appendix we remove the simplifying assumption that the interest rate follows a bivariate stochastic process. To do so we use Berk's (1999) model. The reader will find in that source careful statements of the relevant hypotheses and of the results.

When the current consol interest rate $r(t)$ follows a generic stochastic process and uncertainty does not vanish after one period, the investment rule is as follows: It is optimal to invest the first time that inequality

$$\text{(A1)}\left(\frac{\Pi}{r_m(t)}-1\right)\geq 0$$

is satisfied, where $r_m(t) > r(t)$ is the mortgage rate at time t (see the Proposition on p. 1322 in Berk, 1999).

Let us now introduce taxation. As we know, neutrality holds if the post-tax ranking in profitability is the same as the pre-tax one, namely

$$\text{(A1)}\left(\frac{\Pi}{r_m(t)}-1\right)\geq 0 \Leftrightarrow \text{[A2]}\left(\frac{\Pi-T(t)}{r_m(t)}-1\right)\geq 0 .$$

Under a dual tax system, the current tax burden is

$$\text{(A3)}\;\; T(t)=\left[\tau_l r_E(t)+\tau_h(\Pi-r_E(t))\right],$$

where $r_E(t)$ is the imputation rate at time t. Substituting (A3) into (A2), it is straightforward to see that neutrality holds if $r_E(t)=\frac{\tau_h}{\tau_h-\tau_l}\cdot r_m(t)$. In fact, (A2) is simplified as follows

$$\text{(A2)}\,(1-\tau_h)\cdot\left(\frac{\Pi}{r_m(t)}-1\right)\geq 0 ,$$

and, hence, the ranking in profitability is unchanged. If, otherwise, we set the imputation rate equal to the current consol rate $r(t)$, namely $r_E(t)=\frac{\tau_h}{\tau_h-\tau_l}\cdot r(t)$, we would obtain

$$(1-\tau_h)\cdot\left(\frac{\Pi}{r_m(t)}-\frac{r(t)}{r_m(t)}\right)>(1-\tau_h)\cdot\left(\frac{\Pi}{r_m(t)}-1\right),$$

namely the ranking in profitability would be distorted and underinvestment would take place.