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ON CORPORATE TAX ASYMMETRIES AND NEUTRALITY

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Abstract

This article discusses the effects of corporate tax asymmetries under investment irreversibility. We introduce a tax scheme where the tax base is given by the firm's return net of a rate of relief. When the firm's return is less than the imputation rate, however, no tax refunds are allowed. Unlike symmetric tax systems, the scheme proposed is neutral with respect not only to income uncertainty but also to policy uncertainty.

Keywords: Corporate taxation, irreversibility, neutrality, uncertainty

JEL Classification: H25

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1. Introduction

As stated by Dixit and Pindyck (1994, p.3) 'Most investment decisions share three important characteristics, investment irreversibility, uncertainty and the ability to choose the optimal timing of investment'. Investment 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. 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 outsiders. Due to reconversion costs, however, the firm can sell the capital at a considerably low price than an insider would be willing to pay if it did not face the same bad conditions as the seller.

A recent strand of research has been studying corporate taxation under investment irreversibility (see e.g. McKenzie (1994), Alvarez and Kanniainen (1997, 1998), and Faig and Shum (1998)). The main results obtained by this literature show that investment irreversibility seems to amplify the distortions caused by corporate taxation. In reality, the tax systems analysed were originally designed for fully reversible investment, which implies that the bad and good states of nature affect the firms' decisions symmetrically. In this case, therefore, it is straightforward to obtain neutrality by assuming that profits and losses are treated symmetrically as well.

When investment is irreversible, instead, Bernanke (1983) shows that only the bad states of nature affect the firm's decisions: this is the well-known Bad News Principle. When designing a neutral tax system under irreversibility, therefore, the symmetric treatment of profits and losses may no longer be a necessary condition.

The aim of this article it to show that tax asymmetries may be neutral if the effects of uncertainty are asymmetric. Though it is generally believed that an asymmetric system is inherently distortive, we show that, in principle, it is not so.

In particular, we present a tax system which is similar to that proposed by Garnaut and Ross (1975). Namely the tax base is given by the firm's return net of an imputation rate. Contrary to the Garnaud-Ross proposal, however, when the firm's return is less than the imputation rate of relief, no tax refunds are allowed. Under this scheme, firms undertake investment when profitability is relatively low and current taxation is null. Since only future taxation matters, this tax design is neutral with respect to policy uncertainty as well.

This article is structured as follows. Section 2 discusses the related literature on tax asymmetries and irreversibility. It also summarises the main findings of this strand of literature in two propositions. Section 3 introduces a simple discrete-time model where uncertainty lasts for one period. Section 4 derives the sufficient neutrality conditions under both reversible and irreversible investment. In sections 5 and 6, we apply the asymmetric tax system and show that, unlike the symmetric tax systems, the scheme proposed is neutral not only with respect to income uncertainty but also to policy uncertainty. Finally, section 7 summarises the results and discusses their implications.

2. The related literature

In the existing literature on corporate tax neutrality there are two basic 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) takes an important step forward, and finds that the Boadway and Bruce (1984) general neutrality principle holds even under uncertainty, provided that the tax credit and liabilities are certainly redeemed and that the tax rate is known and constant. But, more importantly, he proves that such a neutrality design could by achieved by simply setting the deductible nominal cost of finance equal to the risk-free nominal interest rate. Thus the tax design turns to be much less informationally demanding.

Recently, Bond and Devereux (1995) have proven that a business tax scheme, based on the Boadway-Bruce Principle is neutral even when income, capital and bankruptcy risk are introduced. They have also proven that the imputation rate ensuring neutrality remains the nominal interest rate on default-free bonds.

Despite the above generalisations, the existing neutrality results are based on quite restrictive assumptions. In particular, neutrality holds provided that: a) the treatment of profits and losses is symmetric, and b) the statutory tax rate is known and constant.

Unfortunately, these conditions are difficult to implement. The symmetry condition a) fails because of the possibility of fraudulent losses. Moreover, the symmetry device may require negative tax payments to expanding firms as well. In discussing the Bond-Devereux proposal, Isaac (1997) wonders how far companies feel an incentive to make tax-motivated (rather than business-motivated) take-overs. He then adds that "...there is both survey and anedoctal evidence that both governments and companies commonly place considerably more value on cash flow than is measured by conventional NPV arithmetic" [pp. 308-9][1].

Similarly, condition b) is hard to implement. Under the realistic assumption that future tax rates are neither known nor constant the Boadway-Bruce result fails to hold. We agree with Sandmo (1979) that "academic discussions of tax reform in a world of unchanging tax rates is something of a contradiction in terms" [p. 176].

Under policy uncertainty, distortions are likely to imply a time inconsistency as well. In fact, firms which have paid a investment cost may be taxed at a higher rate for the profits produced with the installed capital. Since firms are aware of this possibility, they can decide to reduce investment (see e.g. Nickell (1977, 78)

[1] A similar critique is also contained in Auerbach (1986), who argues that the utilisation of carryforward or carrybackward devices is distortive: "While the high probability of a tax loss may discourage the low-return firm from investing initially, once the investment is sunk and, with some probability, the tax loss occurs, further investment decisions will be made taking account of the loss carryforward. Since such accumulated tax losses decay in value over time, firms may increase their investment to use them up [...] A "loser" may suffer more from the absence of a loss offset but may also be more likely to accelerate investment to use up loss carryforwards" [p. 206]. According to Michael Devereux, however, Auerbach's comment only applies if there are financial constraints.

and Mintz (1995)), unless government precommits itself.

Finally, it must also be noted that a common feature of the articles of Boadway and Bruce (1984), Fane (1987), and Bond and Devereux (1995) is the implicit assumption of full investment reversibility. Namely, investment can be resold without any additional cost. On the contrary, empirical evidence shows that investment is, at least, partially irreversible (see e.g. Guiso and Parigi, 1998).

For this reason, in the last decade, tax economists studied the interactions between, on the one hand, irreversibility, uncertainty and investment timing, and, on the other hand, corporate taxation.

A pioneering article dealing with irreversibility is that of MacKie-Mason (1990), who shows that, under non-refundability the corporation tax always reduces the value of the investment project. Under some circumstances, moreover, he finds a tax paradox: increasing the corporate income tax rate can stimulate investment by lowering the option value of the project.

In two interesting papers, Alvarez and Kanniainen (1997, 1998) show that, under irreversibility, the Johansson-Samuelson theorem[2] fails to hold. In fact, taxation leaves the project's value unchanged but raises the option value of the project, thereby discouraging investment. Moreover, they show that the lack of full refundability makes the cash-flow taxation distortive as well[3].

Faig and Shum (1999) confirm the above results. In particular, they find that the higher the degree of irreversibility, the more distortive is a corporate tax system. Furthermore, distortions are amplified by tax asymmetries[4]. Finally, Pennings (2000)shows that a combination of a lump-sum subsidy with a symmetric profits tax stimulates irreversible investment even if the expected tax revenues are null.

Some authors have also studied the effects of irreversibility on some existing tax schemes. In particular, McKenzie (1994) analysed the Canadian corporate tax system and showed that, due to imperfect loss-offset provisions, the higher the degree of irreversibility the more distortive is the taxation. Zhang (1997) studied the British Petroleum Revenue Tax (PRT), which allowed a tax holiday for new

[2]For further details on this theorem, see Sinn (1987).

[3]Alvarez and Kanniainen (1997) justify the absence of full refundability by arguing that future positive revenues may be non sufficient to draw previous losses. For further details see also Ball and Bowers (1983).

[4]It is worth noting that Faig and Shum (1999) also propose an interesting reinterpretation of Stiglitz' (1973) neutrality result, under irreversibility. In fact, they show that tax distortions are lower if the firm is debt-financed at the margin.

investment. Similarly, due to its asymmetries[5], the PRT was distortive.

The above results show a common feature which can be summarised in the following

Proposition 1- *Under investment irreversibility, the more asymmetric the tax system, the more distortive is corporate taxation.*

It is worth noting that none of the above articles deals with policy uncertainty. Since the pioneering article of Lucas (1976), however, it became clear that a shock generated by a stochastic process had different effects from a change in the process itself. As argued by Dotsey (1990), therefore, when predicting the reaction of economic agents to tax rate changes, an economist should carefully consider agents' forecasting problems.

As we know, future tax rates are neither known nor constant, and the standard neutrality results fail to hold. Moreover, a full-refundability tax scheme turns to be distortive even if a *credible* tax rate change is previously announced (see e.g. Sandmo (1979), Auerbach (1989), Panteghini (1995) and Bond and Devereux (1995)). The distortive effects may be amplified when future tax rates are not only variable but also uncertain. As shown by Alvarez, Kanniainen and Södersten (1998), in fact, timing uncertainty may deeply affect a representative firm's reversible investment decision[6].

The effects of tax policy on the investment decisions depend on the characteristics of the tax policy change. As shown by Hassett and Metcalf (1994, 1995), if the tax policy follows a Brownian motion (i.e. a continuous random walk) the firm's trigger point is increased, and irreversible investment is postponed[7]. If, conversely, tax policy is described by a Poisson process, namely with discrete changes, the firm's trigger point is reduced and investment is stimulated. Of course, this latter assumption on tax policy is more realistic than the former, since tax parameters are likely to remain constant for a long period and, then, show sudden jumps.

[5]The PRT was characterised by a kink, since only when a given initial tax-deductible allowance was null, taxes were paid by the firm.

[6]See also Nickell (1977, 78) and Bizer and Judd (1989). The latter show that uncertain investment tax policy causes a welfare loss.

[7]This result is a direct implication of Pindyck's (1988) findings. See also Aizenman (1996), who uses a general equilibrium model with uncertain jumps in the tax rate. He shows that this kind of policy uncertainty discourages investment.

Finally, Cummins, Hassett and Hubbard (1994, 1995, 1996) find evidence of statistically significant investment responses to tax changes in 12 of the 14 countries.

Although it is not clear whether policy uncertainty stimulates or discourages investment, we can summarise the above results in the following

Proposition 2- *Under investment irreversibility, policy uncertainty is an additional source of corporate tax distortions.*

As will be shown in sections 5 and 6, the above Propositions are false.

3. The model

In this section we introduce a simple discrete-time model describing the behaviour of a competitive risk-neutral firm. First, we study the firm's investment decisions under the alternative assumptions of reversibility and irreversibility. Then, we introduce taxation, and show how the sufficient condition for tax neutrality depends on whether investment is reversible or not.

The model and the notation are those of Dixit and Pindyck (1994, Ch. 2). In particular, the following hypotheses hold:

i) risk is fully diversifiable;

ii) the risk-free interest rate r is fixed;

iii) there exists an investment cost I.

At time 0 the gross profit is equal to Π_0. At time 1, it will change: with probability q, it will rise to $(1+u)\Pi_0$ and with probability $(1-q)$ it will drop to $(1-d)\Pi_0$. Parameters u and d are positive and measure the downward and upward profit moves, respectively. For simplicity, at time 1 uncertainty vanishes and the gross profit will remain at the new level forever. Finally, we assume that the following inequalities hold

$$\frac{(1+u)\Pi_0}{r} > \frac{I}{1+r} > \frac{(1-d)\Pi_0}{r}$$

where

$\sum_{t=1}^{\infty} \frac{1}{(1+r)^t} \cdot (1+u) \cdot \Pi_0 = \frac{(1+u)\Pi_0}{r}$

and

$\sum_{t=1}^{\infty} \frac{1}{(1+r)^t} \cdot (1-d) \cdot \Pi_0 = \frac{(1-d)\Pi_0}{r}$
measure the present discounted value of the flow of future profits from time 1 to infinity, if gross profits increase and decrease, respectively. Finally, $\frac{I}{1+r}$ is the discounted cost of the investment undertaken at time 1. Clearly, if the discounted cost of investment is greater than the present discounted value of future profits (i.e. when the downward jump takes place), real investment is not profitable. This implies that a downward jump in the firm's profitability can be interpreted as 'bad news' and vice versa.

3.1. The Bad News Principle

Let us now study the firm's investment policy. If investment is reversible, or it is irreversible but the firm cannot postpone it in the future (see Dixit and Pindyck, 1994, p.6), the optimal investment rule is based on the net present value of the investment. Namely, the firm will invest if the expected net present value at time 0 (NPV_0) of its future payoffs, net of the investment cost, is positive:

$$[1] \quad NPV_0 = -I + \Pi_0 + \sum_{t=1}^{\infty} \frac{1}{(1+r)^t} \cdot [q(1+u) + (1-q)(1-d)] \cdot \Pi_0 > 0.$$

When, instead, investment is irreversible, and the firm is able to postpone it, the above rule is incorrect. Under investment irreversibility, in fact, the firm's decision is riskier with respect to the reversible case, since the firm cannot resell the installed capital: thus a positive value of NPV_0 is not a sufficient condition for investing. However, if the firm can postpone investment, it has the possibility of waiting for new information. This implies that the firm is endowed with an option to delay[8]. To decide when investing, therefore, the firm compares NPV_0 with the expected net present value of the investment opportunity at time 1

$$[2] \quad NPV_1 = -\frac{qI}{1+r} + \sum_{t=1}^{\infty} \frac{1}{(1+r)^t} \cdot q(1+u)\Pi_0.$$

Note that equation [2] implies that the firm is rational, namely it invests at time 1 only if it receives good news (i.e. it faces an upward shift in profits). The firm

[8]As shown by McDonald and Siegel (1985, 1986), the opportunity to invest is analogous to a perpetual European call option.

chooses its optimal investment time by comparing NPV_0 and NPV_1. If, therefore, the inequality $NPV_0 > NPV_1$ holds, immediate investment is undertaken. If, instead, $NPV_1 > NPV_0$ waiting until time 1 is better.

The investment rule can be rewritten by comparing the alternative policies. Setting [1] equal to [2], we thus obtain the trigger value of the initial gross profits, above which immediate investment is preferred

$$[3] \quad \Pi_0^* = \frac{r + (1-q)}{r + (1-q)(1-d)} \cdot \frac{r}{1+r} \cdot I.$$

As shown by equation [3], the investment decision depends on the seriousness of the downward move, d, and its probability $(1-q)$, but is independent of the upward move's parameter. This point can be explained by Bernanke's (1983) *Bad News Principle* (BNP): under investment irreversibility, in fact, uncertainty acts asymmetrically since only the unfavourable events affect the current propensity to invest[9]. The BNP implies that the higher the investment cost I, the higher is the risk premium of investment (and, consequently, the higher is the trigger point).

4. A sufficient condition for tax neutrality

Let us now introduce taxation and derive the sufficient condition for tax neutrality. First, we analyse the sufficient neutrality condition under investment reversibility. Then, we show how this condition changes when investment is irreversible.

4.1. The Brown condition under reversibility

To check whether neutrality holds under reversibility, we recall Brown's (1948) condition. Given a tax rate τ, neutrality is ensured if the post-tax net present value is $(1-\tau)$ times the pre-tax net present value

$$[4] \; NPV_0 - T_0 = (1-\tau) \cdot NPV_0.$$

As explained by Johansson (1969), this condition implies that 'Corporate income taxation is neutral, if [...] identical ranking of alternative investments is obtained

[9] As stated by Bernanke (1983) "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].

in a pre-tax and post-tax profitability analysis' [p. 104]. It is worth noting that if there exists a symmetric treatment of profits and losses, the above condition holds easily.

4.2. The Brown condition under irreversibility

In order to obtain a sufficient neutrality condition, all the costs must be deductible. Under investment irreversibility, therefore, the Brown condition must be modified, in order to embody the firm's option to wait. As stated by Niemann (1999), in fact, ignoring this opportunity cost would overstate the option value, thereby discouraging immediate investment.

Therefore, the sufficient neutrality condition under irreversibility must be obtained by comparing the expected after-tax net present value at time 0 with that at time 1. Namely, neutrality holds if

$$[4'] \; (NPV_0 - T_0) - (NPV_1 - T_1) = (1 - \tau) \cdot (NPV_0 - NPV_1).$$

Condition [4′] implies that there exists an identical ranking in a pre-tax and in a post-tax profitability analysis. Namely, the after-tax trigger point is equal to the pre-tax one shown in equation [3].

The neutrality result can be explained as follows. 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 option value, namely in the opportunity cost of investing at time 0, thereby encouraging investment. When condition [4′] holds, therefore, these offsetting effects neutralise each other.

5. The role of tax refunding

Once we have derived the conditions ensuring neutrality, let us now study the effects of tax refunding. To do so we use two alternative imputation systems[10]. The first system is similar to that proposed by Garnaut and Ross (1975). Namely,

[10] Contrary to the cash-flow tax, which was never implemented, the imputation method has been introduced in some European countries. In the Nineties, in fact, dual tax systems of corporate taxation were introduced in the Nordic countries (see Sørensen, 1998), and in Italy (see Bordignon et al., 2000). According to these tax designs, companies' earnings are split into the following two components:

the tax base is given by the firm's return, net of an imputation rate. This system is symmetric and, hence, when the firm's return is less than the imputation rate, full tax refunds are allowed. The second system is based on the same imputation method. However, it allows no tax refunds when the firm's return is less than the imputation rate[11]. This latter case will be used to falsify Propositions 1 and 2.

5.1. The full-refundability scheme

Let us begin with the full-refundability design. Define τ_t as the tax rate at time t. Also, assume that taxes are paid at the end of each period and that the government knows parameters d, u and q. If entry takes place at time 0, the tax expenditures' present discounted value is equal to

$$[5] \quad T_0^R = \tau_0 \left[\Pi_0 - r_E I\right] + \sum_{t=1}^{\infty} \frac{\tau_t}{(1+r)^t} \cdot \left\{\left[q(1+u) + (1-q)(1-d)\right] \cdot \Pi_0 - r_E I\right\},$$

where r_E is the opportunity cost of finance. Let us temporarily assume that the tax rate τ_t is constant ($\tau_t = \tau_0$ for $t \geq 0$)[12]. Under the refundability scheme, the expected after-tax net present value at time 0 is obtained by using [1] and [5]

$$[6] \ NPV_0 - T_0^R = (1-\tau) \cdot \left\{1 + \frac{q(1+u) + (1-q)(1-d)}{r}\right\} \cdot \Pi_0 - \left(1 - \tau \frac{1+r}{r} \cdot r_E\right) I$$

where $\frac{1+r}{r}$ is the present discounted value of 1 Euro from time 0 to infinity. As we know, a tax scheme is neutral if it does not affect the firm's investment behaviour, namely if the after-tax trigger point is equal to the laissez-faire one, Π_0^*. As can

1) An imputed return on new investments financed with equity capital, called the 'ordinary return';

2) The residual taxable profits, namely profits less the ordinary return. The ordinary return, which approximates 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. Also, note that the Allowance for Corporate Equity (ACE), proposed by the IFS Capital Taxes Group (1991) for the British tax system, can be considered as a special case of the dual tax system, where the lower tax rate is null. A form of ACE taxation was adopted in Croatia in 1994, under the name of Interest Adjusted Income Tax (see Rose and Wiswesser (1998)).

[11]Note that both effective and opportunity costs are deductible and, thus, both the tax systems studied do not distort financial decisions.

[12]In the next section this simplifying assumption will be removed.

be seen in equation [6], neutrality holds on condition that the imputation rate is equal to $r_E = \frac{r}{1+r}$. Hence, equation [6] reduces to condition [4]. 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 represents an application of the Modigliani-Miller theorem.

Let us now turn to irreversibility. To compute the value of r_E ensuring neutrality we must also take into account the firm's tax burden if investment is undertaken at time 1. Since the postponed investment is undertaken only if profits rise, the tax expenditures' present discounted value is

$$[7] \quad T_1^R = \sum_{t=1}^{\infty} \frac{q\tau_t}{(1+r)^t} \cdot \{(1+u) \cdot \Pi_0 - r_E I\}.$$

Substituting equations [2], [6], and [7] into the condition [4'], it is straightforward to show that neutrality holds if the imputation rate is $r_E = r/(1+r)$ and $\tau_t = \tau_0 \ \forall t \geqslant 0$. Thus Fane's (1987) neutrality result holds even under investment irreversibility. However, the choice of the risk-free interest rate is not a sufficient condition for neutrality to hold. In fact, it is also necessary that *all* future tax rates are both known and constant[13]. If both these conditions hold, the present discounted value of all future tax deductions $\tau_0 \sum_{t=1}^{\infty} \frac{1}{(1+r)^t} \cdot r_E I$ is equal to $\tau_0 I$. Namely, we have an equivalence between the resource-rent tax and the cash-flow tax (see Sandmo (1979)).

5.2. The non-refundability system

Under non-refundability, if the firm enters at time 0, the present discounted value of all future tax payments is

$$[8] \quad T_0^{NR} = \tau_0 \cdot \max\left[0, \Pi_0 - r_E I\right] + q \cdot \max\left\{0, \sum_{t=1}^{\infty} \frac{\tau_t}{(1+r)^t} \cdot \{(1+u) \cdot \Pi_0 - r_E I\}\right\} +$$

[13] As shown by Bond and Devereux (1995), this condition must hold even in the special case when the tax base coincides with the economic rent earned in each period.

$$+(1-q)\cdot\max\left\{0,\sum_{t=1}^{\infty}\frac{\tau_t}{(1+r)^t}\cdot\{(1-d)\cdot\Pi_0-r_E I\}\right\}.$$

Using equations [1] and [8], one obtains the after-tax value of the project

$$[9]\ NPV_0-T_0^{NR}=\left\langle -I+\Pi_0+\sum_{t=1}^{\infty}\frac{1}{(1+r)^t}\cdot[q(1+u)+(1-q)(1-d)]\cdot\Pi_0\right\rangle-$$

$$-\left\langle\tau_0\cdot\max\left[0,\Pi_0-r_E I\right]+q\cdot\max\left\{0,\sum_{t=1}^{\infty}\frac{\tau_t}{(1+r)^t}\cdot\{(1+u)\cdot\Pi_0-r_E I\}\right\}+\right.$$

$$\left.+(1-q)\cdot\max\left\{0,\sum_{t=1}^{\infty}\frac{\tau_t}{(1+r)^t}\cdot\{(1-d)\cdot\Pi_0-r_E I\}\right\}\right\rangle.$$

It is easy to see that r_E must be greater than $\frac{1+r}{r}$. When the asymmetric device is introduced, in fact, the elimination of a tax benefit (i.e. the loss-offset arrangement) must be compensated with the introduction of a new benefit (namely a higher imputation rate) in order for neutrality to hold (see e.g. Ball and Bowers (1983) and Auerbach (1986)). However, it is hard to compute the neutral rate r_E , since it depends not only on income uncertainty but also on policy uncertainty (regarding the future tax rates).

Fairly surprisingly, the computation of the neutral imputation rate is easier under irreversibility. To show this, let us first define the expected tax burden obtained when the firm invests at time 1

$$[10]\quad T_1^{NR}=q\cdot\max\left\{0,\sum_{t=1}^{\infty}\frac{\tau_t}{(1+r)^t}\cdot\{(1+u)\cdot\Pi_0-r_E I\}\right\}.$$

Using equations [1], [2], [8] and [10], one obtains

$$[11]\ (NPV_0-NPV_1)-\left(T_0^{NR}-T_1^{NR}\right)=\left\langle\frac{r+(1-q)(1-d)}{r}\cdot\Pi_0-\frac{r+(1-q)}{1+r}\cdot I\right\rangle-$$

$$-\left\langle\tau_0\cdot\max\left[0,\Pi_0-r_E I\right]+(1-q)\cdot\max\left\{0,\sum_{t=1}^{\infty}\frac{\tau_t}{(1+r)^t}\cdot\{(1-d)\cdot\Pi_0-r_E I\}\right\}\right\rangle.$$

As can be noted, the taxes paid in the good state are eliminated. Thus the tax burden which can potentially distort the firm's decisions is represented by the current tax liability plus the present discounted value of future taxes paid in the bad state. But, if we set $r_E \geqslant \Pi_0/I$, this tax liability is null, and equation [11] reduces to

$$[11'] \ (NPV_0 - NPV_1) - \left(T_0^{NR} - T_1^{NR}\right) = (NPV_0 - NPV_1) \, .$$

Applying Brown's modified condition [4'], therefore, the asymmetric tax design is equivalent to a cash-flow tax with the rate null, and the trigger point is equal to the laissez-faire one Π_0^*.

What is the minimum rate ensuring neutrality? To compute this trigger rate it is sufficient substituting Π_0^* into inequality $r_E \geqslant \Pi_0/I$, thereby obtaining

$$r_E \geqslant r_E^* = \frac{r + (1-q)}{r + (1-q)(1-d)} \cdot \frac{r}{1+r}.$$

As can be easily shown, the parameter r_E^* is always greater than the ex-ante interest rate $r/(1+r)$ since the difference $[r_E^* - r/(1+r)]$ represents the minimum compensation for the lack of the tax refunds arrangement. If, therefore, the firm invests at time 0, it enjoys a tax holiday (see Garnaut and Ross (1975)). If, instead, it waits, no taxes are paid. Thus, equality $T_0^{NR} = T_1^{NR}$ holds irrespective of the firm's decision to whether invest or wait. The following result has thus been proven.

Falsification of Proposition 1-*If the imputation rate is high enough, i.e.* $r_E \geq r_E^*$*, the non-refundability tax scheme is neutral.*

As we know, the elimination of the refundability arrangement must be compensated with the introduction of a higher imputation rate in order for neutrality to hold. What is novel in the irreversible case, however, is the identification of a set of r_E guaranteeing neutrality, instead of a single value[14].

To better understand the above result, let us recall an interesting interpretation of the non-refundability devices, proposed by van Wijnbergen and Estache

[14] Note that inequality $r_E < (1+u)\Pi_0/I$ must also hold in order for the government to collect positive taxes. If, in fact, the rate r_E were greater, neutrality would hold but the result would be trivial, since the tax scheme would prevent the government from collecting any taxes. As shown by Panteghini (1997), however, this upper limit disappears when assuming that uncertainty does not vanish after one period.

(1999). Following Domar and Musgrave (1944), they argue that the corporate tax is equivalent to equity participation. When the losses are non-refundable, however, the government is also endowed with a *put option with strike price zero* written on the firm's profits (p.81). If, namely, the firm's return drops below zero, the government benefits from the non-refundable arrangement. Thus, it acts as if it sold its equity participation at price zero, and it does not share any losses. The government's participation will then be rebought (at price zero) when the firm faces a positive result.

The interpretation of van Wijnbergen and Estache (1999) is useful to explain why we obtain a set of neutral imputation rates instead of a single value. In the $r_E \in [r_E^*, \infty)$ region, in fact, the effects of an increase in the imputation rate are twofold. On the one hand, the government's equity participation decreases (namely the expected tax burden decreases). On the other hand, the value of the government's put option increases (namely, the non-refundability arrangement is more valuable). These two effects neutralise each other.

It is worth noting that uncertainty asymmetrically affects the minimum rate. In fact the rate r_E^* depends on the size of the downward move and its probability, but is independent of the upward move's parameter. Deriving r_E^* with respect to d and q one obtains $\frac{\partial r_E^*}{\partial d} > 0$ and $\frac{\partial r_E^*}{\partial q} < 0$, namely the worse the news, the higher is the minimum rate ensuring neutrality. The rationale for this result is due to the BNP. To see this, let us compare the two alternative decisions of immediate and postponed investment.

Start with the case of immediate investment. Since the imputation rate is high enough (i.e. $r_E \geqslant \Pi_0^*/I$), the firm investing at time 0 neither pays any current taxes nor benefits from any relief; hence, its decisions are not affected by current taxation. At time 1 the firm's profits will change. If they jump upwards, the firm will pay taxes and will benefit from the deduction of the imputation cost: in this case, the firm's value will be equal to $(1-\tau)$ times its laissez-faire value, (and the Brown neutrality condition will hold). If, otherwise, profits decrease, the firm will not pay taxes and will not benefit from any relief. Hence, the firm's value will be equal to its laissez-faire value. In both cases, therefore, taxation does not affect the firm's decisions.

If investment is postponed, the current tax rate τ_0 is not influent, while future taxation will be effective only if profits jump upwards at time 1. Therefore, the firm's value will be equal to $(1-\tau_0)$ times its laissez-faire value. Thus, the asymmetric tax treatment of profits and losses interacts with the asymmetric effects of uncertainty, caused by the BNP. Namely, if the firm receives good news, which do not affect investment, taxation is levied. If, conversely, bad news (affecting investment) are received, no taxes are paid.

6. Policy uncertainty

In this section we study the effects of policy uncertainty on investment decisions. As we know, under irreversibility, policy uncertainty also implies a time inconsistency[15]. In particular, the effects of policy uncertainty are twofold. On the one hand, government may announce a tax rate change which is not implemented after (i.e. the tax rate is unknown but remains constant). On the other hand, an unexpected tax change may take place (i.e. the tax rate is unknown and variable). In both cases, firms would become aware that government may undertake actions different from those initially planned and would try to anticipate further government's tax choices.

To study the effects of policy uncertainty, let us assume a given current value τ_0, and treat the future tax rates τ_t as inherently uncertain. Let us define $E_0(.)$ as the expectations operator. Under full refundability we rewrite equations [5] and [7] as

$$[5'] \quad E_0\left(T_0^R\right) = \tau_0\left[\Pi_0 - r_E I\right] + E_0\left\langle \sum_{t=1}^{\infty} \frac{\tau_t}{(1+r)^t} \cdot \left\{\left[q(1+u) + (1-q)(1-d)\right] \cdot \Pi_0 - r_E I\right\} \right\rangle,$$

and

$$[7'] \quad E_0\left(T_1^R\right) = E_0\left\langle \sum_{t=1}^{\infty} \frac{\tau_t}{(1+r)^t} \cdot q\left\{(1+u) \cdot \Pi_0 - r_E I\right\} \right\rangle,$$

respectively. Using [1] and [2], and rearranging the neutrality condition [4′], the imputation rate $r_E = \frac{r}{1+r}$ is no longer neutral, unless the future uncertain tax

[15] As argued by Mintz (1995), "When capital is sunk, governments may have the irresistible urge to tax such a capital at a high rate in the future. This endogeneity of government decisions results in a problem of *time consistency* in tax policy whereby governments may wish to take actions in the future that would be different from what would be originally planned..." [p.61].

changes neutralise each other so as to make the net present value of the tax burden equal to that raised with the initial rate τ_0[16].

The non-refundability system, instead, acts like a pre-commitment for the government and guarantees neutrality even under policy uncertainty.

Falsification of Proposition 2- *If the imputation rate is high enough, i.e.* $r_E \geq r_E^*$*, the non-refundability tax scheme is neutral even though future tax rates are uncertain.*

Proof-To falsify Proposition 2, let us recall equations [8] and [10] and compute the expected present discounted value of all future tax payments at time 0

$$[8'] \quad E_0\left(T_0^{NR}\right) = \tau_0 \cdot \max\left[0, \Pi_0 - r_E I\right] + \\ +E_0\left\langle q \cdot \max\left\{0, \sum_{t=1}^{\infty} \frac{\tau_t}{(1+r)^t} \cdot \{(1+u)\cdot\Pi_0 - r_E I\}\right\} + \\ +(1-q)\cdot\max\left\{0, \sum_{t=1}^{\infty} \frac{\tau_t}{(1+r)^t} \cdot \{(1-d)\cdot\Pi_0 - r_E I\}\right\}\right\rangle.$$

and at time 1

$$[10'] \quad E_0\left(T_1^{NR}\right) = E_0\left\langle q \cdot \max\left\{0, \sum_{t=1}^{\infty} \frac{\tau_t}{(1+r)^t} \cdot \{(1+u)\cdot\Pi_0 - r_E I\}\right\}\right\rangle,$$

respectively. If we set $r_E \geq r_E^*$, it is straightforward to see that equality $E_0(T_0^{NR}) = E_0(T_1^{NR})$ holds and equation [11] simplifies to [11′]. The Proposition 2 is thus false.

[16]Namely, the following equality must hold

$$(NPV_0 - E_0(T_0^R)) - (NPV_1 - E_0(T_1^R)) = (1-\tau_0)\cdot(NPV_0 - NPV_1)$$

which can be simplified and rewritten as

$$\frac{E_0(T_0^R) - E_0(T_1^R))}{\tau_0} = -\left[\frac{r-(1-q)(1-d)}{r}\cdot\Pi_0 + \frac{1-q}{1+r}\cdot I\right].$$

If, conversely, an inequality is obtained, the firm underinvests if $\frac{E_0(T_0^R)-E_0(T_1^R))}{\tau_0}$ is greater than $-\left[\frac{r-(1-q)(1-d)}{r}\cdot\Pi_0 + \frac{1-q}{1+r}\cdot I\right]$ and vice versa.

QED

If the imputation rate is high enough, in fact, the firm investing at time 0 will benefit from a tax holiday: more precisely, it will neither pay any tax nor benefit from any tax refund. Like the firm investing at time 1, therefore, it will pay taxes only in the future. Since only future taxation matters, whether investment is immediate (at time 0) or postponed (at time 1), neutrality holds and time consistency is guaranteed.

Note that the above result holds irrespective of the stochastic process followed by the tax rate (namely irrespective of whether tax changes are continuous or discrete). Neither, it is necessary for the firm to know the distribution of probabilities of the uncertain event. Recalling the Knightian definition of uncertainty, it seems more realistic to consider policy as uncertain rather than risky. And, the above result holds even if the stochastic process of the tax rate is not known ex ante and the firm undertakes a gradual process of learning.

7. Conclusion

In this article, a non-refundability corporate tax system has been discussed. Though it is generally believed that an asymmetric design is distortive, this is not so if the rate of relief is adjusted to neutralise the effects of tax asymmetry. Since this rate is not affected by the statutory tax rate, the non-refundability system turns out to be neutral.

As shown in this article, the neutrality results are inherently linked to the nature of investment. In particular, when investment is irreversible, the assumption of tax symmetry may no longer be necessary in order for neutrality to hold.

The system discussed is neutral from a dynamic point of view as well. We have shown that the effects of future uncertain taxation on both the project and option value neutralise each other. Under this regime, therefore, time consistency problems are not relevant and the government may benefit from a higher degree of freedom.

To conclude, it is worth noting that the above results do not depend on the bivariate stochastic process describing income uncertainty. As shown by Panteghini (1997), the same neutrality results can be obtained even if uncertainty lasts to infinity (instead of vanishing after one period). Moreover, the quality of the results is unchanged if, following McDonald and Siegel (1985, 1986), we assume that the shareholders of the representative firm are risk-averse.

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